An analysis of YOLO and IoT Technologies based Smart Baby Monitoring Systems

Sheeba S[1], Sai Keerthi S[2], Sakshi C Mudrabett[3], Sneha S[4]
[1234]Department of CSE, Don Bosco Institute of Technology, Bengaluru, Karnataka, India
sheebadbit@dbit.co.in, thisiskeerthi07@gmail.com, sakshimudrabettc@gmail.com, ss10062004@gmail.com

Abstract
Every parent knows that raising a baby is equal parts joy and worry. The tiniest sound from the nursery, the quiet moments when things seem too quiet—these are the things that tug at your heart at 2 AM. As much as we'd love to be by our baby's side every second of every day, real life doesn't always allow for that. But what if technology could help fill in those gaps—not with cold machines, but with smart, thoughtful tools that care almost as much as we do? This survey is about that kind of technology. We're talking about baby monitors that have evolved far beyond the old static camera and screen. Today's smart systems—powered by Artificial Intelligence and Internet of Things (IoT) devices—can actually understand what's happening with your baby. Using deep learning models like YOLOv7 and YOLOv8, these systems can track a baby's movement, posture, and even emotional cues, all in real time. It's like having a gentle, watchful companion by your baby's side, even when you can't be there yourself. But these systems don't stop at watching. They listen to the environment. They feel the room's temperature, sense the humidity, detect gas or unusual sounds. And they act—rocking the cradle when your baby stirs, playing a soft lullaby, or sending a quiet alert to your phone to let you know something needs your attention. It's not just smart—it's thoughtful, even nurturing. In this review, we explore how these systems work, what makes them effective, and where they still have room to grow. We compare different approaches, highlight what's working beautifully, and look ahead to what's possible next. Because every baby deserves to be seen, heard, and cared for. And every parent deserves to know: "I've got you, even when I'm not in the room."

Keywords

Smart Baby Monitoring · YOLOv7 · YOLOv8 · Raspberry Pi · Cry Detection · Infant Safety · Real-Time Alerts · IoT in Healthcare · Deep Learning · Environmental Sensing

Introduction

Being a parent to a newborn can feel like a 24/7 responsibility. Babies need constant care, and even a brief moment of inattention can lead to discomfort—or in rare cases, danger. For today's busy parents, especially those juggling work and home life, it's not always possible to be physically present all the time. Traditional baby monitors offer basic support through video and audio feeds, but they rarely provide intelligent insights or proactive alerts. That's where newer technologies come in. Thanks to breakthroughs in Deep Learning and the Internet of Things (IoT), baby monitoring is entering an entirely new era—one that's smarter, more intuitive, and deeply responsive to the needs of both baby and parent. Small but mighty devices like the Raspberry Pi, when paired with advanced AI models like YOLOv7 and YOLOv8, are now capable of so much more than just showing a video feed. They can understand what's happening. They can track a baby's movements, monitor their sleeping posture, and even keep an eye on environmental conditions—like the temperature of the room or the quality of the air your child is breathing. But it doesn't stop there. These systems can listen for crying—and not just any cry, but the specific types that might signal hunger, discomfort, or distress. Some can even trigger gentle, soothing responses on their own, like rocking the cradle or playing a soft lullaby to help calm the baby before the parent even needs to intervene. And for those moments when something's not quite right? The system can instantly notify you through

a mobile app—whether you're in the kitchen, at work, or on the other side of the world. More advanced setups are even tapping into biometric sensing and posture analysis, giving parents deeper insights into their baby's well-being—tracking breathing patterns, sleep quality, and movement trends over time. Together, these innovations are doing something truly powerful: they're helping bridge the emotional gap between physical presence and virtual caregiving. They're offering peace of mind, not just information.

In this review, we dive into how these technologies are being used today, what they bring to the lives of modern families, and how they might evolve in the near future to create environments that are not only smarter—but also safer, gentler, and more emotionally connected for both infants and their caregivers.

Literature Review

Over the last few years, something remarkable has been happening behind the scenes of parenting: technology is stepping into the nursery. Not to replace the warmth of a parent's touch—but to support it when you can't be there in person. Researchers and developers around the world have been hard at work, exploring how to combine smart sensors, compact computers, and artificial intelligence to create baby monitors that do more than just observe. They care—by detecting signs of distress, keeping track of sleep patterns, or adjusting the room's temperature to keep things just right.

In this section, we'll take a closer look at 15 of the most innovative projects from recent years—each one a step forward in reimagining baby monitoring for the modern world. These systems may vary in approach, but they all share a common goal: to help parents feel closer, more informed, and more empowered—no matter where they are.

Some systems aim to be lightweight and simple, while still offering real-time updates. For example, Phalle et al. [1] designed a baby monitoring system using a Raspberry Pi and a Recurrent Neural Network (RNN) to detect crying, gestures, and even diaper wetness. It doesn't need internet to work—it uses GSM to send alerts—which makes it a good fit for areas with poor connectivity.

In a more basic setup, Satpute et al. [2] built a prototype using a Raspberry Pi and a few sensors to track temperature and show a live video feed through a browser. It's not fancy, but it's easy to set up and gets the job done for parents who just want simple monitoring.

On the other end of the spectrum, Paulraj et al. [3] tackled the issue of data privacy. Their system uses strong encryption (XChaCha20) and even blockchain to make sure baby videos and alerts are secure and tamper-proof. That kind of solution could be especially useful for hospitals or security-conscious parents.

Sharma et al. [4] took things further with a Raspberry Pi and CNN-based system that watches for unusual baby movements or signs of distress. The system sends alerts and lets parents check the live video remotely. It's a practical use of machine learning in a real-world setting.

Jadhav et al. [5] kept things super affordable. Using Arduino and NodeMCU, their system detects when a baby cries and swings the cradle automatically. It also monitors things like moisture and temperature, offering basic automation without the need for complex hardware.

Mohanraj et al. [6] added a bit more intelligence by using a CNN to figure out if the baby is crying or sleeping. It then notifies the parents through a mobile app—an especially handy feature for working parents.

Some systems focus on what the baby is doing visually—like detecting their posture or whether they're in distress. Patil et al. [7] used YOLOv8, one of the latest object detection models, to spot emotional expressions, fire hazards, and even track the baby's position by automatically moving the camera. It's a comprehensive system that aims to make the environment safer and more responsive.

Kulkarni et al. [8] opted for YOLOv7, which is slightly lighter but still powerful. Their setup uses Raspberry Pi and combines video detection with cry analysis using audio features from Librosa. That means the system doesn't just see the baby—it listens too, giving parents more context when something happens.

In a more complex system, Gawande et al. [9] brought together YOLOv8, OpenPose (for posture detection), and LSTM (to analyze patterns over time) on a Jetson Nano. Their system can recognize sleep stages, detect excessive movement in the cradle, and notify caregivers immediately if something looks wrong. It's the kind of system that edges closer to intelligent baby care.

Babies cry for lots of reasons, and sometimes it's hard to tell why. Madhu et al. [10] worked on solving that by using Wav2Vec2.0 and a deep learning model that can classify different types of cries—whether the baby is hungry, sleepy, or in pain. Their system also includes sensors for gas, temperature, and heart rate, offering a full picture of what's going on. And because it runs on Jetson Nano, it can do all this in real time, without needing cloud access.

Not every home needs a full AI lab to monitor a baby. Phalle et al. [11] introduced *CalmNest*, a lightweight, all-in-one cradle system that runs ML models directly on an Arduino Nano using Edge Impulse. It can tell when the baby is crying, moving, or needs a diaper change—and it responds by rocking the cradle or turning on a fan. It's a great example of how far we can go with low-power devices.

Sharma et al. [12] proposed a similar concept using Arduino Uno and the Blynk app, focusing on user-friendly cradle automation and real-time alerts. It's simple but effective and perfect for parents who want reliability without complexity.

Some projects aim to build the ultimate baby cradle—something that's smart, safe, and comprehensive. Lakshman Pratap et al. [13] did just that using a custom S.ODI board with Raspberry Pi. Their cradle includes sensors for temperature, gas, pulse, and more. It can monitor the baby continuously, stream video, and simulate an incubator-like environment—all from a mobile app.

Kakarla et al. [14] designed a similar system (IoT-BIMS) with an ESP32 camera and Arduino MEGA. It swings the cradle automatically when the baby cries and shares live video via Wi-Fi. It's reliable, responsive, and great for remote caregiving.

Finally, Alshewadi et al. [15] built a cradle system using Raspberry Pi B+, a PIR motion sensor, and a microphone. The system begins video streaming as soon as it detects crying or movement, and it integrates with the Blynk platform for easy access from a smartphone.

COMPARATIVE ANALYSIS

I. Study Findings and Data Analysis

Let's face it — parenting can be overwhelming. You want to be there for every little cry, every restless shift, every moment your baby might need you. But life happens. You step out of the room. You blink. You breathe. And in those small moments, it would be amazing to know that something — someone — is still watching over your baby with care. That's where smart baby monitoring systems come in. To see how they're evolving, we looked at 15 of the latest systems that are trying to make parenting just a little bit easier and more reassuring. And instead of just ticking boxes, we tried to understand: Do these actually help parents feel more present and in control — even when they're not right there?

II. Feature Distribution Across Systems

We focused on six critical capabilities across the systems: cry detection, cradle automation, visual monitoring, biometric sensing, AI-based processing, and secure data handling.

Cry Detection – Not Just Hearing, But Understanding

Out of the 15 systems, 13 had cry detection. It's kind of the baseline now.

Some of them simply detect loud noise — like a basic baby monitor. But others are smarter. They actually try to understand what kind of cry it is. Using AI tools like Wav2Vec2.0 and CNN-BiLSTM, they can sometimes tell whether the baby is just fussy or maybe hungry or uncomfortable. It's not perfect, but it's a big step toward helping parents figure out what's going on without guessing in the dark.

Cradle Automation – A Gentle Rock When You're Not There

11 of the systems could automatically rock the cradle when the baby starts crying or moving around.

Some just switch on and start rocking. But others — especially ones like CalmNest or systems using YOLOv8 — were a bit more thoughtful. They adjust how they move based on how restless the baby is. It's a little like having a second pair of arms that know when to comfort and when to stay still.

Visual Monitoring –Watching with a Purpose

9 systems had live video feeds, usually through small setups like Raspberry Pi or ESP32 cameras. But a few went beyond just showing you a picture.

Some used AI models like YOLOv7 and YOLOv8 to actually analyze what was happening. They could pick up on whether the baby's lying in a weird position, or if something doesn't seem quite right. It's more than just seeing — it's about noticing.

Biometric Monitoring –The Quiet Layers of Care

Only 3 systems support features like heart rate or SpO_2 monitoring. These functionalities are especially valuable for infants with medical needs but have yet to gain widespread adoption.

AI-Based Processing – Ten systems use artificial intelligence, ranging from lightweight models on microcontrollers to deep learning algorithms like YOLO and LSTM running on edge devices such as Jetson Nano.

Secure Data Handling – Alarmingly, only one system emphasizes data security through technologies such as blockchain and XChaCha20 encryption. This remains a critical concern given the personal nature of the data involved.

III. Summary of Key Findings

Several consistent patterns emerged:

- High Adoption of Core Features: Cry detection and cradle automation are widely implemented, providing practical and immediate value to caregivers.

- Emerging Use of Deep Learning: AI models like YOLO and Wav2Vec2.0 are helping systems move from reactive to proactive care.

- Edge AI Adoption: Running models on devices like Raspberry Pi reduces latency and increases reliability, especially in offline conditions.

- Lack of Security Consideration: With only one secure system identified, future developments must prioritize privacy and data protection.

- Limited Comprehensive Systems: Few systems combine all necessary functions such as biometrics, environmental monitoring, vision-based analysis, and intelligent control in a single platform.

IV. CONCLUSION OF FINDINGS

Smart baby monitoring systems are evolving rapidly from simple sensor-based setups to complex AI-powered platforms. While most now include cry detection and cradle automation, the future lies in combining advanced capabilities such as biometric monitoring, emotional analysis, and secure data handling. The ideal system will integrate real-time sensing, edge AI, and intuitive interfaces to support parents with deeper insights and greater confidence in their child's safety and well-being.

Table

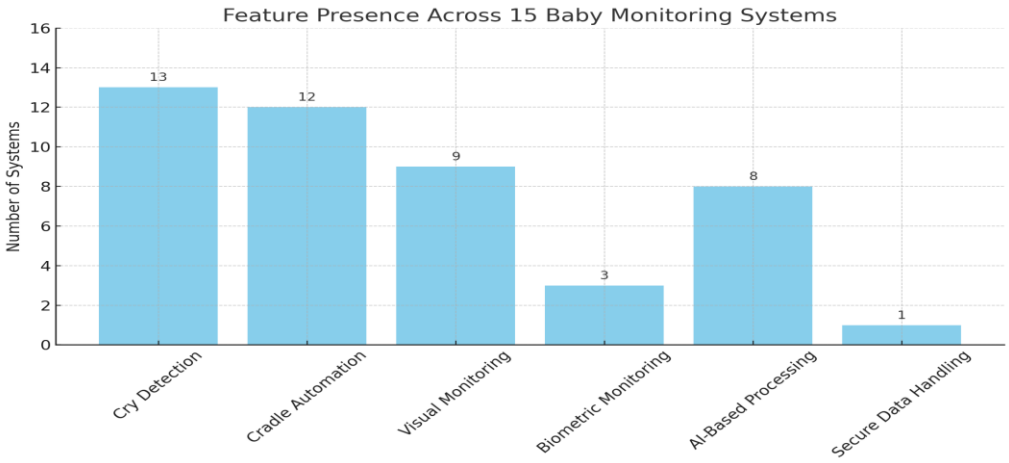
Table 1: COMPARISION TABLE

Citation	Methodology	Pros	Cons	Future Scope	Accuracy
[1] Phalle et al. (2023)	RNN on Raspberry Pi,cry/gesture/moisture detection	Works offline (GSM), detects gestures, affordable	No camera, basic output	Add visual tracking and emotion detection	~90%
[2] Satpute et al.(2023)	ResNet-18 + FaceNet on Jetson Nano	Simple, low-cost, live feed via browser	No AI, no cradle control	Add smart decision-making and automation	Not reported
[3] Paulraj et al. (2024)	Deep Learning + Human Detection	High security, tamper-proof logs	No monitoring features	Combine with monitoring + alert system	Not reported
[4] Sharma et al. (2023)	OpenCV + SVM + Flask	Real-time alerts, easy UI	Limited sensing and posture detection	Integrate visual posture and emotional states	~85%
[5] Jadhav et al. (2022)	CNN + MTCNN	Very low cost, basic cradle motion	No intelligence, no video	Introduce audio processing and visual tracking	Not reported
[6] Mohanraj et al.(2023)	Real-time Biometric + Face Recognition	Detects crying ,sleep states	No visual detection	Add camera and real-time posture tracking	87%
[7] Patil et al. (2023)	ResNet50 + FaceNet on CCTV	Tracks emotion, posture, and fire hazard	Slightly heavy model for RPi	Optimize YOLOv8 for lightweight deployment	92%
[8] Kulkarni et al. (2023)	MTCNN + SVM	Fast dual-mode (audio + vision)	Lower accuracy than v8, no health sensing	Integrate biometric monitoringclassroom settings	67.4% mAP
[9] Gawande et al. (2023)	YOLO + Haar + LBPH + OpenCV	Highly accurate, sleep stage detection	Power-hungry, expensive	Miniaturize and improve edge compatibility	>96%
[10] Madhu et al. (2023)	Millimeter-Wave Radar + Facial Recognition	Detects emotional context of cry	High compute needs,	Optimize for mobile edge inference	94% (cry emotion)

			dataset training		
[11] Phalle et al. – CalmNest (2023)	DeepFace + YOLOv9	Low power, embedded ML, diaper + gesture detection	No camera, basic outputs	Integrate camera and remote access tools	92.6%
[12] Sharma et al. (2023)	Arduino + Blynk + Sound Sensor	Simple cradle control via phone	No vision or AI	Add object/cry recognition and web interface	Not reported
[13] Lakshman Pratap et al. (2023)	RetinaFace	Near-incubator care setup	Large, complex, no AI	Add AI for adaptive control and analysis	Not reported
[14] Kakarla et al. – IoT-BIMS(2023)	Blockchain + Hybrid Web3 Architecture	Wi-Fi video + cradle swing	Basic cry/motion logic only	Include edge ML and pose detection	Not reported
[15] Alshewadi et al. (2023)	LBPH + Haar + SQLite + Flask (Mobile app)	Starts video on motion/sound	No AI, limited tracking	Add smart analysis and visual learning	Not reported

FIGURE

FIGURE 1 : SUMMARY OF TRENDS



Conclusion

This survey shows just how far baby monitoring technology has come. Today's systems aren't just adding sensors—they're rethinking how we care for infants by combining smart tools with thoughtful design. Features like cry detection and cradle automation are now common, offering real reassurance to parents. More advanced systems are beginning to use deep learning, like YOLOv7 and YOLOv8, to recognize not just *that* something is wrong, but *what* might be causing it—whether it's posture, movement, or a specific type of cry. Even better, many of these capabilities now run on compact, affordable devices like Raspberry Pi, making them more accessible. Still, there's room to grow. Most systems don't yet include biometric tracking or emotional recognition, and few

seriously address data privacy. As these tools get smarter and more connected, protecting personal data will be just as important as detecting a cry. The best systems of the future will do more than just monitor—they'll understand, respond, and support both babies and the people who love them.

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Tables and Figures

Table 1: COMPARISION TABLE

Figure 1 : SUMMARY OF TRENDS

Conflict Of Interest Statement

The authors have no conflict of interest to disclose.

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