

IOT Based Incubator Monitoring System in Health Sector

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Abstract - The IoT-Based Incubator Monitoring System is an advanced and intelligent solution designed to improve the safety, comfort, and continuous monitoring of infants in neonatal and home care environments. Infants, especially newborns and premature babies, are highly sensitive to environmental changes and require constant supervision. Traditional monitoring systems often lack automation, real-time data access, and multi-parameter integration, making them insufficient for modern healthcare needs. This project proposes a smart incubator system combining an Arduino Mega 2560 microcontroller with Internet of Things (IoT) technology to provide a reliable, automated, and cost-effective monitoring solution. The system integrates an IR sensor for movement detection, a raindrop sensor for wetness (diaper hygiene) monitoring, and a DHT11 sensor for continuous temperature measurement. When temperature exceeds a safe threshold, a CPU fan activates automatically to regulate the environment. A GSM module sends SMS alerts to caregivers, a buzzer provides local notifications, and a NodeMCU (ESP8266) module transmits real-time data to the ThingSpeak IoT cloud platform for remote visualization. An IP camera enables live video surveillance. The system is tested and validated, demonstrating accurate sensing, timely alert generation, and successful remote monitoring capability, significantly reducing the need for manual supervision while enhancing infant safety.

Key Words: IoT, Infant Monitoring, Arduino Mega 2560, NodeMCU, DHT11, GSM Module, IR Sensor, Smart Incubator, Remote Monitoring, Temperature Control.

1. INTRODUCTION

The IoT-Based Incubator System for Infant Health Monitoring addresses the growing demand for continuous, reliable, and real-time monitoring of infants, particularly in neonatal care environments. Newborns and premature babies require constant attention and a carefully controlled environment to ensure healthy development. Traditional monitoring methods rely on manual observation or basic devices, which may be insufficient to detect sudden changes in the baby's condition.

This system combines embedded systems and IoT technology to create a smart monitoring platform capable of tracking multiple parameters simultaneously. An Arduino Mega 2560 acts as the central processing unit, integrating an IR sensor for movement detection, a raindrop sensor for wetness monitoring, and a DHT11 sensor for temperature measurement. If temperature exceeds a safe limit, a CPU fan is activated automatically. If wetness or unusual movement is detected, the system generates alerts via a buzzer and SMS through a GSM module. Real-time data is transmitted to an IoT cloud platform via NodeMCU, and live video is provided by an integrated IP camera.

2. PROBLEM STATEMENT

Infant health monitoring is a critical aspect of neonatal care requiring constant attention and precise environmental control. Existing systems typically offer only one or two functionalities such as audio monitoring or temperature display without integrating multiple parameters into a single platform.

The major problems with existing systems include: (i) lack of real-time monitoring and automation, leading to delayed human responses; (ii) absence of remote monitoring capabilities, limiting caregiver flexibility; (iii) independent operation of monitoring devices without unified integration; and (iv) no data logging for pattern analysis. A unified intelligent system monitoring multiple parameters with automated responses and remote access is therefore essential.

3. OBJECTIVES

The objectives of the proposed system are:

- To design a centralized control system using Arduino Mega 2560 for efficient coordination of all components.
- To continuously monitor infant movement using an IR sensor.

- To detect diaper wetness using a raindrop sensor for hygiene monitoring.
- To measure and regulate ambient temperature using DHT11 and a CPU fan.
- To send SMS alerts via a GSM module and local alerts via a buzzer.
- To enable real-time IoT data transmission and visualization via NodeMCU and ThingSpeak.
- To integrate an IP camera for live video surveillance of the infant.

4. LITERATURE SURVEY

Several IoT-based infant monitoring systems have been proposed in recent literature. Bhuvaneshwari et al. designed a smart infant care incubator with sensors for heart rate, oxygen, temperature, humidity, and air quality, using IoT connectivity for real-time data transmission to mobile and web applications [1].

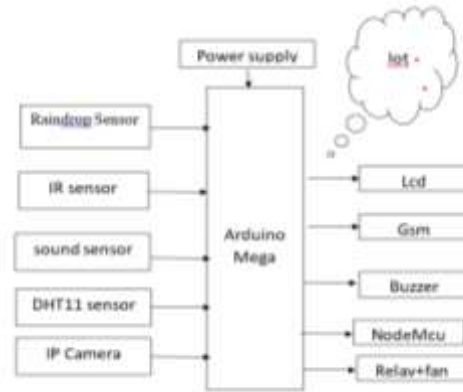
Anto Gracious et al. explored Wireless Sensor Networks (WSNs) in healthcare, demonstrating how Body Area Networks (BANs) and Ambient Assisted Living (AAL) systems support continuous patient monitoring including fall detection and chronic disease management [7].

Yadla Nithin Kumar et al. integrated Arduino and NodeMCU in an IoT healthcare system, collecting physiological data and transmitting it to ThingSpeak for real-time visualization [3]. Similarly, Subba Reddy et al. presented a real-time patient monitoring system using GSM and cloud-based alerts for timely medical intervention [6].

Existing systems suffer from high cost, limited parameter integration, network dependency, security concerns, and lack of real-time automation. The proposed system addresses these gaps by combining movement, hygiene, and temperature monitoring with automated control, dual alert mechanisms, and IoT cloud connectivity at low cost.

5. PROPOSED METHODOLOGY

5.1 System Architecture



The proposed IoT-Based Incubator System consists of interconnected hardware components including sensors, an Arduino Mega 2560 microcontroller, communication modules, and output devices. The Arduino acts as the central processing unit, continuously reading sensor data and controlling output devices based on predefined thresholds.

Input sensors include: an IR sensor for movement detection, a raindrop sensor for wetness monitoring, and a DHT11 sensor for temperature and humidity measurement. Output devices include: an I2C LCD display for real-time data display, a buzzer for local alerts, a CPU fan controlled via a relay module for temperature regulation, a GSM module (SIM800) for remote SMS alerts, a NodeMCU (ESP8266) for IoT cloud connectivity, and an IP camera for live video surveillance.

5.2 Hardware Components

Arduino Mega 2560: The main controller based on ATmega2560, featuring 54 digital I/O pins, 16 analog inputs, 4 UARTs, and 256 KB flash memory. It processes all sensor data and coordinates system operations.

NodeMCU (ESP8266): Provides Wi-Fi connectivity for IoT data transmission to the ThingSpeak cloud platform, enabling remote monitoring through any internet-connected device.

DHT11 Sensor: Measures ambient temperature (0–50°C, ±2°C accuracy) and humidity (20–90% RH, ±5% accuracy), triggering the cooling fan when temperature exceeds the safe threshold.

IR Sensor: Detects infrared radiation emitted by the infant to monitor movement and identify restlessness or unusual activity patterns.

Raindrop Sensor: Detects moisture using copper tracks as a variable resistor, indicating diaper wetness for hygiene

monitoring. Operates at 5V with both digital and analog output.

GSM Module (SIM800): Enables SMS notification to caregivers during abnormal conditions using AT commands over serial communication.

Relay Module & CPU Fan: The relay acts as an electromagnetic switch controlled by Arduino to activate the CPU fan when temperature exceeds the predefined threshold.

IP Camera: A networked video camera providing live streaming over the internet, allowing caregivers to visually monitor the infant from any remote location.

5.3 Software Requirements

The system uses Arduino IDE with Embedded C for microcontroller programming, ESP8266 libraries for NodeMCU communication, ThingSpeak/Blynk as the IoT cloud platform, and a web/mobile application for remote data access and visualization.

5.4 System Operation

Upon power-on, the Arduino initializes all sensors and modules. The system enters a continuous monitoring loop: (i) DHT11 reads temperature — if above threshold, the fan activates via relay; (ii) the raindrop sensor checks for wetness — if detected, the buzzer sounds and an SMS alert is sent via GSM; (iii) the IR sensor monitors for movement — abnormal movement triggers alerts; (iv) all sensor readings are transmitted to the NodeMCU, which uploads data to the ThingSpeak IoT dashboard every 15 seconds; (v) the I2C LCD displays current readings locally; and (vi) the IP camera streams live video continuously.

6. IMPLEMENTATION AND RESULTS

6.1 Hardware Setup

The complete hardware prototype was assembled using an Arduino Mega 2560 as the central controller connected to all sensors, relay modules, and communication devices via a breadboard and jumper wires. The NodeMCU was interfaced with the Arduino via serial communication. The raindrop sensor board was placed in the incubator to detect moisture, the DHT11 was positioned to measure ambient conditions, and the IR sensor was placed to monitor infant movement.

6.2 Temperature Monitoring

The DHT11 sensor continuously tracked ambient temperature and displayed readings on the ThingSpeak IoT dashboard. During testing, when the ambient temperature exceeded 32.5°C, the system automatically activated the CPU fan via the relay module. Temperature

readings were updated on the cloud dashboard at regular intervals, confirming reliable real-time monitoring.

6.3 Wetness Detection

The raindrop sensor successfully detected moisture conditions, registering a drop in output value on when wetness was introduced. Upon detection, the buzzer triggered immediately and an SMS alert was dispatched via the GSM module, demonstrating effective hygiene monitoring capability.

6.4 Movement Detection Results

The IR sensor reliably detected presence and movement of the infant. The binary output (0/1) was logged on the IoT dashboard, showing clear transitions when movement was detected or ceased. This feature provides continuous activity monitoring and enables detection of unusual movement patterns.

6.5 IoT Dashboard Performance

Real-time data from all sensors was successfully transmitted to and visualized on the ThingSpeak platform. Sound sensor values, rain (wetness) values, IR movement values, and temperature readings were all displayed as individual field charts, providing caregivers comprehensive remote monitoring access from any internet-connected device.

Table 1: Result Analysis Summary

Parameter	Sensor	Alert Type	Status
Temperature	DHT11	Fan / SMS	Success
Wetness	Raindrop	Buzzer / SMS	Success
Movement	IR Sensor	IoT Alert	Success
Video Feed	IP Camera	Live Stream	Success
IoT Upload	NodeMCU	ThingSpeak	Success

7. ADVANTAGES AND APPLICATIONS

Key advantages of the proposed system include: real-time multi-parameter health monitoring; automated environmental control (fan activation); dual alert mechanism (local buzzer + remote SMS); IoT-enabled remote monitoring accessible from anywhere; live video surveillance via IP camera; low-cost implementation using affordable components; and scalability for home and hospital environments.

Applications include: home-based newborn care, hospital neonatal wards, neonatal intensive care units (NICUs), daycare and nursery centres, and baby care facilities

where continuous supervision is required but resources are limited.

8. CONCLUSION

This paper presented an IoT-Based Incubator Monitoring System for infant health monitoring that integrates embedded systems, multiple sensors, and IoT connectivity into a comprehensive, automated, and low-cost solution. The system successfully monitors temperature, movement, and wetness in real time, automatically activates a cooling mechanism, generates both local and remote alerts, and provides live video streaming.

Testing confirmed that all subsystems perform reliably: temperature regulation, wetness detection, movement monitoring, cloud-based visualization via ThingSpeak, and SMS-based alerting via GSM module all operated as designed. The system reduces caregiver burden, improves response time, and enhances infant safety. Using affordable components such as Arduino Mega 2560 and NodeMCU, it provides a practical and widely deployable solution.

Future enhancements may include integration of medical-grade sensors for SpO₂ and heart rate monitoring, AI/ML-based anomaly detection, advanced data encryption for IoT security, battery backup for uninterrupted operation, and a dedicated mobile application with graphical data representation and voice alerts.

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