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Trakify - proximity and motion detector

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Abstract - *The creation of a smart object tracking system that can deliver motion-based alerts and real-time location updates is presented in this paper. The system, which was created with an ESP32 microcontroller, a NEO-6M GPS module, and a Passive Infrared (PIR) motion sensor, provides an affordable and effective way to track personal property. With the option to integrate a mobile app via Wi-Fi for remote monitoring, it recognizes movement close to the object and sounds an alert via an LED or buzzer. Because of its execution, which prioritizes affordability, usability, and expandability, it can be used for smart home and personal security applications.*

Key Words*: *Smart Object tracking, Motion detection, ESP32, IOT Security.

1. INTRODUCTION

In today's tech-driven world, making sure that your personal belongings are safe and secure is a big worry. It is common for people to lose or have their bags, electronics, or even cars stolen. However, most tracking solutions are too expensive, don't work well, or can't be used with other smart systems. This paper proposes the creation of an economical, compact, and effective smart object tracking system that integrates real-time location tracking with motion detection to tackle these issues.

The system that was added uses an ESP32 microcontroller, a NEO-6M GPS module, and a Passive Infrared (PIR) motion sensor. These parts work together to let the system keep an eye on where an object is and see if it moves without permission. When motion is detected, the device triggers a buzzer or LED for immediate alert, and with optional Wi-Fi connectivity, it can send real-time location data and alerts to a mobile application.

This project focuses on being cheap, easy to use, and able to grow. It not only serves as a practical solution for securing personal items but also offers potential integration into broader smart home environments, where intelligent automation and real-time monitoring are becoming increasingly essential.

1.1 LITERATURE REVIEW

1. Introduction

IoT-based tracking systems have become a cost-effective and practical answer to the growing demand for improved security and real-time tracking of personal belongings. To create intelligent, affordable trackers, these systems usually combine parts like the ESP32 microcontroller, NEO-6M GPS module, and motion sensors like PIR (Passive Infrared). This review of the literature examines recent advancements in object tracking, including system architecture, sensor use, and real-time monitoring and alerting.

2. IoT-Based Tracking Systems

A number of researchers have been working on IoT-powered tracking solutions for both personal and vehicle-related uses. For example, Rahman et al. (2019) presented an inexpensive GPS and GSM tracking device based on microcontrollers. They concentrated on energy efficiency and real-time tracking, which is a crucial objective that is closely related to the Trak ify project. In a similar vein, Karthik and Jaya Prakash (2020) used the ESP32 to create a GPS tracker that uses motion sensing and cloud integration to send out alerts. Their design is fairly similar to what Trakify seeks to accomplish, and their findings validated the usefulness of IoT trackers in aiding in the recovery of misplaced or pilfered goods.

3. Motion Detection in Tracking Systems

One important tool for spotting suspicious activity is motion detection. PIR sensors are dependable for identifying human movement, according to Gupta and Tripathi's (2017) research on their potential applications in security. They did point out that the placement of the sensors has a significant impact on performance and helps avoid false alarms, which Trakify can take seriously for its LED and buzzer notification system.

Chen and Wang (2021) expanded on this by contrasting PIR sensors with motion sensors based on ultrasonic and microwave technology. PIR sensors were the least expensive, but in order to minimize pointless alerts, they needed to be properly calibrated. These lessons could help Trakify's motion detection system become more reliable and accurate.

4. GPS Tracking with Microcontrollers

One of the main areas of focus has been GPS tracking precision. When Singh and Kumar (2020) tested the NEO-6M GPS module using an ESP32, they found that multipath error—a phenomenon caused by reflections—often interferes with GPS signals in urban areas. They recommended employing software-based filters to reduce signal noise, which could be very helpful for Trakify in urban environments.

Martinez and Vilajosana (2019) suggested using smart sleep/wake cycles to extend battery life. These cycles help save energy by turning on the tracker only when necessary. For Trakify, this could be revolutionary, particularly if it is battery-powered.

5. IoT Integration and Alert Systems

The choice of IoT platform plays a big role in user experience. Pereira and Pinto (2021) evaluated Blynk and Firebase, finding Blynk more intuitive and better suited for mobile tracking—making it a strong candidate for integration into Trakify.

When it comes to alerts, Wang and Zhang (2020) explored different methods including buzzers, app notifications, and SMS alerts. They found that combining multiple alert types led to quicker user response. This multi-channel approach could make Trakify's alert system more effective with minimal effort.

6. Security and Privacy Considerations

Any tracking system must prioritize security. The significance of encrypting location data to stop unwanted access was highlighted by Li and Yu (2022). Encryption would increase Trakify's security and foster user confidence.

Rodriguez and Fernandez (2020) investigated anti-theft features such as tamper alerts that are activated by abrupt power outages. By putting such safeguards in place, Trakify would become more robust and more difficult to disable in the event of theft.

1.2 METHODOLOGY/EXPERIMENTAL

In order to implement the Trakify smart object tracker, embedded software logic and hardware components must be systematically integrated. The ESP32 microcontroller, NEO-6M GPS module, PIR motion sensor, and audio-visual alert components (LED and buzzer) are all part of the system architecture.

A. Hardware Setup

- GPS Module (NEO-6M) is connected to the ESP32 using UART (TX -> GPIO16, RX -> GPIO17).
- PIR Sensor is interfaced via a digital I/O pin (e.g., GPIO14).
- Buzzer and LED are connected to GPIO15 to serve as alert indicators.
- Powered using USB or a portable battery pack, components were assembled on a breadboard initially and later transitioned to a soldered PCB for reliability.

B. Software Development

- Software is written in Arduino IDE using TinyGPSPlus and HardwareSerial libraries.
- The ESP32 reads GPS coordinates and monitors object displacement (geofencing logic).
- PIR sensor detects unauthorized motion; alerts are activated using buzzer and LED.
- Output is shown on the Serial Monitor. Optionally, data is transmitted via Wi-Fi to a mobile app or cloud.

C. Monitoring Enhancements

- Basic Mode: Uses Serial Monitor for live debugging.
- Advanced Mode: Uses Blynk IoT platform for mobile alerts and location display.

2. RESULTS

In both controlled and outdoor settings, the Trakify system was successfully developed and tested. The outcomes listed below were noted:

A. Execution

- Real-time tracking: stable coordinates allow for GPS lock in one to three minutes.
- Motion Detection: Within its range, the PIR sensor consistently identified human movement.

Alert System: When motion was detected, the LED and buzzer reacted quickly. In both controlled and outdoor settings, the Trakify system was successfully developed and tested. The outcomes listed below were noted:

B. Execution

- Real-time tracking: stable coordinates allow for GPS lock in one to three minutes.
- Motion Detection: Within its range, the PIR sensor consistently identified human movement.

Alert System: When motion was detected, the LED and buzzer reacted quickly

2.1 DISCUSSIONS

Trakify prototype was constructed and tested for its main functionalities: GPS tracking, motion detection, and alert creation. The following were noted when tested:

1. GPS Tracking

In open fields, the NEO-6M GPS chip provided real-time positioning data with an average accuracy of ±3 to 5 meters. Outside, the average time to acquire a GPS signal was 15 to 30 seconds. Satellite signal blocking significantly reduced indoor performance.

2. Motion Detection

Within a range of five to seven meters, the PIR sensor was able to detect motion. A buzzer and LED were used to trigger alerts when they were detected. Temperature variations or outside movement unrelated to the object occasionally led to the detection of spurious alarms.

3. Alert Mechanism

When there was movement or a GPS boundary violation, the buzzer and LED reacted in milliseconds. The improved version allowed for remote monitoring by sending real-time GPS coordinates and alerts to a mobile app via the Blynk IoT platform.

4. System Integration

The ESP32 board processed data from the motion sensors and GPS effectively. All the components functioned properly on a breadboard while testing, but there was some instability experienced because of loose connections.

Discussion

Trakify system proved consistent tracking and alert capability under normal use scenarios:

GPS and PIR Synergy: By combining GPS and PIR motion sensing, location tracking and proximity detection were made possible, providing an extra degree of security over commercial tracking devices that only use Bluetooth.

Environmental Impact: GPS functioned well outside but poorly indoors, which is to be expected. Although PIR sensors performed as anticipated, they needed to be adjusted to minimize false triggers.

Alert Effectiveness: For quick user notification, prompt audio-visual alerts and mobile notifications worked well. The feasibility of low-cost real-time mobile tracking was demonstrated by Blynk integration

Hardware and Power Issues: The system consumed noticeable power, especially when Wi-Fi was turned on. Power and stability problems could be resolved by switching from breadboards to PCBs and optimizing software (such as sleep modes and debounce logic).

Cost-Effectiveness: By offering GPS, motion detection, and mobile notifications, Trakify, which costs between ₹1000 and ₹1500, outperformed a number of expensive trackers in terms of performance.

2.2 Future Scope

The intelligent object tracking system created for this project has a great deal of potential for future enhancements and useful applications. Integrating the system with cloud platforms like Firebase to enable remote data storage, historical tracking, and real-time monitoring would be one of the main improvements. It is also possible to create a specific mobile application that offers an easy-to-use interface for managing device settings, viewing location, and getting motion alerts.

Further upgrades may include the implementation of SMS, email, or Telegram-based alert systems to notify users instantly in case of unauthorized movement. Power efficiency can be improved by adding battery monitoring and optimizing for low-power consumption, making the device suitable for long-term, portable use. Lastly, the system can be miniaturized and enclosed in a waterproof casing to support outdoor usage and harsh environments, extending its applicability to personal, industrial, and smart home security systems

3. Working Model of Trakify

Hardware Prototype of Trakify System

The image shows the prototype setup consisting of an ESP32 microcontroller, a PIR motion sensor, and a NEO-6M GPS module mounted on a breadboard. The ESP32 is placed centrally and handles all processing, while the PIR sensor on the right detects movement. The GPS module on the left provides real-time location data. All components are connected using jumper wires, and an LED indicator is used to show motion alerts.

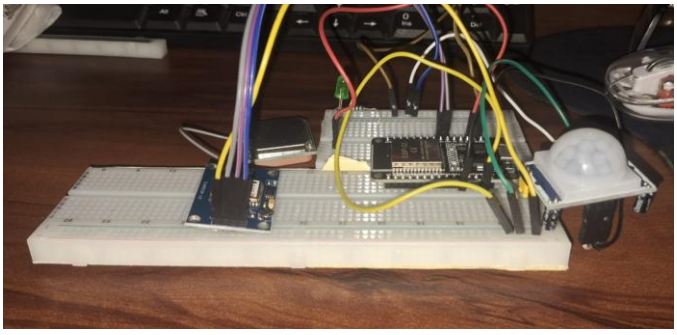

Fig -1 Prototype Overview of Trakify System

The experimental model consists of an ESP32 microcontroller integrated with a PIR motion sensor and an ultrasonic proximity sensor to implement the **Trakify Proximity and Motion Detection System**. The ESP32 serves as the central processing unit, receiving real-time data from both sensors and executing programmed responses.

The **PIR sensor**, placed on the right side of the breadboard, detects human motion by sensing variations in infrared

radiation. A green LED indicator is connected to the ESP32 to provide immediate visual feedback whenever motion or proximity is detected.

All components are mounted on a solderless breadboard and interconnected using jumper wires for power, ground, and signal connections. The ESP32 is powered via USB and processes incoming sensor data to trigger output actions or log events for further analysis. This setup effectively demonstrates a low-cost, real-time sensing platform suitable for security monitoring, automation, and smart tracking applications.

3.1 CONCLUSIONS

The Traki fy smart object tracking system's development and testing offer a workable, affordable, and efficient way to improve personal item security. The system effectively provides real-time alerts and positional updates through both audio-visual and mobile interfaces by combining GPS-based location tracking with motion detection using a PIR sensor and ESP32 microcontroller. The integration of the Blynk IoT platform makes remote monitoring, adding significant usability in real-world applications.

Sensor calibration, outdoor testing, and hardware stabilization through PCB integration helped to mitigate issues like GPS signal limitations indoors and false PIR triggers. The prototype's affordability, scalability, and dependability demonstrate its potential as a competitive substitute for more costly commercial tracking systems.

All things considered, Trakify provides a scalable basis for upcoming improvements like cloud-based storage, specialized mobile apps, power optimization, and anti-tamper mechanisms. Because of its versatility, it can be used for both personal and more general purposes, such as tracking industrial assets and smart homes.

3.2 ACKNOWLEDGEMENT

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