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A Microcontroller-Based Ultrasonic Intrusion Detection System for Low-Cost Security Applications.

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Abstract: *Security is a growing concern globally, especially in low-resource settings where traditional systems are often unaffordable. This paper presents the development and evaluation of an ultrasonic intrusion detection system utilizing a microcontroller platform. The system combines the HC-SR04 ultrasonic sensor, Arduino Uno, GSM module, and a buzzer to detect intrusions and provide real-time alerts. It emphasizes affordability, simplicity, and effectiveness for applications in homes, offices, and small businesses. The study includes technical design, software development, user perception, performance evaluation, and ethical considerations. Results indicate that this low-cost system can accurately detect motion and notify users within seconds, making it a promising tool for enhancing personal security.*

Keywords*-security, technical design, software development, detection.*

1. INTRODUCTION

In recent years, the importance of security has escalated due to increasing incidents of theft, vandalism, and unauthorized access to private and institutional premises[1]. Surveillance and security systems are now vital, yet many are financially inaccessible or too complex for small-scale users in developing countries[2]. This motivates the development of affordable, reliable, and easy-to-install systems[3]. Ultrasonic intrusion detection systems offer a promising solution. They utilize ultrasonic sensors to measure distance by emitting and receiving high-frequency sound waves[4]. By connecting these sensors to a programmable microcontroller and integrating alert mechanisms, it becomes possible to create a smart and low-cost security system[5]. This project presents the design, implementation, and evaluation of such a system, demonstrating its suitability for homes, small businesses, and academic institutions[6].

1.2 PROBLEM STATEMENT

The current market lacks affordable and reliable security systems that can be easily installed in homes, small businesses or storage facilities[7]. High installation cost and complexity deter widespread adoption. This project seeks to bridge the gap by offering simple yet effective solution using ultrasonic sensor technology[8].

1.3 OBJECTIVES

1.3.1 Main Objective

The main objective is to design an ultrasonic-based intrusion detection system.

1.3.2 Specific Objectives

- To study and utilize ultrasonic sensor principles for accurate motion detection.
- To develop system logic and implementation using microcontroller technology.
- To integrate alert system for real time notification.
- To ensure the design is low-cost, energy-efficient and scalable.

1.4 CONTRIBUTION OF THE STUDY

Firstly, it promotes cost-effectiveness by offering an affordable alternative to traditional security solutions, which often involve high installation and maintenance costs. The use of inexpensive components such as ultrasonic sensors and microcontrollers makes the system accessible to individuals, small businesses, and institutions with limited budgets.

Secondly, the project emphasizes ease of deployment and operation. Its simple design ensures that installation and maintenance require minimal technical expertise, thus enhancing accessibility and encouraging wider adoption, especially in regions where technical support may be limited.

Thirdly, the project aims to contribute to enhanced safety and security. By enabling real-time intrusion detection and immediate alerting mechanisms, it improves the responsiveness to unauthorized access, potentially reducing property loss and enhancing personal safety in homes and commercial spaces.

Lastly, the system is designed with scalability and adaptability in mind. The modular nature of the setup allows for future integration with other sensors, communication modules, and smart systems, providing a flexible foundation for more sophisticated security networks as user needs evolve.

2. METHODOLOGY

2.1 System design overview

The system was developed to detect motion within a specific range and alert users immediately via SMS and buzzer activation. The main components are:

- HC-SR04 Ultrasonic Sensor: Measures distance changes using time-of-flight of ultrasonic pulses.
- Arduino Uno Microcontroller: Acts as the processing unit to interpret sensor readings.
- SIM800L GSM Module: Sends SMS notifications to the user's phone.
- Piezo Buzzer: Emits an audible alert.
- 5V DC Power Supply: Ensures continuous system operation.

2.2 Architecture design (described)

The system's architecture follows a linear flow:

- Input: HC-SR04 ultrasonic sensor detects object movement.
- Processing: Arduino receives distance data and executes conditional logic.
- Output: Buzzer sounds when movement is detected.

This modular design ensures scalability and potential for future integration with internet of things (IoT) networks.

3. RESULTS AND DISCUSSION

3.1 Demographic Information of the Respondents

- Respondents: 30 participants
- Gender: 60% Male, 40% Female
- Age Group: 70% between 20–30 years
- Occupational Status: 100% students

3.2 Awareness and Understanding

- Awareness of ultrasonic technology: 76% had heard of ultrasonic sensors.
- Functional understanding: 48% could explain how the sensor detects motion.
- Perception of importance: 90% considered the system beneficial for local security enhancement.

Preferred features: Real-time SMS alerts, low cost, and simple setup.

3.3 Functional Testing Results

- In a closed room, motion was reliably detected and alerts sent without delay.
- The buzzer and GSM module operated effectively within a 30-meter radius and standard GSM signal range.
- Users receiving SMS alerts were able to respond within 15 seconds on average.

4. CONCLUSION AND RECCOMENDATIONS

4.1 Conclusion

This paper demonstrates that a microcontroller-based ultrasonic intrusion detection system can be a viable security solution for low-income environments. The system is low-cost, easy to deploy, and performs reliably under normal indoor conditions. By using widely available components and basic programming logic, the system meets the needs of small-scale users.

4.2 Recommendations

- Enhancement: Incorporate Passive Infrared Sensors (PIR) for better accuracy.
- Power Backup: Add rechargeable battery modules or solar panels.
- Mobile App Integration: Improve user interface and control.
- AI Integration: Use machine learning to reduce false positives.
- Weather-Proofing: Allow for outdoor implementation.

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REFERENCES

[1] H. A. B. A. Karim, "Smart Home System Based on GSM Network," 2018.

[2] M. R. Sumit Samanta, Sonu Kumar, Rahul Mahapatra, Mohsin Reza, Diganta Chattopadhyay, "Smart Home Security System Using GSM Module," 2024.

[3] K. U. M. Asadullah, "Smart home automation system using Bluetooth technology," 2017.

[4] E. C. E. A. T.L, Oranugo C.O., "GSM Based Smart Security System Using Arduino," 2019.

[5] R. M. A. Al Ib, M. M. Rahman, M. S. Rana, M. S. Islam, and F. I. Abbas, "GSM Based Home Safety and Security System," *Eur. J. Eng. Technol. Res.*, vol. 6, no. 6, pp. 69–73, 2021, doi: 10.24018/ejers.2021.6.6.2580.

[6] E. Anthi, L. Williams, M. Slowinska, G. Theodorakopoulos, and P. Burnap, "A Supervised Intrusion Detection System for Smart Home IoT Devices," *IEEE Internet Things J.*, vol. 6, no. 5, pp. 9042–9053, 2019, doi: 10.1109/JIOT.2019.2926365.

[7] S. Darshankumar C. Dalwadi, B. Goradiya, K. R. Karthic, Rahul Rai, "GSM based Security System," 2019.

[8] J. B. N. Veeranjaneyulu, G. Srivalli, "Home Automation and Security System Using IOT," 2019.