Microcontroller Home-Based Security Reporting System using GPS-enabled Technology

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***Abstract*— This study addresses the rising threat of theft and burglary by proposing a microcontroller-based security system utilizing GPS technology for enhanced home safety. Comprising a microcontroller unit, Neo-6M GPS module, and SIM800L communication module, the system enables real-time breach tracking and reporting with a user-friendly single-button activation. It ensures swift reporting of precise coordinates and nearby locations to a designated recipient without compromising security. Affordability, adaptability, and effectiveness distinguish this solution, overcoming existing security limitations. The results demonstrate accurate location tracking, rapid message transmission, and timely alerts. Future recommendations include solar panel integration and alternative coordinate conversion methods. In essence, this GPS-based Arduino microcontroller system strengthens home security, ensuring prompt response and homeowner safety.**

Keywords*— *microcontroller, GPS-enabled technology, home security, GSM, Arduino, Neo6M.

I. INTRODUCTION

The security reporting system in homes works as a deterrent against burglars by giving homeowners the ability to report any suspicious activity that they see occurring around their house or property via a wireless device such as a smart phone or tablet computer, enhancing traditional alarm-based security methods [1], which relies on alarm systems to deter intruders and alert homeowners of potential threats. Several security challenges in home automation systems are identified by [2], including security vulnerabilities, interoperability, and complexity. Conventional home security, reliant on costly surveillance systems, faces limitations due to network speed and expense. Accessibility disparities arise from the necessity of high-speed internet. Achieving widespread, affordable security remains challenging. To address these challenges, researchers have proposed several solutions. These include the development of standardized protocols [3], the use of artificial intelligence (AI) algorithms to detect anomalies and potential threats [4], as well as integrating GPS with security measures such as motion sensors and alarms improves overall system effectiveness [5]. This microcontroller-based home security reporting system with GPS technology termed (MHB-SRSGT) addresses a critical gap in existing home security systems. The study's novelty lies in its ability to provide swift incident response by

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transmitting precise coordinates to designated recipients, eliminating the need for physical presence. Existing systems often lack precise object localization for tracking and navigation, limiting their effectiveness in areas with limited emergency services. This research aims to revolutionize home security, ensuring prompt incident reporting and homeowner safety with advanced tracking and navigation capabilities.

II. LITERATURE REVIEW

Recent research has led to a surge in real-time coordinate provision systems employing SMS and integrating GPS and GSM modules, revolutionizing areas such as domestic violence reduction [6], household power quality monitoring [7], vehicle tracking using ThingSpeak and Freeboard for data display or connect to a web server [8], [9]. Additionally, strides have been made in home security through SMS-based alerts, employing image recognition technology [10], as well as in smart city and public transportation technology, incorporating Raspberry Pi 3 and web system development [11], while [12] employs a PIR sensor system to promptly alert neighbors and homeowners upon detecting unusual movements. Furthermore, [13] introduced an economical IoT-based Door Security System, providing efficient monitoring and prompt alerts in cases of unauthorized access. [14] presented a portable smart surveillance system harnessing IoT and 5G technology, bolstering security with gyroscope sensors and seamless connectivity through Blynk. A user-friendly IoT-based smart home system [15], integrates LPC1769 gateway board, Ethernet module, and DP83848 chip for enhanced security. A wearable smart device [16] with microcontroller, GPS, GSM, and switching unit ensures child safety through continuous monitoring and parent communication in emergencies. GSM-based solutions [17] address theft, gas leaks, and fires, emphasizing the crucial role of GPS and GSM in advancing system efficiency.

III. PROPOSED SYSTEM FLOW AND METHODS

A. Description and Design of the Proposed System

Powered by a battery, the proposed MHB-SRSGT shown in Figure 1 employs interconnected components for emergency activation and transmitting coordinates for real-time tracking. This comprehensive solution revolutionizes security incident reporting from the comfort of one's residence.

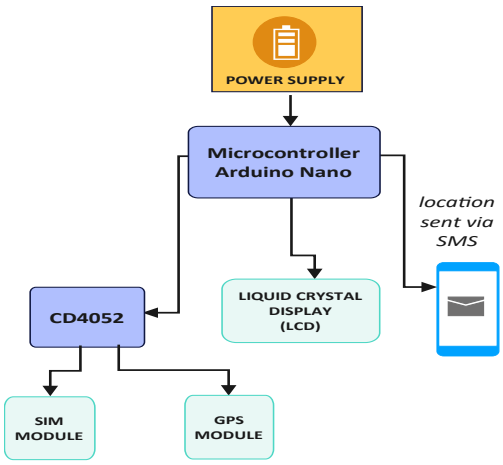

Fig. 1 Block Diagram of the Proposed System

B. System Architecture

The MHB-SRSGT's architecture (Figure 2) defines core operations systematically. It prioritizes necessary elements, interfaces, and data structures, emphasizing high-level structure and system organization for optimal behavior. The SMS module transmits location details via an SMS provider for navigation on Google Maps, meeting security reporting needs effectively and efficiently.

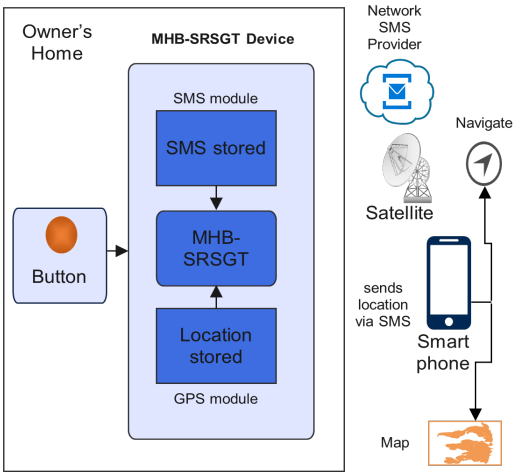

Fig. 2 Architecture of the Proposed System

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IV. IMPLEMENTATION AND SETUP

A. Hardware Requirements

i. Arduino Nano ATMEGA-328 Microcontroller (Figure 3): This compact IC manages embedded systems' CPU, RAM, ROM, and I/O ports, crucial for data processing.

ii. Global Positioning System Module (NEO-6M) (Figure 4): Equipped with a processor and antenna, it receives timestamped positional data from satellites, providing accurate latitude, longitude, and UTC coordinates for real-time tracking.

iii. Subscriber Identification Module (SIM800L) (Figure 5): An advanced low-power GSM module with enhanced signal reception and lower cost, requiring an external antenna.

iv. Button: A simple, essential activation component with a plastic knob for message sending.

MHB-SRSGT's hardware includes a 16*2 LCD for efficient visual output, a shift register, for storing binary data like coordinates, and a protective plastic case. Switches control power states, and voltage management is crucial for the Arduino board (7-12V) and SIM800L module (3.4-4.4V) to prevent damage.

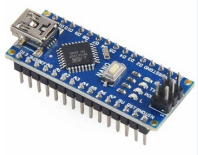

Fig. 4 ATmega328P microcontroller

Fig. 3 Neo-6M GPS module

Fig. 5 SIM800L GSM Cellular module

B. Software Requirements and Design

MHB-SRSGT development requires a compatible OS (e.g., Windows 11, Windows 10, MAC OS) and Google Maps with Navigation for Map Go on the user's Android device. The Arduino IDE serves as the code editor and communicates with hardware, while Google Maps provides searchable location data, and Navigation for Map Go offers voice-guided GPS for low-memory devices.

V. RESULTS AND DISCUSSION

The system's hardware setup establishes connections, verifies input ports, and ensures power supply on the Arduino microcontroller. Arduino software facilitates programming, with codes uploaded via a power jack cable. The ATMEGA-328 microcontroller processes accurate analog or digital inputs. The MHB-SRSGT provides an affordable, customizable, and reliable security solution, addressing existing limitations. Figure 6 illustrates the hardware system successfully tested for alignment with the planned algorithm. This architecture, featuring a single-button device for activating security reporting, stands out for its simplicity and efficiency in transmitting coordinates to a designated recipient.

Fig. 6 The MHB-SRSGT Complete Hardware Setup

Figure 7 displays a user-friendly SMS interface with sender coordinates, phone number, and activity timestamp during a security alert. This aids agents in promptly locating emergencies via Google Maps on any platform, expediting responses. The entire system uses interconnected components for data processing and transfer via a shift register. This data is then sent to the agent's mobile phone as SMS and stored in the SQLite database.

A. System Evaluation and testing

The MHB-SRSGT underwent rigorous evaluation, yielding consistently positive results in usability, learnability, functional suitability, and understandability presented in Table 1. Meticulous unit testing and battery-powered scrutiny confirmed module functionality. Automatic code-writing tests in

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the Arduino IDE ensured accurate syntax. Integrated testing on hardware validated robustness and effective operation. All four test samples demonstrated positive performance, affirming the system's adherence to usability criteria. Table 2 further exemplifies the system's comprehensive evaluation, showcasing its robust functionality in scenarios requiring incident reporting. The testing approach establishes the system as a reliable and user-friendly security system, meeting varied user expertise levels and performing seamlessly even under component failures.

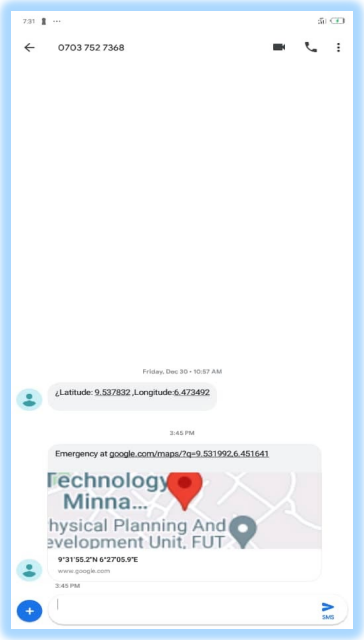

Fig. 7 Readable format of the message from the database

TABLE I. USABILITY TESTS FOR THE MHB-SRSGT

Test Criteria	Test Samples			
	1	2	3	4
Learnability	P	P	P	P
Functional Suitability	P	P	P	P
Understandability	P	P	P	P
Usability	P	P	P	P

[a] *Letter P stands for positive outcome*

TABLE II PERFORMANCE EVALUATION TESTING

CRITERIA	CRITERIA'S DESCRIPTION
Accuracy of coordinates	Ensures precise GPS tracking of device location coordinates (longitude and latitude).
User-readable format	Validates LCD screen displays readable user-friendly data format.
Time Accuracy	Confirms time synchronization between the user-activated security button and message receipt by security agents.
Performance	Ensures the system functions as expected, sending security messages with each device action promptly.
Interoperability	Confirm the system's ability to send security alerts to registered phone numbers without limitations on cell numbers.
Mobility	Verify that the system can track any location anywhere in the world

VI CONCLUSION

This study introduces a cost-effective, customizable security solution, overcoming existing limitations. The proposed GPS-enabled architecture ensures accurate location tracking and real-time reporting of breaches. Rigorous validation, including unit testing and Arduino IDE syntax checks, confirms functionality. Evaluation criteria (usability, learnability, functional suitability, and understandability) all yield positive results, validating the architecture. Communication between the microcontroller and SIM800L GSM module facilitates area coordinate retrieval and SMS exchange. Future recommendations involve solar panel integration and coordinate conversion refinements for enhanced functionality. The study contributes a reliable, accessible security solution with the potential for further improvements in usability and performance.

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REFERENCES

[1] S. Chitnis, N. Deshpande, A. Shaligram, S. Chitnis, N. Deshpande, and A. Shaligram, "An Investigative Study for Smart Home Security: Issues, Challenges and Countermeasures," *Wireless Sensor Network*, vol. 8, no. 4, pp. 61–68, Apr. 2016, doi: 10.4236/WSN.2016.84006.

[2] W. Ali, G. Dustgeer, M. Awais, and M. A. Shah, "IoT based smart home: Security challenges, security requirements and solutions," *2017 23rd International Conference on Automation and Computing (ICAC)*, pp. 1–6, Oct. 2017, doi: 10.23919/ICONAC.2017.8082057.

[3] K. Taghizad-Tavana, M. Ghanbari-Ghalehjoughi, N. Razzaghi-Asl, S. Nojavan, and A. Alizadeh, "An Overview of the Architecture of Home Energy Management System as Microgrids, Automation Systems, Communication Protocols, Security, and Cyber Challenges," *Sustainability*, vol. 14, no. 23, 2022, doi: 10.3390/su142315938.

[4] P. Baroni *et al.*, "Self-Aware Effective Identification and Response to Viral Cyber Threats," in *2021 13th International Conference on Cyber Conflict (CyCon), Tallinn, Estonia*, May 2021, pp. 353–370. doi: 10.23919/CyCon51939.2021.9468294.

[5] N. M. Hussien, Y. M. Mohialden, B. K. Abbas, and I. S. Mohammed, "Review of an Accurate System Utilizing GPS Technology," *Journal La Multiapp*, vol. 3, no. 6, 2023, doi: 10.37899/journallamultiapp.v3i6.746.

[6] S. K. Yadav, K. Sharma, and A. Gupta, "SafeWomen: A Smart Device to Secure Women's Environment Using ATmega328 with an Android Tracking App," *International Journal of Digital Crime and Forensics*, vol. 13, no. 1, pp. 48–64, Jan. 2021, doi: 10.4018/IJDCF.2021010103.

[7] S. Y. Radin, B. Sarker, S. H. Zahedee, T. T. I. Shanto, M. Islam, and A. S. N. Huda, "Microcontroller Based Automatic Home Appliances Protection System From Voltage and Current Disturbances," in *2022 International Conference on Energy and Power Engineering (ICEPE), Dhaka, Bangladesh*, Nov. 2022, pp. 1–5. doi: 10.1109/ICEPE56629.2022.10044881.

[8] S. Verma, A. S. Jamwal, S. Chauhan, and S. Mohanty, "Vehicle Tracking System Using GPS and GSM," in *Advances in Communication and Computational Technology. ICACCT 2019. Lecture Notes in Electrical Engineering, vol 668. Springer, Singapore*, G. S. Hura, A. K. Singh, and L. Siong Hoe, Eds., Singapore: Springer Nature Singapore, 2021, pp. 779–786. doi: 10.1007/978-981-15-5341-7_59.

[9] A. H. Alquhali, M. Roslee, M. Y. Alias, and K. S. Mohamed, "IOT Based Real-Time Vehicle Tracking System," in *IEEE Conference on Sustainable Utilization and Development in Engineering and Technologies (CSUDET), Penang, Malaysia*, Nov. 2019, pp. 265–270. doi: 10.1109/CSUDET47057.2019.9214633.

[10] J. Bangali and A. Shaligram, "esign and implementation of security systems for smart home based on GSM technology," *International Journal of Smart Home*, vol. 7, no. 6, pp. 201–208, 2013, doi: 10.14257/ijsh.2013.7.6.19.

[11] A. Zacepins, E. Kalnins, A. Kviesis, and V. Komasilovs, "Usage of GPS Data for Real-time Public Transport Location Visualisation," in *Proceedings of the 5th International Conference on Vehicle Technology and Intelligent Transport Systems - VEHITS*, May 2019, pp. 277–282. doi: 10.5220/0007350902770282.

[12] S. Sinha, E. H. Teli, and W. Tasnin, "Remote Monitoring and Home Security System," in *2021 Innovations in Power and Advanced Computing Technologies (i-PACT), Kuala Lumpur, Malaysia*, Nov. 2021, pp. 1–8. doi: 10.1109/i-PACT52855.2021.9696996.

[13] S. R, ATA. K. Kumar, A. Titus, S. Hemajothi, J. Venkatesh, and L. A, "Design and Development of an AI based Intelligent Door for Home Security System," in *2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India*, IEEE, May 2023, pp. 1–8. doi: 10.1109/ACCAI58221.2023.10200307.

[14] A. Karnik, D. Adke, and P. Sathe, "Low-Cost Compact Theft-Detection System using MPU-6050 and Blynk IoT Platform," in *2020 IEEE Bombay Section Signature Conference (IBSSC)*, Dec. 2020, pp. 113–118. doi: 10.1109/IBSSC51096.2020.9332214.

[15] C. Sisavath and L. Yu, "Design and implementation of security system for smart home based on IOT technology," *Procedia Comput Sci*, vol. 183, pp. 4–13, Jan. 2021, doi: 10.1016/J.PROCS.2021.02.023.

[16] N. Nigar, "Microcontroller based Autistic Child Monitoring System in Bangladesh," *Jurnal Kejuruteraan*, vol. 33, no. 1, pp. 83–88, 2021, doi: 10.17576/jkukm-2020-33(1)-09.

[17] M. A. Raja, G. R. Reddy, and Ajitha, "Design and implementation of security system for smart home," in *2017 International Conference on Algorithms, Methodology, Models and Applications in Emerging Technologies (ICAMMAET)*, Feb. 2017, pp. 1–4. doi: 10.1109/ICAMMAET.2017.8186705.

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