International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 07 | Jul 2026 www.irjet.net p-ISSN: 2395-0072

IOT-Based Bag Theft Detection System Using NodeMCU and IoT

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Abstract-*With the rising cases of bag theft in public places, a smart security solution is needed. This project presents an IoT-based bag theft detection system to protect personal belongings.The system uses sensors like motion or vibration sensors to detect unauthorized movement of the bag. A microcontroller (such as Arduino or Raspberry Pi) processes the data and triggers an alarm if suspicious activity is detected. It also sends alerts to the user's Smartphone through IoT technology. Additionally, GPS and GSM modules can be used to track the bag's real-time location, helping in quick recovery. The system can be easily integrated with mobile applications for better user control and monitoring. It is simple to use and requires minimal maintenance.This system is low-cost, portable, and provides real-time monitoring, helping to reduce theft and improve personal security*

Key Words: Internet of Things (IoT), Bag Theft Detection, Motion Sensor, Vibration Sensor, GPS Tracking, GSM Module, Real-Time Monitoring, Smart Security System.

1. INTRODUCTION

The rapid advancement of Internet of TE-style paper:hings (IoT) technology has enabled the development of intelligent security systems capable of protecting personal belongings through continuous monitoring, real-time data processing, and wireless communication. IoT connects physical devices with the internet, allowing them to exchange information and respond automatically to various situations. This technology has found applications in smart homes, healthcare, transportation, industrial automation, and personal security systems.

Bag theft is a common problem faced by travelers, students, office employees, and the general public, especially in crowded places such as railway stations, bus terminals, airports, shopping malls, colleges, and public events. Conventional bags rely mainly on mechanical locks or zippers, which provide only physical protection and cannot detect theft attempts or notify the owner when unauthorized access occurs. As a result, valuable belongings such as laptops, mobile phones, wallets, important documents, and personal items remain vulnerable to theft.

To overcome these limitations, the proposed IoT-Based Bag Theft Detection System provides a smart and efficient solution for protecting personal belongings. The system integrates multiple sensors, including a PIR motion sensor and a vibration sensor, with a NodeMCU (ESP32/ESP8266) microcontroller. These sensors continuously monitor the bag for any unusual movement, vibration, or unauthorized handling. Whenever suspicious activity is detected, the microcontroller immediately processes the sensor data and activates a buzzer to alert nearby people.

In addition to the local alarm, the system uses a GSM module to send an instant SMS notification to the owner's registered mobile number, informing them about the possible theft. A GPS module is incorporated to determine the real-time location of the bag and transmit its coordinates, enabling the owner to track and recover the bag quickly. The system can also be integrated with a mobile application such as , allowing users to remotely monitor the device, enable or disable the security system, and receive real-time notifications from anywhere.

The proposed system is designed to be compact, portable, affordable, and energy-efficient, making it suitable for everyday use. It requires minimal maintenance and can be easily attached to backpacks, handbags, luggage, laptop bags, or travel bags without affecting normal usage. By combining IoT technology with real-time sensing, wireless communication, and location tracking, the system significantly enhances personal security and minimizes the risk of theft.

Overall, the IoT-Based Bag Theft Detection System offers a reliable, user-friendly, and cost-effective solution for safeguarding valuable belongings. Its real-time monitoring, instant alert mechanism, and location tracking capabilities make it an effective anti-theft system for modern-day personal security applications.[1], [2], [3], [4]

2. PROBLEM STATEMENT

Bag theft has become a significant security concern in today's fast-paced world, particularly in crowded public places such as railway stations, bus terminals, airports, shopping malls, educational institutions, offices, hotels, and tourist destinations. People frequently carry valuable belongings such as laptops, smartphones, wallets, identification documents, certificates, cash, electronic gadgets, and other personal items in their bags. The increasing number of theft incidents has highlighted the need for smarter and more reliable security solutions that can protect personal belongings in real time.

Conventional bags rely mainly on mechanical locks, zippers, or password locks to provide security. Although these methods offer basic physical protection, they are unable to detect unauthorized movement, tampering, or theft attempts. They also lack the capability to notify the owner immediately when suspicious activity occurs. In most cases, the owner becomes aware of the theft only after the bag has already been stolen, significantly reducing the chances of recovering the lost belongings.[5], [6], [7]

Furthermore, many existing solutions lack integration with a centralized monitoring platform, making them less effective for continuous surveillance and rapid response. To address these challenges, there is a need for an intelligent, IoT-enabled bag security system that provides continuous monitoring, real-time theft detection, and instant user notification. The proposed IoT-Based Bag Theft Detection System integrates a NodeMCU (ESP32) microcontroller with a PIR motion sensor and a vibration sensor to detect suspicious movement or unauthorized handling of the bag. Once a theft attempt is detected, the system immediately activates a buzzer to alert nearby people, sends an SMS notification to the owner's registered mobile number through the SIM800L GSM module, and obtains the bag's current location using the GPS module.

The location and security status of the bag are then transmitted to a web application, where users can remotely monitor their bag, view live location updates, and receive real-time security notifications. The web-based interface provides easy accessibility from any internet-connected device without requiring a dedicated mobile application.

Therefore, the proposed system aims to overcome the limitations of conventional and existing electronic security systems by providing an affordable, portable, energy-efficient, and user-friendly solution. By combining IoT technology, multi-sensor detection, GSM communication, GPS tracking, and web-based monitoring, the system enhances the safety of personal belongings, enables rapid response to theft incidents, and improves the likelihood of recovering stolen bags.

Several electronic security systems, such as RFID tags, Bluetooth trackers, or standalone GPS trackers, have been developed to improve bag security. However, these systems have several limitations. RFID systems require dedicated readers and have a limited operating range. Bluetooth-based trackers function only within a short communication distance and become ineffective when the bag moves beyond the Bluetooth coverage area. Standalone GPS trackers provide location information but cannot detect theft automatically or generate immediate alerts based on unauthorized movement.

3. LITERATURE SURVEY

Recent advancements in the Internet of Things (IoT) have led to the development of intelligent anti-theft and luggage monitoring systems. Researchers have proposed several solutions using technologies such as GPS, GSM, RFID, Bluetooth, PIR sensors, and microcontrollers to improve the security of personal belongings. However, many existing systems suffer from limitations such as limited communication range, lack of real-time theft detection, or dependence on a single sensing technology. The following literature survey reviews the most relevant research related to the proposed IoT-Based Bag Theft Detection System.

A. IoT-Based Theft Detection for Women Handbags (2023) Sale-Ghodake et al. proposed an IoT-based handbag security system that uses a PIR sensor, GPS, GSM, buzzer, and camera to detect unauthorized access. When motion is detected, the system captures images, activates an alarm, and sends the bag's location to the owner. The work demonstrates the usefulness of combining IoT with sensing technologies for personal security. However, the system mainly depends on motion detection and image capture, which may increase hardware complexity and power consumption.[8], [9], [10], [11], [12]

B. Smart Luggage Theft Detection and GPS Tracking System (2025)Navya et al. developed a smart luggage tracking system using an Arduino microcontroller with GPS and GSM modules. The system continuously monitors luggage location and transmits tracking information through SMS, allowing users to locate misplaced or stolen baggage. Although the system provides effective location tracking, it primarily focuses on tracking after luggage is lost and does not include intelligent theft detection using multiple sensors.

C. Review of Smart Bag Research and Applications (2024) Wang et al. presented a comprehensive review of smart bag technologies and discussed the integration of IoT, tracking systems, wireless communication, and intelligent sensing in modern luggage applications. The review highlighted the increasing demand for smart security features and identified the need for low-cost, portable, and user-friendly anti-theft solutions capable of real-time monitoring.[13], [14], [15], [16]

4. RESEARCH GAP

The literature indicates that many existing systems provide either location tracking or theft detection, but very few integrate multiple sensing technologies with real-time notification and remote monitoring in a single, low-cost solution. RFID and Bluetooth-based systems have limited operating ranges, while standalone GPS trackers cannot detect theft automatically. Some camera-based systems increase system complexity and power consumption.

To overcome these limitations, the proposed IoT-Based Bag Theft Detection System combines a PIR motion sensor and a vibration sensor for accurate theft detection. The system uses a NodeMCU (ESP32) microcontroller to process sensor data, activates a buzzer to alert nearby people, sends an SMS notification through the SIM800L GSM module, and provides live GPS location tracking. In addition, the system is integrated with a web application, allowing users to monitor the bag's status and location remotely in real time. This combination of multi-sensor detection, GSM communication, GPS tracking, and web-based monitoring provides a more reliable, portable, and cost-effective solution compared to existing methods.[17], [18], [19], [20]

5. MATERIALS AND METHODS

The proposed IoT-Based Bag Theft Detection System is designed using a combination of IoT hardware components, wireless communication modules, and a web-based monitoring platform. The objective of selecting these components is to develop a portable, reliable, low-cost, and energy-efficient anti-theft system capable of detecting unauthorized movement, alerting the owner instantly, and providing real-time location tracking.

1. NodeMCU ESP32 Microcontroller

The NodeMCU ESP32 is the central processing unit of the proposed system. It controls the complete operation of the device by collecting data from the sensors, processing the received information, and coordinating communication with the GSM module, GPS module, buzzer, and web application. The ESP32 contains a dual-core processor, built-in Wi-Fi, multiple GPIO pins, UART communication interfaces, PWM outputs, ADC channels, and low-power operating modes. These features make it suitable for IoT-based embedded applications requiring wireless connectivity and fast data processing.

The ESP32 continuously reads the sensor values and compares them with predefined threshold conditions. If abnormal movement is detected, the controller executes the security algorithm, activates the buzzer, sends SMS notifications, and uploads the location and security status to the web application.

2. PIR Motion Sensor

The Passive Infrared (PIR) sensor detects the movement of people around the protected bag. It works by sensing changes in infrared radiation emitted naturally by the human body. Under normal conditions,the sensor continuously monitors the surrounding environment without generating false alarms. Whenever an unauthorized person approaches or attempts to move the bag, the infrared pattern changes, causing the PIR sensor to generate a digital output signal.

The PIR sensor consumes very little power and provides reliable human motion detection. It serves as the first level of security by identifying suspicious human presence before the bag is physically moved.

3. Vibration Sensor

The vibration sensor detects mechanical disturbances such as lifting, shaking, dragging, dropping, or sudden impacts on the bag. Unlike the PIR sensor, which detects nearby human movement, the vibration sensor directly monitors physical interaction with the bag itself.
Using both sensors together improves system reliability. The dual-sensor approach minimizes false alarms caused by environmental conditions while increasing the probability of detecting actual theft attempts. The ESP32 analyzes the outputs from both sensors before deciding whether to trigger the alarm.

4. SIM800L GSM Module

The SIM800L GSM module enables wireless communication over the GSM network. It is responsible for transmitting SMS alerts to the owner's registered mobile number whenever theft is detected.After receiving a theft signal from the ESP32, the module automatically sends an emergency message indicating that unauthorized movement has been detected. The SMS may also include GPS coordinates or a link to the web application where the bag's location can be viewed.

5. GPS Module

The GPS module continuously communicates with GPS satellites to determine the geographical coordinates of the bag. It provides latitude, longitude, altitude, speed, and time information.

When theft is confirmed, the ESP32 retrieves the latest GPS coordinates and uploads them to the web application. The owner can then monitor the bag's live location remotely and share the coordinates with authorities if necessary.

Real-time GPS tracking significantly improves the possibility of recovering stolen belongings.

6. Buzzer

The buzzer acts as the immediate local warning device of the proposed security system. Once unauthorized movement is detected, the ESP32 activates the buzzer, producing a loud audible alarm.

The alarm serves two important purposes:

- It alerts nearby people about the theft attempt.
- It discourages the thief from continuing the theft.

The buzzer remains active until the system is reset or the owner disables the alarm through the web application.

7. Web Application

A dedicated web application is developed to monitor and control the proposed security system remotely.

The web application provides the following functions:

- Displays the current security status of the bag
- Shows live GPS location on an interactive map.
- Displays theft alert notifications.
- Allows the user to monitor the system from any internet-connected device.
- Maintains records of detected theft events (if database support is included).
- Provides a simple and user-friendly interface for remote monitoring.
- Unlike Bluetooth-based systems, the web application allows unlimited monitoring distance as long as internet connectivity is available.

8. Power Supply

The proposed system is powered using a rechargeable battery that supplies sufficient voltage to the ESP32, GSM module, GPS module, sensors, and buzzer. The portable battery allows the device to operate independently without requiring an external power source, making it suitable for installation inside backpacks, handbags, travel luggage, and laptop bags.

6. METHODS

The implementation of the proposed system follows a sequential process to detect theft, alert the owner, and provide real-time tracking.

Step 1: System Initialization

When power is supplied, the ESP32 initializes the PIR sensor, vibration sensor, GPS module, SIM800L GSM module, buzzer, Wi-Fi connection, and web application interface. The controller checks whether all modules are functioning correctly before entering monitoring mode.

Step 2: Continuous Monitoring

The PIR sensor continuously scans the surrounding area for human movement, while the vibration sensor monitors physical disturbances such as lifting or shaking of the bag.
The ESP32 continuously reads sensor values and stores them for processing.

Step 3: Theft Detection

Whenever abnormal movement or excessive vibration is detected, the ESP32 compares the sensor outputs with predefined threshold values.
If the sensor readings indicate unauthorized activity, the controller classifies it as a theft attempt.

Step 4: Alarm Activation

Immediately after theft detection, the ESP32 activates the buzzer. The audible alarm warns nearby people and acts as a deterrent to discourage the thief.

Step 5: SMS Notification

Simultaneously, the ESP32 sends AT commands to the SIM800L GSM module.

The GSM module automatically sends an SMS notification to the owner's registered mobile number indicating that unauthorized movement has been detected.

Step 6: GPS Location Acquisition

The GPS module continuously receives signals from satellites and determines the current geographical coordinates of the bag.The ESP32 extracts the latitude and longitude information from the GPS data.

Step 7: Data Transmission

The ESP32 transmits the GPS coordinates and theft status to the web application using its built-in Wi-Fi connectivity. The information is updated in real time, enabling continuous monitoring.

Step 8: Web-Based Monitoring

The owner accesses the web application through a browser on a smartphone, tablet, or computer.

The application displays:

- Current system status
- Theft alert notifications
- Live GPS location
- Time of the detected event

This enables the owner to monitor the bag from any location with internet access.

Step 9: System Reset

After the bag is recovered or the situation is resolved, the owner can reset the system through the web application or restart the ESP32 to resume normal monitoring.

Working Principle

The proposed system operates on a multi-sensor detection mechanism. The PIR sensor identifies human presence near the bag, while the vibration sensor detects physical movement or handling. Once theft is confirmed, the system immediately performs three actions simultaneously:

- Activates the buzzer.
- Sends an SMS alert through the SIM800L GSM module.
- Uploads the live GPS location and security status to the web application.

This combination of sensing, communication, and remote monitoring provides an effective, real-time anti-theft solution with improved reliability compared to conventional bag security systems.

7. SOFTWARE COMPONENTS

1. IDE for Arduino

The main software platform for creating and uploading computer code to the ESP32 microcontroller is the Arduino IDE. It offers a simple programming environment for creating, assembling, testing, and debugging embedded programs. The software enables the integration of several sensor libraries needed for the suggested system and supports ESP32 board setting.The Arduino IDE is utilized to implement sensor interface, signal processing, Wi-Fi connection, web server construction, and stress classification algorithms in the proposed AIoT-based Multi-Model Stress Monitoring and Smart Intervention System. The software processes physiological and behavioral data, continuously reads sensor values, and manages the entire system. During system development, the Arduino IDE's serial monitor is helpful for troubleshooting the software and viewing sensor outputs.

2. Programming in Embedded C/C++

The control logic of the suggested system is developed using the embedded C/C++ programming language. Embedded C/C++ is used to implement all aspects of the stress monitoring system, including sensor data collection, signal processing, threshold comparison, stress analysis, and Internet of Things connectivity.
Sensor readings from the heart rate, SpO2, temperature, microphone, and tilt sensors are all continuously monitored by the application. The software divides stress circumstances into normal, medium, and high stress levels usingmulti-model sensing logic and predetermined threshold conditions. Additionally, the code manages wireless connectivity between the ESP32 and linked devices as well as the web dashboard interface.

3. LIBRARIES FOR THE SENSORS

The WiFi.h library is used to connect the ESP32 microcontroller to a wireless network. It enables internet connectivity, allowing the device to transmit sensor data and GPS coordinates to the web application in real time.

Functions:

- Connects the ESP32 to a Wi-Fi network.
- Maintains internet communication.
- Transfers sensor data to the web server.
- Supports remote monitoring through the web application.

1. Tiny GPS Plus Library

The Tiny GPS Plus library is used for processing data received from the GPS module. It extracts important information such as latitude, longitude, altitude, speed, date, and time from NMEA sentences transmitted by the GPS receiver.

2. Hardware Serial Library

The Hardware Serial.h library provides serial communication between the ESP32 and external devices such as the SIM800L GSM module and the GPS module. Since the ESP32 has multiple hardware UART ports, this library enables reliable communication with multiple serial devices simultaneously.

Functions:

- Serial communication with the SIM800L module.
- Serial communication with the GPS module.
- Data transmission and reception.
- High-speed UART communication.

3. HTTP Client Library

The HTTPClient.h library enables the ESP32 to communicate with the web server using the HTTP protocol. It sends sensor readings, GPS coordinates, and theft alerts to the web application.

Functions:

- Sends HTTP GET and POST requests.
- Uploads live GPS coordinates.
- Updates theft status.
- Transfers sensor data to the server.

4. Web Server Library (Optional)

The WebServer.h library is used if the ESP32 itself hosts the web interface. It allows the ESP32 to create a lightweight web server for displaying sensor data and device status directly.

Functions:

- Hosts web pages.
- Displays live sensor values.
- Shows system status.
- Provides a browser-based interface.

5. Arduino Core Libraries

The Arduino core libraries are automatically included with the ESP32 board package. They provide essential functions such as digital input/output operations, analog input reading, timing functions, interrupts, and PWM generation.

4. Software for Web Dashboards

The proposed IoT-Based Bag Theft Detection System uses several software libraries and web technologies to establish communication between the ESP32 microcontroller, sensors, GSM module, GPS module, and the web dashboard.

These libraries enable real-time monitoring, theft detection, location tracking, and remote control of the security system. web-based dashboard is developed to provide users with remote monitoring and control of the bag security system through a smartphone, tablet, or computer.

web-based dashboard is developed to provide users with remote monitoring and control of the bag security system through a smartphone, tablet, or computer. The dashboard is accessible using any standard web browser and does not require the installation of a separate mobile application. The dashboard communicates with the ESP32 through Wi-Fi and displays real-time information about the security system. It provides a simple and user-friendly interface that allows users to monitor the bag from any location with internet access.

8. METHODOLOGY

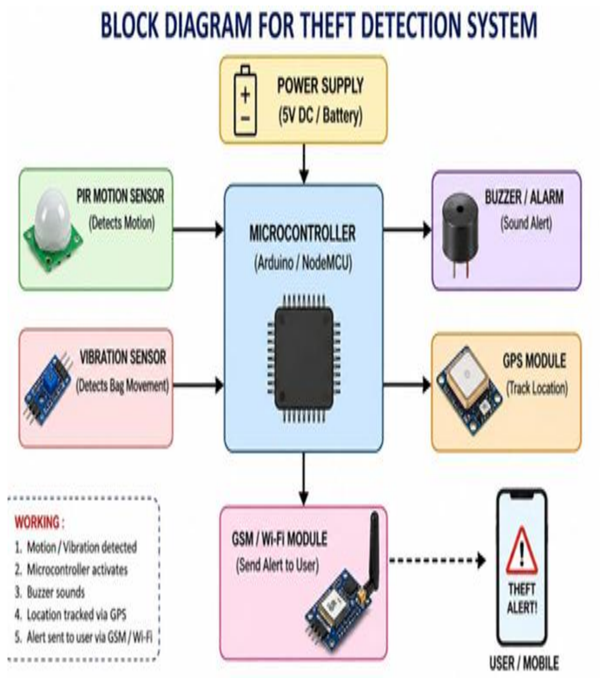

Fig.1. Block Diagram for Theft Detection System

The proposed **IoT-Based Bag Theft Detection System** adopts a multi-sensor approach integrated with wireless communication technologies to provide real-time monitoring and protection of personal belongings. The methodology focuses on continuous monitoring of the bag using motion and vibration sensors, followed by immediate notification and location tracking whenever unauthorized activity is detected. The ESP32 microcontroller serves as the central controller that coordinates all sensing, processing, communication, and monitoring operations.

1. System Initialization

Initially, the system is powered using a rechargeable battery or DC power supply. After power-up, the ESP32 initializes all connected hardware modules, including the PIR motion sensor, vibration sensor, GPS module, SIM800L GSM module, buzzer, and Wi-Fi interface. The ESP32 establishes a connection with the configured Wi-Fi network and communicates with the web server to synchronize the device with the web dashboard. Once initialization is completed successfully, the dashboard displays that the device is online and ready for operation.

2. User Authentication and System Activation

The security system is controlled through a web-based dashboard that can be accessed using any smartphone, tablet, or computer connected to the internet. The dashboard provides an ON/OFF switch that allows the user to remotely activate or deactivate the anti-theft system.

When the user switches the system ON, the ESP32 enters monitoring mode and continuously reads data from the connected sensors. If the system is switched OFF, all theft detection activities are suspended while maintaining communication with the web dashboard.

3. Continuous Sensor Monitoring

After activation, the ESP32 continuously monitors the outputs of the PIR motion sensor and the vibration sensor. The PIR motion sensor detects human movement near the protected bag by sensing changes in infrared radiation. At the same time, the vibration sensor detects physical disturbances such as lifting, shaking, dragging, or sudden impacts. The sensor outputs are sampled continuously to ensure immediate detection of suspicious activity.

4. Theft Detection Process

The ESP32 processes the data received from both sensors using predefined decision logic. If either the PIR sensor detects human movement close to the bag or the vibration sensor detects abnormal movement, the controller identifies the event as a potential theft attempt.

To improve system reliability, the controller verifies the sensor inputs before triggering the alarm. This multi-sensor approach minimizes false alarms caused by environmental disturbances while maintaining high detection accuracy.

5 Alarm Generation

Once a theft attempt is confirmed, the ESP32 immediately activates the buzzer connected to the system. The buzzer generates a loud audible alarm that alerts nearby people and acts as a deterrent to discourage theft. The alarm remains active until the user resets the system or deactivates it through the web dashboard.

6. SMS Notification Using GSM Module

Simultaneously with alarm activation, the ESP32 communicates with the SIM800L GSM module through UART serial communication. The GSM module sends an SMS alert to the registered mobile number of the user. The message informs the owner that unauthorized movement has been detected and advises immediate action. This feature ensures that users receive notifications even when they are far away from the protected bag.

7. GPS-Based Location Tracking

After the SMS notification is transmitted, the ESP32 requests the current geographical coordinates from the GPS module. The GPS receiver acquires signals from satellites and calculates the latitude and longitude of the bag. These coordinates are processed by the ESP32 and prepared for transmission to the web server.
The availability of live GPS coordinates significantly increases the possibility of recovering the bag after a theft attempt.

H. Data Transmission to the Web Dashboard

The ESP32 transmits the theft status and GPS coordinates to the web server using its built-in Wi-Fi module. The web server updates the dashboard in real time, allowing users to monitor the operational status of the security system remotely.

The dashboard displays:

- System ON/OFF status
- Motion sensor status
- Vibration sensor status
- Theft detection alerts
- Live GPS location
- Date and time of detected events
- Device connectivity status

Users can access the dashboard from any internet-enabled device without requiring a dedicated mobile application.

9. Continuous Monitoring and System Recovery

After completing the alert process, the ESP32 continues monitoring the sensors to detect any further unauthorized activities. The monitoring process remains active until the user manually switches the system OFF using the web dashboard.

If the bag is recovered, the user can reset the system through the dashboard, after which the ESP32 resumes normal monitoring operation.

Working Principle

The proposed system operates by integrating **motion sensing**, **vibration sensing**, **embedded processing**, **GSM communication**, **GPS tracking**, and **web-based monitoring** into a single intelligent security platform. The ESP32 continuously analyzes data from the PIR motion sensor and vibration sensor. Whenever suspicious movement or vibration is detected, the controller immediately activates the buzzer, sends an SMS notification through the SIM800L GSM module, retrieves the live GPS location, and uploads the event details to the web dashboard via Wi-Fi.

The integration of multiple sensing technologies with real-time communication enables rapid theft detection, immediate user notification, remote monitoring, and accurate location tracking. This methodology improves the security of personal belongings while providing a practical, low-cost, and reliable solution suitable for real-world deployment in public places such as railway stations, airports, shopping malls, educational institutions, and offices.

9. EXPERIMENTAL RESULTS AND DISCUSSION

1. Experimental Setup

The proposed IoT-Based Bag Theft Detection System was implemented using an ESP32 microcontroller integrated with a PIR motion sensor, vibration sensor, GPS module, SIM800L GSM module, buzzer, and a web-based dashboard. The ESP32 served as the central processing unit responsible for acquiring sensor data, processing theft detection logic, and coordinating communication between the hardware modules and the web server. The PIR motion sensor was positioned to detect human movement around the bag, while the vibration sensor was attached inside the bag to detect physical disturbances such as lifting, shaking, or dragging. The SIM800L GSM module was configured with an active SIM card to transmit SMS alerts to the registered user, and the GPS module was used to obtain the real-time geographical location of the bag. A web-based dashboard was developed to display the system status, sensor readings, live GPS location, and provide remote ON/OFF control. The complete prototype was powered using a rechargeable power supply and tested under different operating conditions to evaluate its performance.

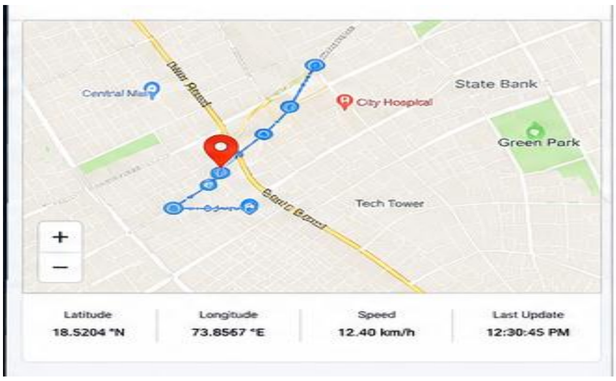

Fig.2. Real-time geographical location of the bag

2. Experimental Procedure

The experimental evaluation was carried out by activating the security system through the web dashboard and testing the prototype under different scenarios. Initially, the ESP32 established a Wi-Fi connection with the web server and entered monitoring mode after the user enabled the system through the dashboard. During normal operation, the system continuously monitored the outputs of the PIR motion sensor and vibration sensor. To simulate theft attempts, various activities such as human approach, lifting, shaking, dragging, and sudden movement of the bag were performed. Whenever the sensor readings exceeded the predefined threshold, the ESP32 processed the sensor data and classified the event as an unauthorized movement. Immediately after theft detection, the controller activated the buzzer, transmitted an SMS notification through the SIM800L GSM module, acquired the current GPS coordinates, and updated the web dashboard with the theft status and live location. Each experiment was repeated several times under different environmental conditions to verify the stability, consistency, and reliability of the proposed system.

3. Experimental Results

The experimental results demonstrated that the proposed IoT-Based Bag Theft Detection System operated successfully under all test conditions. The PIR motion sensor accurately detected human movement near the protected bag, while the vibration sensor reliably identified physical disturbances caused by lifting, shaking, and dragging. Upon detecting unauthorized activity, the ESP32 immediately activated the buzzer and generated an audible alarm. Simultaneously, the SIM800L GSM module successfully transmitted SMS notifications to the registered mobile number, while the GPS module provided accurate real-time location information. The web dashboard was updated instantly with the current system status, theft alerts, and live GPS coordinates, allowing users to monitor and control the system remotely. The repeated experiments confirmed stable communication between the ESP32 and the web dashboard, reliable GSM message delivery, accurate GPS tracking, and consistent sensor performance. The successful execution of all functional modules validates the effectiveness of the proposed system for real-time bag theft detection and monitoring.

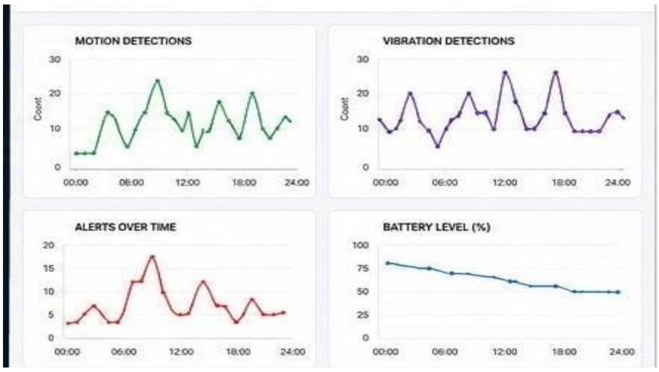

Fig.3. Web dashboard

10. DISCUSSION

The obtained experimental results confirm that the proposed IoT-Based Bag Theft Detection System is capable of providing reliable and real-time protection for personal belongings. The integration of the PIR motion sensor and vibration sensor improved the accuracy of theft detection by identifying both the presence of a person near the bag and any unauthorized physical movement. This multi-sensor approach reduced the possibility of false alarms compared with conventional single-sensor systems. The ESP32 microcontroller efficiently processed sensor data and coordinated communication among all hardware modules with minimal response time.

The GSM-based SMS notification feature ensured that the user was immediately informed whenever a theft attempt was detected, even when located far from the protected bag. In addition, the GPS module successfully provided live location information, which significantly improves the possibility of recovering the stolen bag. The developed web dashboard functioned as an effective monitoring platform by displaying sensor status, theft alerts, and GPS coordinates while also allowing users to remotely activate or deactivate the system through the ON/OFF control. Overall, the experimental findings demonstrate that the proposed system provides an efficient, low-cost, and user-friendly solution for bag security. Its ability to combine real-time sensing, wireless communication, GPS tracking, and web-based monitoring makes it suitable for deployment in public places such as airports, railway stations, shopping malls, educational institutions, and offices where the risk of bag theft is high. Furthermore, the modular design of the system allows future enhancements and integration with advanced IoT and cloud technologies, making it scalable for wider real-world applications.

Fig.4. Mobile Dash Board

The dashboard displays the current status of the security system, including whether the system is ON or OFF, the outputs of the PIR motion sensor and vibration sensor, theft alert status, device connectivity, and battery level (if available). It also presents the live GPS location of the bag on an interactive map, enabling users to track the bag in real time.

The dashboard displays the current operational status of the security system, indicating whether the anti-theft mechanism is active or inactive. In the displayed interface, the system status is shown as "SYSTEM OFF," indicating that the monitoring process has been temporarily disabled. The Sensor Status section continuously updates the current state of the PIR motion sensor and vibration sensor. When the system is turned off, the dashboard displays "Monitoring Stopped," confirming that the sensors are not actively detecting motion or vibration.

The dashboard also includes an Alert Message section that provides immediate feedback regarding system events and user actions. In this example, the message "System turnedfrom web page" confirms that the system status was successfully changed through the web interface. During actual operation, this section displays notifications related to theft detection, unauthorized movement, and system events, enabling users to remain informed about the security status of their belongings.

Two dedicated control buttons, SYSTEM ON and SYSTEM OFF, allow users to remotely activate or deactivate the anti-theft system. When the SYSTEM ON button is selected, the ESP32 begins continuously monitoring the PIR motion sensor and vibration sensor. If unauthorized movement is detected, the controller immediately activates the buzzer, sends an SMS notification through the SIM800L GSM module, retrieves the current GPS location, and updates the dashboard with the latest alert information. The SYSTEM OFFbutton disables monitoring while maintaining communication with the web server, allowing the user to control the system according to their requirements.

The web dashboard provides a user-friendly interface for real-time monitoring, remote device control, and status visualization. Its responsive design ensures compatibility across different mobile devices and web browsers, making the proposed IoT-Based Bag Theft Detection System practical, accessible, and suitable for everyday use in protecting personal belongings from theft.

11. CONCLUSION

The proposed IoT-Based Bag Theft Detection System provides an intelligent, portable, and cost-effective solution for protecting personal belongings against theft. The system integrates a NodeMCU ESP32 microcontroller, PIR motion sensor, vibration sensor, SIM800L GSM module, GPS module, buzzer, and a web-based dashboard to achieve real-time monitoring, instant alert generation, and live location tracking.

The multi-sensor approach enhances the reliability of theft detection by combining motion sensing and vibration sensing, thereby reducing false alarms and improving overall detection accuracy. Upon detecting unauthorized activity, the system immediately activates a local buzzer, sends an SMS notification to the registered user through the GSM module, and updates the bag's live GPS location on the web dashboard. The dashboard further enables users to remotely monitor the security status of the bag and control the system through an ON/OFF interface using any internet-connected device.

Experimental evaluation demonstrated that the proposed system successfully detected unauthorized movement, generated timely alerts, accurately tracked the bag's location, and maintained stable communication with the web dashboard. The integration of IoT technology with wireless communication and GPS tracking significantly improves user awareness and increases the probability of recovering stolen belongings.

Compared with conventional bag security systems, the proposed solution offers continuous monitoring, remote accessibility, real-time notification, and intelligent theft detection while maintaining low implementation cost and ease of use. Therefore, the developed system is well suited for deployment in railway stations, airports, educational institutions, shopping malls, offices, public transportation, and other crowded environments where bag theft is a common concern.

11. FUTURE SCOPE

The proposed IoT-Based Bag Theft Detection System successfully provides real-time theft detection, SMS alerts, GPS-based location tracking, and remote monitoring through a web dashboard. Although the developed prototype demonstrates reliable performance, several enhancements can be incorporated in future versions to improve functionality, security, scalability, and user convenience. One potential improvement is the integration of Artificial Intelligence (AI) and Machine Learning (ML) algorithms to distinguish between normal bag movements and actual theft attempts. Intelligent activity recognition can significantly reduce false alarms by analyzing movement patterns and user behavior.

The system can also be enhanced by developing a dedicated Android and iOS mobile application in addition to the web dashboard. A mobile application would provide a more convenient interface for receiving instant notifications, viewing live GPS locations, and remotely controlling the security system from anywhere.Future versions may incorporate cloud computing services such as Firebase, AWS IoT, or Microsoft Azure IoT for secure data storage and continuous synchronization. Cloud integration would enable users to access historical records, theft logs, and GPS tracking information from multiple devices while ensuring data backup and scalability.

Overall, these enhancements will improve the intelligence, efficiency, reliability, and scalability of the proposed IoT-Based Bag Theft Detection System, making it a more comprehensive and robust solution for next-generation smart asset protection.

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