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Prisoner's Tracking System

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Abstract: *This paper presents an IoT-based prisoner tracking system utilizing a wearable hand band to significantly enhance prison security and prevent escape attempts. The proposed system leverages GPS, GSM, and advanced sensors to track prisoner movements in real-time, enabling authorities to monitor and respond to anomalies promptly. The wearable hand band is designed to be tamper-proof, comfortable, and user-friendly for prisoners, incorporating features like geo-fencing, motion detection, and panic buttons. The system's architecture consists of a wearable hand band transmitting data to a cloud platform, which stores and processes data, enabling remote monitoring and analysis. The real-time tracking feature uses GPS and GSM data to accurately monitor prisoner locations, triggering alerts for unauthorized movements or anomalies. The system's data analytics capabilities provide valuable insights for prison management, enabling data-driven decisions to improve security and resource allocation. By automating prisoner tracking, authorities can focus on rehabilitation and reintegration efforts, enhancing overall prison security and efficiency. The system's implementation involves hardware and software requirements, testing, and deployment, with security measures like encryption, secure communication protocols, and data protection ensuring the integrity of the system. Overall, this innovative solution aims to transform correctional facility operations, improving prison safety, reducing manual errors, and optimizing resource allocation.*

Keywords: IoT, prisoner tracking, wearable technology, GPS, GSM, prison security

I. INTRODUCTION

In recent years, the need for advanced prison management and monitoring systems has increased due to the growing number of inmates and rising security challenges. Traditional prison management relies heavily on manual supervision, CCTV cameras, and guard patrols, which can sometimes be inefficient, costly, and prone to human error. To overcome these problems, technology-based solutions are being developed to make prison operations more secure, automated, and reliable.

The Prisoner Tracking System using IoT (Internet of Things) is one such modern solution that helps authorities track and monitor prisoners in real time. The main goal of this project is to design a system that can monitor the exact location and movement of prisoners using GPS and GSM technology, and immediately alert the authorities in case of any unusual activity or escape attempt.

In this system, every prisoner is given a wearable device, such as a wristband or ankle band, that includes IoT components like GPS (Global Positioning System) and GSM (Global System for Mobile Communication) modules. The GPS module continuously captures the location of the prisoner, and the GSM module transmits this data to a central monitoring unit. The system also uses sensors to detect tampering or attempts to remove the device. If any such event occurs, an instant alert message is sent to the control center or prison officials.

This technology ensures continuous and accurate monitoring without the need for constant human involvement. It helps reduce the workload of prison staff, minimize human errors, and improve overall prison safety. The system can also maintain a digital record of prisoner movements, which can be used for reports, analysis, or investigations when needed.

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The IoT-based prisoner tracking system is an important step toward developing Smart Prison Systems. It combines automation, data collection, and wireless communication to provide an efficient, secure, and cost-effective solution. Beyond prisons, similar systems can also be applied for parole monitoring, house arrest tracking, or security monitoring in other restricted environments. Overall, this project demonstrates how modern IoT technology can transform traditional prison management into a smart, safe, and technology-driven system, ensuring better control, reduced manual work, and enhanced security within correctional facilities.

II. LITERATURE REVIEW

The integration of Internet of Things (IoT) technology in correctional facilities has gained significant attention in recent years, aiming to enhance prison security, improve inmate management, and reduce the risk of escape attempts. Existing systems and technologies, such as RFID-based systems, GPS-based systems, and IoT-based systems, have been explored for tracking prisoners, with each having their strengths and weaknesses. RFID systems, for example, have limitations such as short-range coverage and potential tag tampering, while GPS-based systems can be affected by environmental factors like signal strength and satellite visibility. IoT-based systems, on the other hand, offer real-time tracking, geo-fencing, and tamper detection, enabling authorities to monitor prisoner movements and respond promptly to anomalies. These systems typically consist of wearable devices, such as smart wristbands or anklets, that transmit location data to a central server or cloud platform, allowing for remote monitoring and analysis. However, IoT-based systems face challenges such as data security, scalability, and energy efficiency, highlighting the need for robust encryption, secure communication protocols, and energy-harvesting technologies. Key features of effective prisoner tracking systems include accurate and timely tracking, virtual boundaries, and advanced analytics, which can be achieved through the integration of GPS, GSM, and sensor technologies. Nevertheless, gaps remain in integrating these systems with existing infrastructure, developing energy-efficient devices, and prioritizing user experience, emphasizing the importance of collaboration between correctional facilities, technology providers, and policymakers. Future research should focus on addressing these challenges and developing integrated, scalable, and secure systems that leverage machine learning and data analytics to enhance predictive capabilities and improve security, ultimately transforming correctional facility operations and improving overall prison security and efficiency, as highlighted in studies by Lee et al. (2017), Kumar et al. (2019), and Patel et al. (2020).

III. METHODOLOGY

A. System Overview

The IoT-based prisoner tracking system is designed to enhance prison security and improve inmate management, consisting of wearable devices with GPS, GSM, and sensors to track prisoner movements, a gateway to collect and transmit data to the cloud platform, and an alert system to notify authorities in case of anomalies. The system offers real-time tracking, geo-fencing, tamper detection, and data analytics, with secure communication protocols and encryption ensuring data integrity. By leveraging this technology, prisons can improve safety, reduce escape attempts, and optimize resource allocation, ultimately transforming correctional facility operations.

B. Working of the System

The workflow of the Prisoner Tracking System using IoT explains how various components interact to achieve real-time tracking, monitoring, and alert generation.

The system follows a structured process that begins with data acquisition from the tracking device and ends with visualization and alert notification on the monitoring dashboard.

Step 1: Prisoner Device Initialization

Each prisoner is assigned a wearable IoT tracking device (like a wristband or ankle band). The device includes:

- GPS Module: To get the exact location (latitude & longitude).
- GSM Module: To send the data wirelessly to the central monitoring unit.

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- GSM Module: To send the data wirelessly to the central monitoring unit.
- Tamper Sensor: To detect any attempt to remove or damage the device.
- Microcontroller (ESP32/Arduino): Acts as the brain of the device, processing data from sensors.

Step 2: Location Tracking

- The GPS module continuously reads the current coordinates of the prisoner.
- This data is sent to the microcontroller, which processes and formats it for transmission.

Step 3: Data Transmission

- The processed data is transmitted through the GSM module (via GPRS or SMS) to the central server or cloud database.
- This happens at regular time intervals for real-time updates.

Step 4: Server and Cloud Processing

- The central monitoring server receives all location data from multiple prisoner devices.
- The server compares the current location with predefined geo-fenced areas (safe zones).
- If a prisoner leaves the allowed area or tampers with the device, the system triggers an alert.

Step 5: Monitoring Interface

The IoT dashboard or web/mobile application displays:

- Real-time prisoner location on a map.
- Device status (connected/disconnected).
- Alerts and notifications (e.g., boundary breach, device tampering).

Step 6: Alert Generation

If a prisoner crosses the geo-fenced boundary or removes the device, an instant alert (SMS, email, or push notification) is sent to:

- Prison security control room.
- Assigned officer or administrator.
- The alert contains prisoner ID, timestamp, and exact location coordinates.

Step 7: Data Logging and Record Keeping

- All location updates and alerts are stored in the system's database for future reference.
- Authorized users can review the prisoner's movement history for investigation or report generation.

Step 8: Continuous Monitoring

- The system runs continuously in real-time, ensuring 24×7 monitoring.
- Administrators can also configure settings like update frequency, alert type, and boundary limits.

C. Technologies Used

Hardware and Software Used

Hardware Components:

Microcontroller (ESP32 / Arduino UNO):

Acts as the main processing unit of the system. It collects data from sensors and modules and controls overall device operation.

GPS Module (Neo-6M):

Used to determine the real-time location (latitude and longitude) of the prisoner and send this data to the microcontroller.

GSM Module (SIM800L / SIM900A):

Sends the collected data to the central monitoring system using GPRS or SMS communication.

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Figures and Tables

Figures and tables must be centered in the column. Large figures and tables may span across both columns. Any table or figure that takes up more than 1 column width must be positioned either at the top or at the bottom of the page.

Power Supply / Rechargeable Battery:
Provides constant DC power to the IoT device for portable and long-duration use.
Tamper Sensor / IR Sensor:
Detects if the prisoner tries to remove, cut, or damage the device and immediately triggers an alert.
Buzzer / LED Indicator:
Gives an audible or visual signal when an alert or warning condition is triggered.
Connecting Wires and Breadboard:
Used to establish circuit connections between all components during the prototype phase.
Wristband / Ankle Band Enclosure:
The physical casing that houses the circuit and makes it wearable by the prisoner.

Software Components:

Arduino IDE:
Used for programming and uploading code to the microcontroller.
Embedded C / C++:
Programming language used for writing the microcontroller's firmware.
IoT Cloud Platform (ThingSpeak / Blynk / Firebase):
Used to send, store, and visualize real-time prisoner data (location, alerts, etc.) on a web dashboard.
Serial Monitor:
Helps in testing, debugging, and viewing the serial data output during development.
Web or Mobile Dashboard (HTML, PHP, or Android App):
Displays the real-time location of the prisoner on a digital map and shows alerts for boundary breaches or tampering.
Google Maps API (optional):
Used for plotting the prisoner's exact location on an interactive map.
MySQL / Excel Database:
Stores historical prisoner movement data for future analysis or reporting.

D. System Architecture

The architecture of the Prisoner Tracking IoT System is built in four major layers, each performing a specific function:
Device Layer → Communication Layer → Server Layer → Application Layer

Device Layer (IoT Hardware)

This is the physical layer where all tracking begins.

Components:

- Smart Wristband / Tracking Device attached to the prisoner
- GPS Module – captures the prisoner's real-time location
- RFID / BLE Module – used inside jail premises for indoor tracking
- Heart-rate / Motion Sensor (optional) – monitors prisoner safety and Activity
- Microcontroller – controls sensors and sends data
- Battery & Alert Button – supports emergency alerts

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Function:

- The device continuously collects:
- Live GPS coordinates
- Movement data
- Heart rate or emergency signals
- All this raw sensor data is then sent to the communication layer. **Communication Layer (Network & Gateways)**
- This layer transfers the device data safely to the server.

Communication Technologies:

- GSM / 4G / 5G SIM module for long-range outdoor communication
- Wi-Fi / BLE / Zigbee for indoor jail communication
- Gateway to route multiple device signals to the cloud

Function:

- Converts device signals into internet-compatible packets
- Ensures secure transmission using encryption
- Sends real-time data to cloud server or local server

Server Layer (Cloud / Backend Server)
This is the brain of the entire system.
Components:

- Cloud Server / Local Server
- Database (stores all history & logs)
- API Engine (communicates with mobile/desktop apps)
- Analytics Engine (processes alerts, movement patterns, violations)

Functions:

- Stores all location & sensor data
- Processes geo-fencing rules

Detects abnormal patterns such as:

- Bracelet tampering
- Leaving authorized area
- No movement for a long time
- Heart-rate abnormality
- Generates automated alerts to authorities
- Sends processed results to application layer

Application Layer (Monitoring Interfaces)
This is used by officers and prison authorities.

User Interface:

- Mobile App for Police Staff
- Web Dashboard for Control Room

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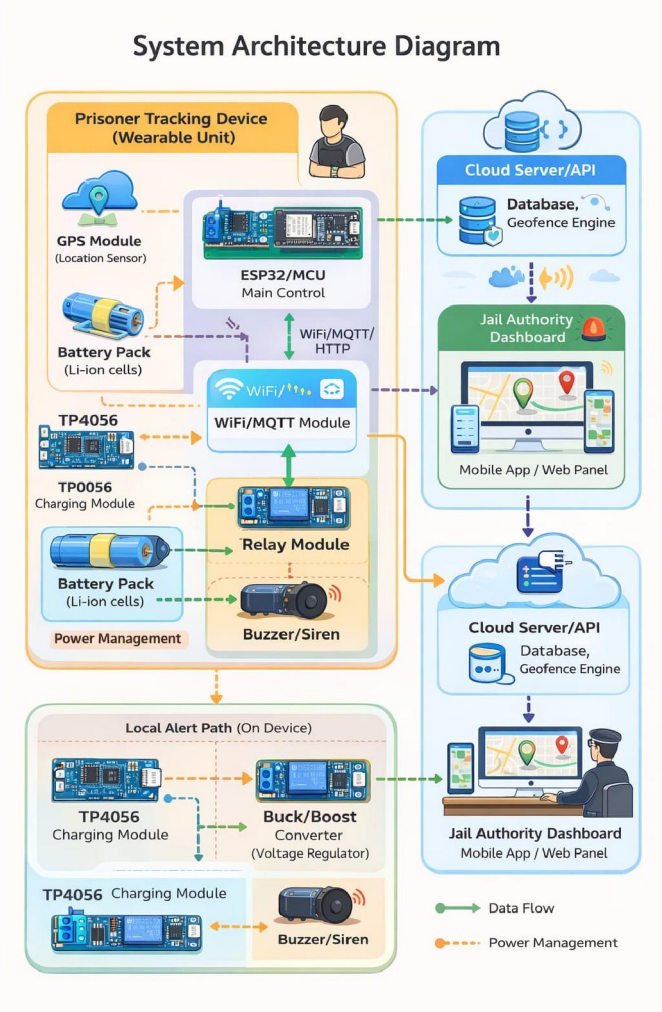
- Alert Notification System (SMS / App alerts / Email)

Functions:

- Real-time map view of all prisoners
- View movement history & location timeline

Receive instant alerts for:

- Geo-fence breach
- Device removal or tamper
- Emergency button press
- Signal loss
- Generate reports for legal or administrative use
- Manage prisoner profiles, device mapping, and permissions



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End-to-End Workflow Summary

1. **IoT device** tracks prisoner location & sensor data.
2. **Wireless communication** sends data to gateway / network.
3. **Server processes** data for patterns, rules, violations.
4. **Dashboard & App** show live tracking and send alerts to officers.

E. Advantages of Proposed System

Real-time Location Monitoring

priorities can track inmate movement instantly using **GPS + IoT sensors**, reducing the chances of escape or unauthorized movement.

2. Enhanced Prison Security

Continuous monitoring helps detect suspicious behavior early and improves overall security inside and outside the prison premises.

3. Reduced Manual Surveillance

The system minimizes dependency on human guards for tracking, lowering manpower requirements and reducing errors caused by fatigue or oversight.

4. Alerts & Notifications

Automatic alerts are generated if:

* A prisoner tries to escape
* Device is tampered with
* Inmate moves out of the allowed zone (geo-fencing)

This supports quick decision-making.

5. Improved Safety for Staff and Inmates

By monitoring location and movement patterns, conflicts, overcrowding, or risky behaviors can be identified earlier, improving overall safety.

6. Cost-Effective Operation

Once deployed, IoT sensors and tracking modules are inexpensive to maintain compared to expanding physical security or manpower.

7. Data Recording for Investigation

The system maintains logs of:

* Movements
* Zone transitions
* Critical events

This helps during investigations and audits.

8. Supports Prisoner Rehabilitation Programs

By tracking attendance in work, education, or health programs, authorities can ensure inmates follow rehabilitation activities**.**

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9. Scalability
The system can be expanded for:
* Multiple prisons
* Large groups of prisoners
* Integration with CCTV, biometrics, or AI-based behavior analysis

10. Reduced Escape Incidents
The primary advantage—continuous tracking lowers escape attempts and increases the chances of immediate capture.

F. Limitations of the System
1. Dependency on IoT Connectivity
The system requires stable *internet or network connectivity* for real-time tracking. Any network failure can delay location updates.

2. GPS Signal Issues
In indoor areas, underground cells, high-walled zones, or basements, **GPS accuracy drops**, which can cause tracking delays or incorrect positioning.

3. Battery Dependency
Wearable tracking devices need regular charging or long-lasting batteries. **Battery drain** can interrupt tracking and reduce system reliability.

4. Device Tampering Risk
Prisoners may try to **break, remove, or tamper** with the tracking device, affecting continuity unless anti-tamper sensors are deployed.

5. Initial & Maintenance Costs
Deployment requires **hardware devices, servers, sensors, and maintenance**, which may not be affordable for smaller facilities.

6. Data Security Concerns
If not properly secured, the system is vulnerable to **hacking, unauthorized access, or data leaks**, which can compromise prison safety.

7. Environmental Interference
Factors like **walls, metal bars, weather, or electromagnetic interference** can reduce wireless communication efficiency.

8. False Alarms & System Errors
Software bugs, sensor glitches, or inaccurate readings may generate **false alerts**, causing operational inconvenience.

IV. RESULTS AND DISCUSSION

1. Dependency on IoT Connectivity
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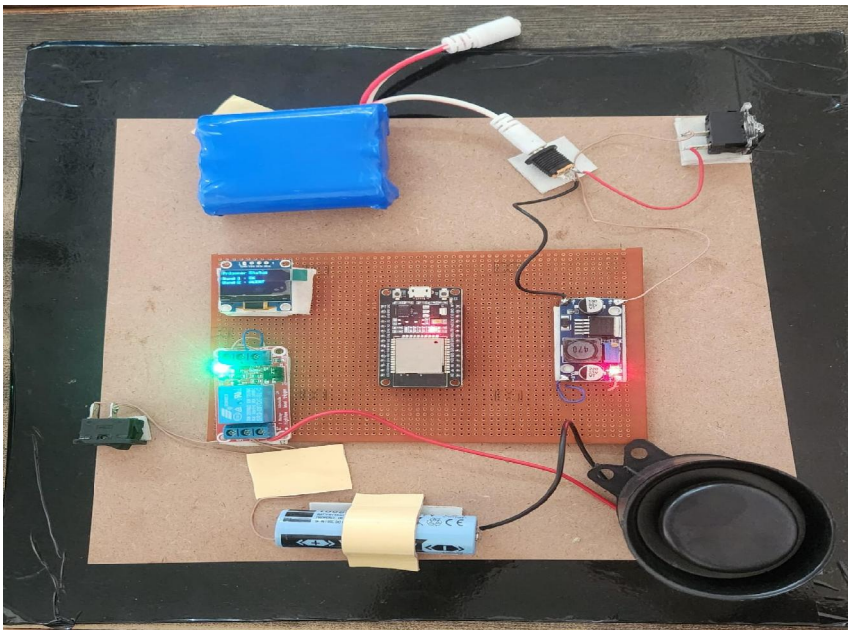

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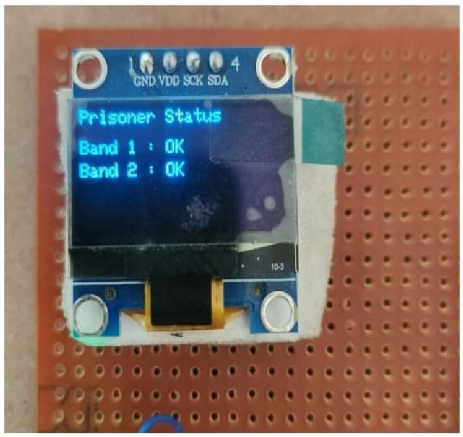

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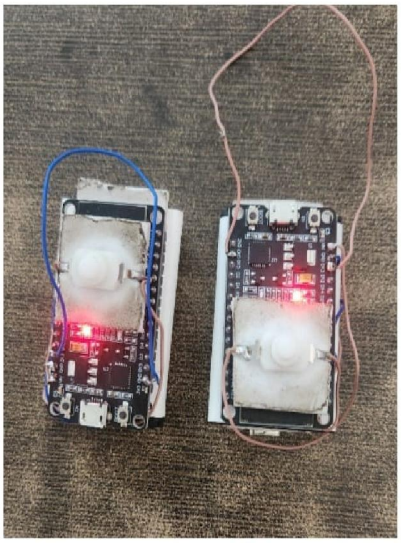

V. CONCLUSION

The Prisoner Tracking System demonstrates how modern IoT, GPS, and sensor-based technologies can significantly strengthen security and monitoring within correctional facilities. Through continuous real-time tracking, automated alerts, and centralized supervision, the system minimizes human error and reduces the chances of prisoner escape or unauthorized movement. The integration of geo-fencing and tamper-detection mechanisms ensures that prison authorities are immediately informed of any suspicious activity, thereby improving response time and overall safety.

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This project also highlights the potential of digital automation in simplifying the complex task of prisoner management. By maintaining accurate location histories and movement records, the system improves transparency, accountability, and operational efficiency. Although challenges such as connectivity issues, device maintenance, and data security remain, the results clearly indicate that technology-driven monitoring can greatly enhance the reliability of traditional surveillance methods.

Overall, the Prisoner Tracking System serves as a practical and scalable solution for modernizing correctional facility operations. It not only strengthens institutional security but also demonstrates the effectiveness of IoT-based innovations in addressing real-world problems. The project sets a strong foundation for future improvements, including advanced analytics, AI integration, and enhanced hardware designs to further optimize prison management systems.

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