Smart Alert Stick for Leopard Intrusion Detection

Andela I. R[1], Miss. Shinde V. N[2], Miss. Shinde S. R[3]
[1]*Assistant Professor Department of Electronic Science S. N. ARTS, D.J.M. COMMERCE & B.N.S SCIENCE COLLEGE (Autonomous), SANGAMNER, Ahilyangar, Maharashtra, India*
[2,3]*Department of Electronic Science S. N. ARTS, D.J.M. COMMERCE & B.N.S SCIENCE COLLEGE (Autonomous), SANGAMNER, Ahilyangar, Maharashtra, India*

***Abstract*—Human wildlife conflict is a problem especially when leopards enter villages and areas from forest. This makes people feel unsafe. We have made a low-cost system to detect animals early and send alerts. The system uses sensor to detect objects and an MQ-135 gas sensor to smell the air. These sensors are connected to an Arduino Uno microcontroller. When something is detected within 100 cm or the air smell changes the system makes a buzzer sound, a light flash and a motor moves to alert people and scare animals away. We tested the system. It worked well in controlled conditions. This system can help protect farms and villages. It needs to be more accurate and work better in different environments. In the future we can make it recognize animals using AI and add communication. The system is a start for keeping people safe in rural areas from wild animals, like leopards. It is cheap, can be used in many places.**

***Index Terms*—Arduino Uno, Ultrasonic Sensor, MQ-135, Animal Detection, Smart Safety System, Embedded Systems.**

I. INTRODUCTION

As cities have grown into forested areas, people and animals have come into contact with each other more often. This has caused leopards to break into villages and farms more often. Traditional ways of keeping an eye on things depend on people being vigilant, which isn't safe or effective.

Recent improvements in sensor and embedded system technologies have made automated monitoring systems possible. This work suggests a Smart Alert Stick System that uses sensors to find nearby animals and environmental cues and sends alerts right away. The goal of the system is to: Detect in real time, make sure it's cheap to set up, and let automatic response systems work

II. PROBLEM STATEMENT

Wild animals like leopards often come into human settlements in rural and forested areas, which can be dangerous for people and damage crops and livestock. Farmers can't use the current systems because they are too expensive and hard to use. So, we need to come up with a simple, cheap system that can find animals and warn people ahead of time to keep them safe.

III. OBJECTIVE

1. To find an obstacle, like a leopard, using an ultrasonic sensor: Measure the distance and find things within a certain range.
2. Use the MQ-135 sensor to find gas that smells like a leopard: Keep an eye on the air quality and smell the gas.
3. To set off an alarm: turn on the buzzer and LED when an obstacle or gas is found.
4. To make things safer and more secure, keep people safe from animals, obstacles, and gas hazards.
5. To make a smart system that doesn't cost much, use cheap and simple electronic parts.
6. To make a system that is easy for basic users to use and understand.

IV. LITERATURE SURVEY

[1] S. Padmapriya, P. S. Abarna, S. Pavalarajan, and C. Manjula Devi, “Smart Tribal Alert: An IoT

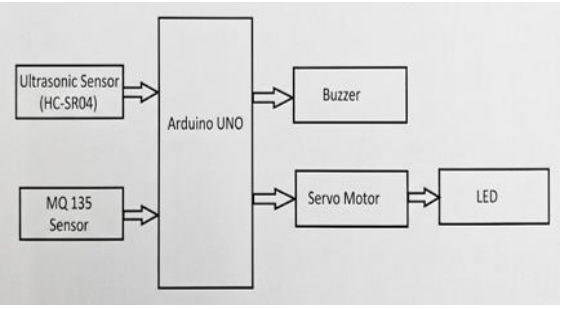
Enabled Solution for Wildlife Intrusion Detection," Proc. IEEE ICESC, 2025.
S. Padmapriya et al. (2025) proposed an IoT-based system integrating motion sensors, infrared detectors, acoustic modules, and cameras for real-time wildlife monitoring. The system uses LoRa communication for alert transmission in remote areas and employs deterrent mechanisms such as alarms and ultrasonic emitters. Although effective, the system has higher complexity and cost.

[2] T. Monikuttan and P. M. Jacob, "Wild Animal Intrusion Detection and Alert System using Machine Vision," Proc. IEEE ICCES, 2025.
Thejas Monikuttan and Pramod Mathew Jacob (2025) developed a machine vision-based system using background subtraction and YOLOv8 deep learning for accurate animal detection. The system improves detection accuracy and reduces false alerts but requires high computational resources, limiting its use in low-power embedded systems.

[3] V. Arinde and L. Idowu, "Multi-sensor Intrusion Detection System," arXiv: 2406.05137, 2024.
Victor Arinde and Liberty Idowu (2024) presented a multi-sensor system using PIR sensors, magnetic switches, and GSM communication for real-time intrusion alerts. The system is reliable and fast but is mainly designed for indoor security Drather than wildlife detection.

[4] L. G. Anand, "Sensor Fusion Anomaly Detection for Redundant Safety in Connected Vehicles," SSRN, 2025.
Ali et al. (2021) – Lawal G. Anand (2025) proposed a sensor fusion framework combining multiple sensors with machine learning techniques to improve anomaly detection accuracy. While highly efficient, the system is computationally complex and more suitable for advanced applications.

Block Diagram



Working:
1. Central Processing Unit: The central processing unit of the system is the Arduino UNO. It is a microcontroller-based platform that handles all operations of the system. The Arduino constantly reads the input signals from the sensors and produces the control signals to the output devices according to the threshold conditions.

2. Input Subsystem (Sensors): Input subsystem is responsible for collecting the real time environmental data and delivering it to the Arduino for further processing.
2.1 Ultrasonic Sensor (HC-SR04): Ultrasonic sensor is employed for the purpose of obstacle detection. The sensor sends an ultrasonic pulse and takes note of the echo signal reflected back from the obstructing object. The distance to the object is computed from the time delay between the emission and reception of the signal. This helps in detecting the presence of animals or objects within the range.
2.2 MQ-135 Gas Sensor: The MQ-135 sensor detects the presence of gases such as ammonia (NH_3), nitrogen oxides (NOx), alcohol, benzene, smoke and carbon dioxide (CO2) which indicates the quality of air in the environment. It generates an analog voltage output which is proportional to the gas concentration.

3. Output Subsystem (Actuators): The output subsystem provides alert and deterrent actions based on the processed data.
3.1 Buzzer: The buzzer generates an audible alert when a detection condition is satisfied. It helps in warning nearby individuals and may also act as a deterrent to animals.
3.2 Servo Motor: The servo motor provides controlled mechanical movement. Upon detection, it rotates within a predefined angle range, creating motion that can help in scaring away animals.
3.3 Light Emitting Diode (LED): The LED serves as a visual indicator. It glows when the system detects an intrusion or abnormal condition, providing a clear visual signal.

4. System Working and Data Flow: The system operates based on a sequential Input → Processing → Output mechanism: Detection: Sensors continuously monitor environmental parameters such as distance and gas concentration. Data Transmission: Sensor

outputs are transmitted to the Arduino through digital (ultrasonic) and analog (gas sensor) input pins.
Processing and Decision Making:
The Arduino evaluates the received data based on predefined conditions:
Condition: $(d \leq 100cm) \vee (G > Gth)$
Where: d = measured distance, G = gas sensor value, Gth = predefined gas threshold.
Execution:
If the condition is satisfied, the Arduino simultaneously activates the buzzer, LED, and servo motor. Otherwise, the system remains in an idle state.

Advantages:

1. Low-Cost Implementation: The system uses affordable components such as Arduino, ultrasonic sensor, and MQ-135, making it suitable for rural deployment.
2. Real-Time Detection: Continuous monitoring ensures immediate detection of animal intrusion or hazardous environmental conditions.
3. Multi-Sensor Integration: Combines distance and gas sensing, improving detection reliability compared to single-sensor systems.
4. Automatic Operation: Works autonomously without human intervention, reducing dependency on manual monitoring.
5. Fast Response Mechanism: Immediate activation of buzzer, LED, and servo motor ensures quick alert and deterrent action.
6. Low Power Consumption: The system remains inactive when no detection occurs, thereby conserving energy.
7. Easy Installation and Maintenance: Simple hardware design and programming make the system user-friendly and easy to maintain.
8. Scalable Design: The system can be enhanced with additional modules such as GSM, IoT, or camera systems.

Applications:

1. Agricultural Field Protection: Prevents crop damage by detecting and deterring wild animals entering farms.
2. Forest Border Monitoring: Useful in areas near forests to alert about animal movement toward human settlements.
3. Rural Safety Systems: Provides early warning to villagers in wildlife-prone regions.
4. Garden and Home Security: Can be used for detecting unwanted movement in residential surroundings.
5. Industrial Safety Monitoring: Detects harmful gases in industrial environments and provides alerts.
6. Parking and Obstacle Detection Systems: Ultrasonic sensing can assist in vehicle parking and obstacle avoidance.
7. Educational and Research Applications: Demonstrates practical implementation of embedded systems, sensors, and automation.
8. Smart Alert and Surveillance Systems: Acts as a basic automated alert system for restricted or sensitive areas.

Limitations:

1. Limited Detection Range: The ultrasonic sensor is effective only within a short range (≈100 cm), which restricts long-distance detection of animals.
2. Lack of Object Identification: The system can detect the presence of an object but cannot differentiate between animals, humans, or other obstacles.
3. Gas Sensor Inaccuracy: The MQ-135 sensor is sensitive to multiple gases and may produce false alerts due to environmental pollution or non-relevant odors.
4. Environmental Dependency: Sensor performance may be affected by factors such as temperature, humidity, dust, and wind conditions.
5. Power Consumption Issues: The servo motor requires higher current, which may lead to unstable operation if not powered properly.
6. Possibility of False Triggering: Small objects, noise, or minor gas variations can activate the system unnecessarily.
7. No Remote Monitoring: The system does not support wireless communication or remote alerting capabilities.

V. CONCLUSION

Using ultrasonic sensors and MQ-135 gas detection sensors, the intelligent alert stick system is able to detect obstacles and gas with great accuracy. By activating the buzzer LEDs and servo motor, the Intelligent Alert Stick provides real-time alerts to

users about potential hazards within their vicinity, making it a great tool for promoting safety when living in rural communities. The Intelligent Alert Stick is very inexpensive, easy to use, and designed for basic animal detection applications. Despite having any limitations at present, it can potentially be improved upon further as additional advanced features such as wireless communication and smart detection will be included in future models.

VI. FUTURE SCOPE

1. Integration with IoT and GSM Modules: The system can be enhanced with WiFi or GSM modules to send real-time alerts to mobile devices.
2. AI-Based Animal Recognition: Adding camera modules with machine learning algorithms can enable identification of specific animals like leopards.
3. Long-Range Detection: Advanced sensors such as infrared or thermal imaging can improve detection range and accuracy.
4. Solar-Powered System: Incorporating solar panels can make the system energy-efficient and suitable for remote areas.
5. Mobile Application Interface: A user-friendly mobile app can be developed for monitoring system status and receiving alerts.
6. Improved Sensor Fusion: Combining additional sensors (PIR, camera, sound sensors) can reduce false alarms and improve reliability.
7. Data Logging and Analysis: Storing detection data can help in analyzing animal movement patterns and improving system performance.

REFERENCES

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