

# **SMART BABY ROOM MONITOR**

## IoT-Based Infant Cry Detection and Sound Analysis System

Universidad Nacional Mayor de San Marcos  
Professional School of Software Engineering  
Internet of Things  
Professor: José Alfredo Herrera Quispe

**Group 2**  
Luis Fernando Maylle Colaca  
Alvaro Bertilo Cueva Mantura  
Laura Cecilia Mendoza Morales

February 22, 2026

# 1 Problem Statement

Parents are not always able to determine whether their baby is crying or if a detected sound in the room is potentially dangerous. Traditional baby monitors only transmit audio or video but do not intelligently analyze sound patterns or generate smart alerts.

There is a need for a low-cost intelligent monitoring system capable of detecting crying events and identifying potentially harmful noise levels in real time.

## 2 Proposed Solution

The Smart Baby Room Monitor is an Internet of Things (IoT) system designed to:

- Detect sound peaks in real time.
- Identify cry-like sound patterns using frequency and duration analysis.
- Trigger immediate alerts to a mobile device.
- Provide local visual and audible feedback.

Unlike a simple noise detector, this system incorporates basic signal processing techniques to differentiate between random noise and structured cry patterns.

## 3 System Architecture

The system follows a four-layer IoT architecture:

1. **Sensing Layer:** INMP441 digital I<sup>2</sup>S microphone.
2. **Processing Layer:** ESP32 microcontroller.
3. **Communication Layer:** WiFi + HTTP REST.
4. **Cloud Layer:** ThingSpeak for monitoring and alerts.

### 3.1 Data Flow

1. Audio is captured continuously by the digital microphone.
2. The ESP32 computes RMS and analyzes frequency characteristics.
3. Sound duration and peak repetition are evaluated.
4. If a cry-like pattern is detected, an alert event is generated.
5. Data is transmitted to the cloud dashboard.
6. Parents receive notification via mobile visualization platform.

## 4 Cry Detection Algorithm

The system does not rely on complex machine learning models in its initial version. Instead, it uses signal processing techniques:

### 4.1 Step 1: RMS Calculation

$$RMS = \sqrt{\frac{1}{N} \sum_{i=1}^N x_i^2}$$

Used to detect sound intensity peaks.

### 4.2 Step 2: Frequency Pattern Approximation

Baby crying typically exhibits:

- Repetitive frequency structure
- Sustained duration (several seconds)
- Consistent amplitude variation

The algorithm evaluates:

- Duration above threshold
- Number of consecutive peaks
- Approximate dominant frequency band

If conditions are satisfied, the event is classified as **Possible Cry Event**.

## 5 Hardware Design

### 5.1 Main Components

Component	Description
ESP32	WiFi-enabled microcontroller
INMP441	Digital I2S microphone
LED	Visual alert indicator
Active Buzzer	Audible alert system
Protoboard	Prototyping platform

Table 1: Hardware Components

The system operates entirely at 3.3V for safety and energy efficiency.

## 6 Internet Connectivity

The ESP32 connects to WiFi and transmits event data to ThingSpeak using HTTP requests.

Data fields include:

- Field 1: RMS Value
- Field 2: Sound Classification (Normal / Cry Detected)
- Field 3: Event Duration

Transmission intervals respect free-tier cloud limitations.

## 7 Smart Features

The Smart Baby Room Monitor qualifies as a Smart Thing because it:

- Continuously senses environmental sound.
- Processes signals locally.
- Makes autonomous decisions.
- Sends remote alerts.

It goes beyond simple monitoring by incorporating embedded signal analysis.

## 8 Future Improvements

Future development includes implementing a lightweight embedded classification model capable of distinguishing between:

- Baby crying
- Object impact (e.g., something falling)
- Ambient noise

This would introduce on-device machine learning, combining:

- IoT connectivity
- Real-time signal processing
- Edge AI inference

Possible techniques:

- TinyML model deployment
- Feature extraction (MFCC or spectral centroid)
- Lightweight neural networks optimized for ESP32

## 9 Innovation Aspect

The project is innovative because:

- It applies embedded signal processing in a real domestic scenario.
- It proposes scalable AI integration.
- It addresses a real parental safety concern.
- It remains low-cost and energy-efficient.

## 10 Evaluation Rubric Alignment

- **It Works** – Real-time cry detection and cloud alert system.
- **Smart Thing** – Autonomous signal processing and decision-making.
- **Internet Connected** – WiFi + ThingSpeak integration.
- **Innovative** – Edge signal processing with AI scalability.
- **Analytics** – Event-based monitoring dashboard.

## 11 Conclusion

The Smart Baby Room Monitor demonstrates the integration of IoT architecture, embedded systems, and real-time signal processing to solve a meaningful real-world problem.

By combining sound peak detection, duration analysis, and frequency-based pattern recognition, the system provides an intelligent monitoring solution that can evolve toward TinyML-based classification, making it a scalable and future-ready IoT device.