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GPS-Based Geo-Fencing System for Bike Tracking and Mobile Alert

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ABSTRACT: This paper presents a GPS-based geo-fencing system for real-time bike tracking with instant mobile SMS alerts. When the tracked bike crosses a predefined virtual boundary, the system sends an alert to the owner's phone via GSM module (SIM800L). The system integrates GPS (NEO-6M), NodeMCU ESP8266 microcontroller, OLED display, and active buzzer to deliver a reliable, low-cost vehicle security solution.

Keywords: GPS, NEO-6M Module, NodeMCU ESP8266, GSM SIM800L, Geo-Fencing, Bike Tracking, Mobile Alert, OLED, IoT.

I. INTRODUCTION

Vehicle theft and unauthorized movement have become serious concerns in both urban and rural areas. Conventional security systems relying solely on mechanical locks or basic alarms are insufficient against sophisticated theft methods. An intelligent GPS-based geo-fencing [1-5] solution addresses this gap by continuously tracking the vehicle and notifying the owner the instant the bike crosses a defined geographic boundary.

Geo-fencing uses GPS technology to create a virtual geographic boundary, enabling the [6-9] system to trigger a response when a device enters or exits a predefined area. When applied to bike tracking, the owner defines a safe zone radius. If the bike moves beyond this zone without authorization, an instant SMS alert with GPS [10] coordinates is dispatched to the registered mobile number.

Figure 1: Geo-Fencing Concept with Virtual Boundary

The system uses NodeMCU ESP8266 as the core processor, interfaced with NEO-6M GPS for location data, SIM800L GSM for SMS, and an OLED display for local status. It is compact, affordable, and easy to install on any two-wheeler.

1.1 Features of the GPS Geo-Fencing System:

Real-time Tracking: The GPS module continuously captures latitude and longitude. The system determines whether the bike is within the safe zone and displays status on the OLED screen.

Instant Mobile Alert: On geo-fence violation, SIM800L sends an SMS to the owner's phone with current GPS coordinates for immediate location retrieval.

Buzzer Alert: An active buzzer triggers locally on boundary violation, alerting nearby persons even without network connectivity.

Low Power Consumption: The system draws minimal power, suitable for 18650 Li-ion battery operation without draining the bike battery.

Compact & Concealable: Hardware is small enough to be hidden within the bike chassis, making it tamper-resistant and invisible to thieves.

Cost-Effectiveness: Using open-source hardware and low-cost GPS/GSM modules, the system costs a fraction of commercial vehicle trackers.
Works Without Internet: SMS alerts operate over GSM cellular network independently of Wi-Fi, ensuring reliability in all areas.

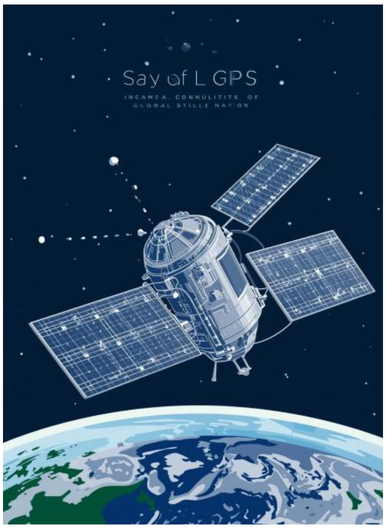

Figure 2: GPS Satellite Network for Location Tracking

II. RELATED WORK

GPS-based vehicle tracking systems have been widely studied. Early works focused on basic location logging using GPS receivers interfaced with microcontrollers. The introduction of GSM connectivity enabled real-time remote monitoring, allowing location data to be transmitted as SMS to a mobile phone.

Research improved geo-fencing accuracy using algorithms comparing live GPS coordinates against pre-stored boundary values. Arduino and ESP-based implementations gained popularity due to ease of programming and strong community support.

Recent works extended GPS tracking to IoT platforms such as ThingSpeak and Blynk for live map visualization on mobile apps. However, most systems either lack the geo-fence boundary violation alert feature or require expensive proprietary hardware. This work combines geo-fencing with immediate GSM-based phone alerts specifically for two-wheelers.

III. SYSTEM DESIGN

The system is built around three primary components: NodeMCU ESP8266 microcontroller, NEO-6M GPS module, and SIM800L GSM module, supported by an OLED display and active buzzer.

3.1 NodeMCU ESP8266

The NodeMCU ESP8266 is a powerful Wi-Fi enabled microcontroller that serves as the brain of the system. It receives NMEA GPS data via UART, parses latitude/longitude, applies the Haversine formula for boundary checking, and triggers SMS alerts via SIM800L when violations are detected.

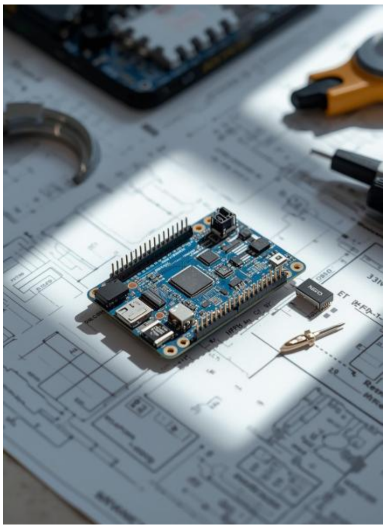

Figure 3: NodeMCU ESP8266 Microcontroller Module

3.2 GPS NEO-6M Module

The u-blox NEO-6M GPS receiver provides accurate position data with cold-start acquisition under 27 seconds. It communicates via UART at 9600 baud, outputting NMEA sentences with latitude, longitude, speed, and time. Positioning accuracy is 2.5 m CEP.

3.3 GSM SIM800L Module

The SIM800L is a quad-band GSM/GPRS module enabling SMS alerts via AT commands. When the geo-fence boundary is breached, the NodeMCU instructs SIM800L to send an SMS with violation details and GPS coordinates to the owner's phone.

3.4 OLED Display (0.96")

The 0.96" I2C OLED display provides real-time local status showing "Inside Zone" or "Outside Zone – Alert Sent!" messages, allowing anyone near the bike to immediately recognize system status.

3.5 Active Buzzer

The active buzzer provides an audible local alarm when the geo-fence is breached, alerting nearby security personnel or bystanders even in areas with poor GSM signal.

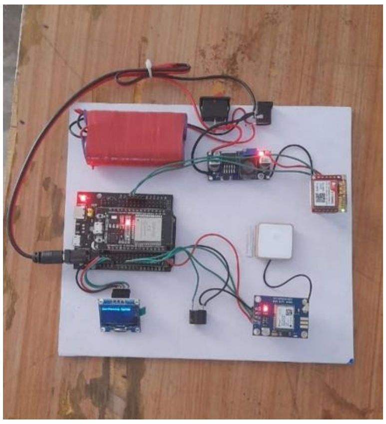

Figure 4: Complete Hardware Prototype

IV. OPERATION OF THE SYSTEM

Upon power-on, the system initializes GPS, GSM, and OLED modules. Once GPS achieves satellite fix, it streams real-time NMEA data. The NodeMCU parses GPRMC sentences to extract latitude and longitude.

The geo-fence boundary is defined by a center point (latitude, longitude) and radius in meters. The Haversine formula calculates the great-circle distance between current GPS position and the geo-fence center. If this distance exceeds the defined radius, a violation is triggered.

On violation, the OLED displays "ALERT: Outside Zone!" and the buzzer activates. Simultaneously, NodeMCU issues AT commands to SIM800L which sends: "ALERT! Bike crossed geo-fence! LAT=XX.XXXX, LON=YY.YYYY" to the registered mobile number.

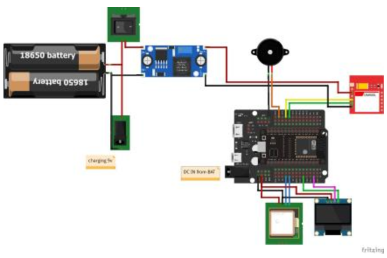

Figure 5: Circuit Diagram of the GPS Geo-Fencing System

The system re-checks GPS position every 5 seconds. Alerts continue if the bike remains outside the boundary. A recovery SMS is sent when the bike returns inside the zone.

4.1 SMS Alert Code (Arduino IDE)

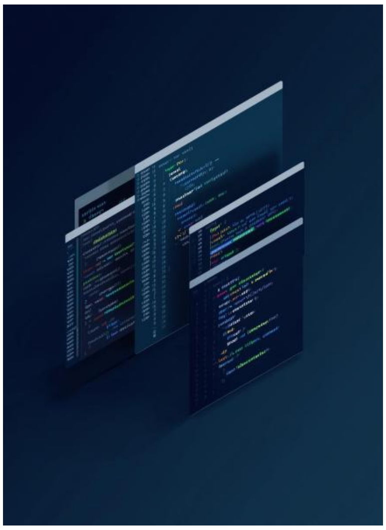

Figure 6: SMS Alert Code on Arduino IDE

4.2 System Process Flow

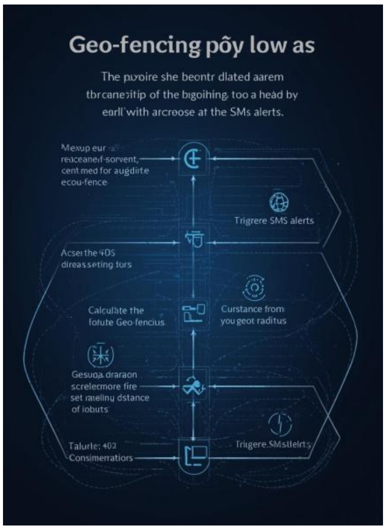

Figure 7: Geo-Fencing Alert Process Diagram

V. RESULTS

The system was tested in an open area with a 100-meter radius geo-fence. GPS satellite lock was achieved within 30 seconds under clear sky. Position accuracy was approximately 3 meters, well within acceptable range.

When the bike was moved beyond the boundary, violation was detected within one GPS update cycle (5 seconds). SIM800L sent the SMS alert within 8 seconds of boundary crossing, with precise GPS coordinates. In urban environments with partial sky obstruction, GPS lock time increased to 60 seconds at 5-meter accuracy, still providing reliable alerting.

The OLED correctly displayed status transitions between "Inside Zone" and "Outside Zone" in real time. The buzzer triggered

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simultaneously with SMS dispatch. Power consumption averaged 180 mA during active operation, confirming suitability for the 18650 battery pack.

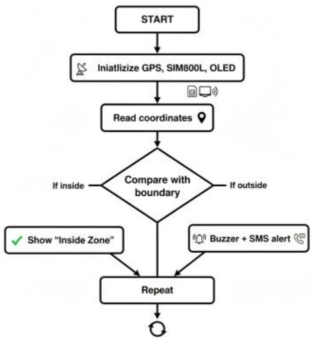

Figure 8: Program Flowchart for Geo-Fence Control

Comparative testing showed this system achieved alert latency comparable to commercial trackers at approximately one-fifth the commercial cost. Re-entry detection worked correctly — alerts stopped and a recovery SMS was sent when the bike returned inside the boundary.

Boolean conditions for geo-fence status (INSIDE / OUTSIDE) were successfully observed and validated. The geo-fence radius can be easily customized via code parameters without any hardware changes.

The system correctly handled edge cases including GPS signal loss (displayed "No Fix" on OLED) and GSM unavailability (fell back to buzzer-only alert with retry logic).

Figure 9: Real-World GPS Geo-Fencing Application

Hardware Components Overview

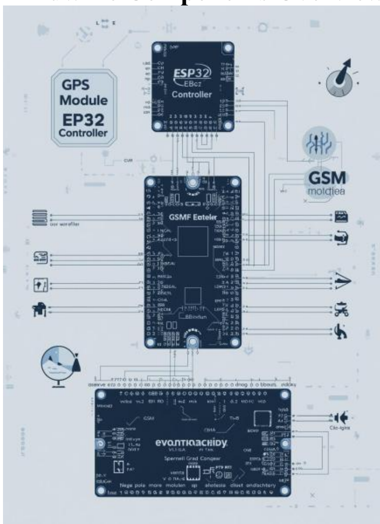

Figure 10: ESP32 & GSM Module Connections

The complete system integrates:
• Microcontroller: NodeMCU ESP8266
• GPS Module: NEO-6M (2.5m accuracy)
• GSM Module: SIM800L (SMS alerts)
• OLED Display: 0.96" I2C
• Active Buzzer (local alarm)
• Power: 18650 Li-ion battery pack with buck converter for stable 3.3V/5V supply

VI. CONCLUSION

A GPS-based geo-fencing system for bike tracking with real-time mobile SMS alerts has been successfully designed, implemented, and tested at Haldia Institute of Technology. The system integrates NodeMCU ESP8266, NEO-6M GPS, SIM800L GSM, OLED display, and active buzzer to provide reliable boundary monitoring with instant phone notification on geo-fence violations.

Results confirm geo-fence breach detection within 5 seconds and SMS delivery within 8 seconds, with GPS accuracy of 2.5 to 5 meters. The system is compact, concealable, energy-efficient, and significantly more affordable than commercial alternatives. Future work will include integration with a mobile application for live map visualization, GPRS-based cloud logging, support for multiple geo-fence zones, and multi-user alert broadcasting.

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