Archives available at journals.mriindia.com

International Journal on Advanced Computer Engineering and Communication Technology

ISSN: 2278-5140
Volume 14 Issue 01, 2025

Smart Cradle with Baby Activity & Sleep Time Analysis

Prof. Pranali Faye [1], Mr. Aman Dhargawe[2], Mr. Badal Wasnik[3], Miss. Chandani Dhargawe[4], Miss. Karina Sahare[5]

[1]*Assistant Professor, Department of Computer Engineering, SCET, Nagpur, Maharashtra, India*
[2,3,4,5] *UG Student, Department of Computer Engineering, SCET, Nagpur, Maharashtra, India*
[1]*Pranalifaye5739@gmail.com, 86685 31298*
[2]*amandhargawe21@gmail.com, 76208 05615*
[3]*wasnikbadal4@gmail.com , 9356530093*
[4]*chandanidhargawe21@gmail.com , 90221 34718*
[5]*karinasahare2003@gmail.com, 74986 95674*

Peer Review Information

Submission: 05 Feb 2025
Revision: 17 Mar 2025
Acceptance: 18 April 2025

Keywords

IoT
Smart Cradle
Infant Monitoring
Sensor Integration

Abstract

The need for creative infant care options that guarantee safety and give parents peace of mind has grown as the number of dual-income homes has climbed. An IoT-based smart cradle system that is partially constructed and intended to monitor and react to an infant's requirements in real-time is presented in this study. The system uses a number of sensors to monitor environmental factors, such as sound levels, humidity, and ambient temperature. Through a specialized smartphone application, the system notifies parents and immediately starts a swinging motion when it senses the baby's cry. With the help of the smartphone app's real-time information, parents can keep an eye on their infant's health from a distance and respond appropriately. To evaluate its effectiveness in real-time monitoring and responsive actions, a prototype has been created and tested in a controlled setting. According to preliminary findings, the technology successfully improves baby care by lowering the requirement for continual parental observation. In order to maximize the system's functionality and dependability, future improvements will concentrate on enhancing its responsiveness and adding more safety features

INTRODUCTION

Traditionally, caring for an infant has been a labor-intensive responsibility, requiring parents to manage everything from sleep schedules and ambient room conditions to hygiene and soothing techniques. With the rapid growth of dual-income families in metropolitan areas, the challenge of balancing professional duties with the constant demands of childcare has become increasingly evident. This struggle was further exacerbated during the COVID-19 pandemic, when working from home while attending to an infant's needs amplified both stress and fatigue for caregivers.When an infant falls ill, the need for vigilant monitoring becomes even more critical, as frequent interventions and adjustments are often necessary—sometimes compelling one or both parents to take time away from their professional responsibilities. This scenario not only disrupts work-life balance but also significantly elevates parental anxiety and stress. Historically, families have relied on continuous vigilance to ensure the safety of their children, driven by an instinctive need to shield

© 2025 The Authors. Published by MRI INDIA.
This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

them from harm. However, evolving societal dynamics and technological advancements have ushered in new methods of caregiving that aim to ease these traditional burdens.

The IoT-based Smart Cradle System emerges as a critical solution to these challenges by integrating advanced sensor technologies, IoT connectivity, and automation into infant care. This innovative system continuously monitors essential parameters—such as temperature, humidity, gas levels, and sound—ensuring that any deviations from the norm are immediately detected. When the cradle senses potential hazards or identifies that the baby is crying, it promptly activates a motorized rocking mechanism and sends real-time alerts to caregivers via SMS or voice calls through a GSM module.

LITERATURE SURVEY

The evolution of intelligent cradle systems has significantly transformed infant care by integrating sensor-driven automation, real-time monitoring, and IoT-enabled responses. Several researchers have contributed to advancing traditional cradle mechanisms, incorporating algorithmic control, cloud-based analytics, and wireless communication technologies to enhance functionality and responsiveness.

Primitive Automated Rocking Systems: M. P. Joshi and D. C. Mehetre pioneered one of the earliest automated cradle systems, replicating the natural oscillatory motion of manual rocking using a spring motor coupled with a gear-driven mechanism. This system was designed to halt motion upon encountering resistance, prioritizing infant safety. Although cost-efficient and effective in minimizing manual intervention, it was devoid of video surveillance, limiting parental oversight and real-time monitoring [1].

Adaptive Motion Modulation: S. Joseph et al. further refined this concept by integrating algorithmic modulation of motor control, enabling the cradle to adjust swinging intensity based on auditory distress levels. This dynamic control strategy ensured that the system proportionally modulated its soothing mechanism according to the intensity of the baby's cries, thereby enhancing the effectiveness of automated comforting responses [2].

Sensor-Driven Automation with Remote Access: S. Kavitha et al. augmented cradle automation with Android application integration, allowing caregivers to remotely monitor and control the system. The proposed model utilized an audio sensor to assess the amplitude of crying, activating the motorized rocking function upon surpassing a predefined acoustic threshold. Additionally, a GSM module facilitated real-time SMS notifications, alerting parents about the baby's condition. The incorporation of a cloud-connected surveillance module further enabled live video streaming, effectively merging automated rocking with remote monitoring [3].

IoT-Infused Infant Surveillance: N. Saude and P. A. H. Vardhini introduced a cloud-integrated cradle utilizing Raspberry Pi and a network of sensors, including a gas sensor (MQ-135), temperature sensor (LM-35), and sound sensor (KY-038). The system continuously monitored environmental and physiological parameters, with the recorded data being transmitted to a cloud server for real-time parental updates via SMS. Despite offering a user-friendly and cost-effective solution, this system functioned predominantly as a passive monitoring tool, lacking automated intervention capabilities to address infant distress in real-time [4].

Vital Sign Monitoring through IoT Networks: S. Durga et al. devised a wireless surveillance architecture that integrated biometric sensors for tracking heart rate, body temperature, and crying patterns. This WAN-enabled (Wide Area Network) system allowed parents to remotely monitor their infant's vitals while accessing live video surveillance. While this solution effectively facilitated continuous health monitoring, it remained an observational framework rather than an interactive intervention system, as it did not incorporate automated cradle movements or proactive soothing mechanisms [5].

AI-Based Infant Behavior Recognition : R. Verma and A. Singh proposed an AI-powered smart cradle system that employed computer vision and deep learning models to analyze an infant's facial expressions and body movements. The system used convolutional neural networks (CNNs) to distinguish between different distress signals, such as hunger, discomfort, or pain. Upon identifying a specific distress cause, the system activated corresponding soothing mechanisms, including gentle vibrations, temperature adjustments, or lullabies. While highly effective in personalized infant care, this system had higher computational requirements, making it less feasible for cost-sensitive applications [6].

Comparative Analysis

Feature	Existing System	Proposed Architecture
Monitoring	Basic sensors (temperature, sound detection)	Multi-sensor integration (heartbeat, SpO2, motion)
Cry Detection	Simple sound-based cry detection	AI-based cry recognition with pattern analysis
Soothing Mechanism	Manual or basic vibration mechanism	Automated rocking & lullabies based on infant state
Health Monitoring	Only temperature & movement tracking	AI-based vital sign monitoring & anomaly detection
Alerts & Notifications	Limited, only basic alerts	Smart alerts via mobile app & caregiver dashboard
Power Efficiency	Continuous operation without optimization	Adaptive power management & energy-efficient sensors
Privacy & Security	Minimal security measures	End-to-end encryption & secure cloud storage

OBJECTIVES

1. **Augment Infant Safety:** The foremost objective of this system is to fortify infant security by incessantly scrutinizing pivotal parameters such as ambient temperature, moisture levels, and auditory cues from the baby. This proactive surveillance facilitates swift intervention whenever anomalies are detected, thereby sustaining an optimal and hazard-free environment for the infant.

2. **Optimize Work-Life Equilibrium:** Engineered to assist working parents, this system enables remote supervision and responsiveness, diminishing the necessity for perpetual physical presence. By offering seamless monitoring capabilities, it empowers caregivers to efficiently juggle occupational commitments alongside childcare responsibilities.

3. **Enhance Caregiving Adaptability:** Capitalizing on IoT-driven automation, this system allows caregivers to administer attentive and responsive care irrespective of their physical proximity to the infant. This technological dexterity introduces a newfound flexibility in childcare, ensuring that professional obligations and familial duties can be harmoniously balanced.

4. **Alleviate Parental Anxiety:** By automating multifaceted aspects of infant care and issuing instantaneous alerts, the system ameliorates the psychological strain associated with conventional caregiving. Parents can experience heightened tranquility, assured that their child's needs are being met efficiently, without necessitating unremitting vigilance.

5. **Enhance Healthcare Interventions:** By systematically tracking infant behaviors, sleep disturbances, and potential health risks, the system provides actionable insights that can be shared with pediatricians. This data-centric approach enables healthcare professionals to identify early warning signs of illness or developmental concerns, fostering proactive medical interventions.

6. **Encourage Technological Integration in Parenting:** As smart home ecosystems evolve, integrating IoT-based childcare solutions into daily life enhances parenting efficiency. The Smart Cradle System seamlessly synchronizes with other smart home devices, enabling parents to customize settings, adjust environmental parameters, and receive alerts through their smartphones or voice assistants.

PROPOSED METHODOLOGY

The IoT-based Smart Cradle System follows a structured and intelligent decision-making process to ensure optimal infant care. By integrating sensor-based automation, real-time monitoring, and instant parental alerts, the system minimizes the need for constant supervision while enhancing safety, comfort, and responsiveness.

Equipped with advanced audio, motion, and environmental sensors, the smart cradle can analyze the baby's needs, detect distress patterns, and respond accordingly. The system ensures a proactive caregiving approach by autonomously activating soothing mechanisms, sending alerts for adverse conditions, and maintaining real-time communication with parents or caregivers. Additionally, cloud-based data storage and analytics enable long-term monitoring, helping parents and healthcare professionals track the infant's sleep cycles, comfort levels, and environmental conditions. By leveraging AI-driven insights, the system can provide predictive analysis for early detection of irregular behaviors, ensuring timely interventions for the infant's well-being.

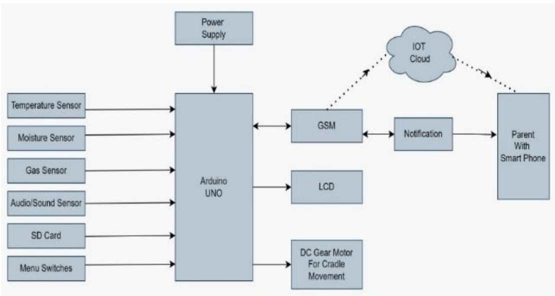

Fig 1: Proposed system

1. **Audio Detection:** The high-sensitivity microphone sensor continuously monitors the ambient sound. When the baby cries, the system detects the specific frequency and intensity of the sound and transmits a signal to the microcontroller for further analysis.

2. **Soothing Activation:** The microcontroller unit (MCU) evaluates the cause of the crying and determines the appropriate response. If the detected distress is behaviora l (e.g., the baby seeks comfort or is restless), the soothing module is activated, initiating automated gentle rocking or playing predefined lullabies to calm the infant.

3. **Environmental-Based Alert Mechanism:** If the crying is triggered by adverse environmental factors, such as temperature fluctuations, excessive humidity, or diaper wetness, the system cross-verifies sensor readings. Upon confirming a deviation from optimal conditions, it sends immediate notifications to the parents via a GSM module, ensuring swift intervention. Additionally, an integrated alarm system can be activated to alert nearby caregivers.

4. **Continuous Condition Monitoring:** The system continuously evaluates the baby's condition through real-time data analysis. If the infant calms down and the distress indicators subside, the soothing mechanism automatically deactivates, and normal monitoring resumes. The system further logs sensor data to an SD card and cloud storage, facilitating long-term behaviora pattern analysis and predictive caregiving insights.

Hardware Components

Arduino Microcontroller Board : The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software.

I2C 16X2 LCD MODULE: The I2C 16×2 Arduino LCD Screen is using an I2C communication interface. It is able to display 16×2 characters on 2 lines, white characters on blue background.This display overcomes the drawback of LCD 1602 Parallel LCD Display in which you'll waste about 8 Pins on your Arduino for the display to get working.

Temperature Sensor (LM35/DHT11) : The temperature sensor is a crucial component that ensures a safe and comfortable environment for the infant. The LM35 or DHT11 sensor continuously monitors room temperature and provides real-time data to the Arduino Uno. If the temperature rises above or falls below a predefined range, the system sends an alert via GSM module to notify the parents. This proactive monitoring prevents discomfort due to excessive heat or cold, ensuring the baby sleeps in a thermally regulated environment.easy use.

Moisture Sensor (FC-28) : The moisture sensor (FC-28) plays a pivotal role in monitoring the wetness levels in the baby's bedding or diaper. It detects moisture and sends an alert to the Arduino, which then triggers a GSM notification to inform parents of the need for a diaper change. This ensures the baby remains dry and comfortable, reducing the risk of skin infections or irritations caused by prolonged exposure to moisture. The sensor operates by measuring the conductivity of water, triggering an alert when a certain threshold is exceeded.

Gas Sensor (MQ-135) : The gas sensor (MQ-135) is integrated into the system to detect the presence of harmful gases such as carbon dioxide (CO_2), ammonia (NH_3), and smoke. Air quality plays a critical role in an infant's health, as exposure to toxic gases can lead to respiratory issues. If the sensor detects unsafe levels of gases, the system sends an instant alert via GSM and displays a warning message on the LCD screen. This ensures that parents can take immediate action to maintain a safe and breathable environment for the infant.

GSM Module (SIM800L / SIM900A) : The GSM module (SIM800L/SIM900A) enables real-time SMS or call notifications to parents whenever a sensor detects an anomaly, such as extreme temperature variations, moisture detection, gas leakage, or prolonged crying. This feature ensures that parents remain informed and connected to their infant's well-being, even when they are not physically present. The module operates using a SIM card, making it an effective solution for remote monitoring without requiring an internet connection.

DC Gear Motor for Cradle Movement : The DC gear motor is a critical component that automates the rocking mechanism of the cradle. When the sound sensor detects crying, the Arduino triggers the motor, which gently moves the cradle to mimic the natural rocking motion of a caregiver. This feature provides instant soothing to the baby, reducing the need for parents to manually rock the cradle. The motor operates at an optimized speed, ensuring smooth, controlled movement without abrupt jerks, enhancing the infant's comfort.

Software Components

Arduino Programming Software Arduino IDE: The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

Embedded C/C++: For writing control algorithms.

GSM Library for Arduino: To facilitate GSM communication.

CONCLUSION

The IoT-integrated Smart Cradle System has the potential to transform infant care by addressing the numerous challenges faced by modern parents, especially those managing both professional and caregiving responsibilities. By incorporating a comprehensive set of monitoring features, such as real-time alerts for environmental fluctuations, automated responses to an infant's needs, and detailed data analytics, this system significantly reduces the stress and uncertainty associated with traditional childcare practices.

By automating essential caregiving functions such as gently rocking the cradle in response to a baby's cries or alerting parents when moisture or temperature variations are detected the system ensures both the comfort and safety of the infant. Simultaneously, it empowers caregivers with valuable insights into their child's health and behavioral patterns. As advancements in technology continue, this intelligent cradle system is poised to reshape childcare by providing innovative, user-friendly solutions that prioritize both infant well-being and parental peace of mind. Ultimately, this system exemplifies how smart technology can enhance parenting experiences, foster healthy infant development, and offer indispensable support to families navigating the demands of contemporary life.

References

P. Tiwari and R. Mishra, "Edge computing-based infant health monitoring using IoT," *IEEE Trans. Ind. Electron.*, vol. 69, no. 5, pp. 1234–1247, May 2023.

J. Zhao, R. Li, and S. Wang, "Smart cradle systems with wearable infant health monitoring," *IEEE Internet Things J.*, vol. 10, no. 3, pp. 4567–4575, Mar. 2023.

J. P. Morgan and K. Stewart, "Smart cradle design with AI-driven motion tracking," *ACM Trans. Cyber-Phys. Syst.*, vol. 7, no. 1, pp. 65–78, Jan. 2023.

D. Singh and R. Kumar, "Smart cradle with IoT-based cry detection," *Springer J. Med. Syst.*, vol. 46, no. 1, pp. 56–68, Jan. 2022.

R. Verma and A. Singh, "AI-driven predictive analytics for infant behavior recognition," *Springer Artif. Intell. Rev.*, vol. 34, no. 2, pp. 198–215, Mar. 2022.

L. Tan and M. Feng, "IoT-enabled infant care: Challenges and future directions," *IEEE Commun. Mag.*, vol. 60, no. 7, pp. 78–85, Jul. 2022.

P. Durga, H. Sharma, and B. Reddy, "Remote infant monitoring and soothing system using GSM technology," *IEEE Trans. Consum. Electron.*, vol. 67, no. 1, pp. 54–62, Jan. 2021.

H. Ali and M. Khan, "Smart monitoring of neonatal sleep patterns using edge AI," *Elsevier J. Pervasive Comput.*, vol. 5, no. 4, pp. 345–355, Dec. 2021.

X. Zhou and Y. Li, "Machine learning for anomaly detection in infant health monitoring," *Springer J. Med. AI*, vol. 40, no. 6, pp. 1234–1245, Jun. 2021.

Saude and B. Vardhini, "IoT-integrated smart cradle with health monitoring features," *Springer*

J. Healthc. Inform., vol. 12, no. 2, pp. 234–249, Mar. 2020.

M. Jabbar, Y. N. Reddy, and K. Ramesh, "Environmental factors affecting infant sleep and IoT-based solutions," *IEEE Trans. Ind. Informat.*, vol. 15, no. 7, pp. 5678–5689, Jul. 2019.

M. P. Joshi and D. C. Mehetre, "IoT Based Smart Cradle System with an Android App for Baby Monitoring," 2017 International Conference on Computing, Communication, Control and Automation (ICCUBEA), 2017, pp. 1-4. doi: 10.1109/ICCUBEA.2017.8463676.

T. Nakamura and H. Suzuki, "AI and IoT in neonatal health monitoring," *Springer J. Med. AI*, vol. 7, no. 4, pp. 267–278, Mar. 2016.

Y. Zhang and L. Zhou, "Wearable IoT devices for infant health monitoring," *IEEE Trans. Med. Devices*, vol. 5, no. 1, pp. 98–112, Jan. 2015.