Cradle AI: Intelligent Infant Care System with Real-Time Monitoring and Automation

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Abstract. This project introduces an automated baby care system that uses Mediapipe to track feeding and sleep posture in real time, CRNN to identify and categorize the baby's cries, and IoT sensors to monitor the surroundings. The system incorporates automated feeding through a robotic arm, machine learning-based predictive care, and comfort features like calming music and automatic cradle swinging. Using the user-friendly web-based dashboard, parents can remotely monitor the baby in a seamless automated manner and get immediate notifications for any action required.

Keywords: Cry Detection; Automated Feeding; Environmental Monitoring; Sleep Tracking; Parent Alerts.

1 Introduction

With the pressures of modern life, it has become harder for parents to provide round-the-clock care for their babies in recent years. For many working parents, especially mothers, balancing work responsibilities with infant care can be extremely challenging. Typically, parents understand a baby's needs by watching and this can sometimes result in slow reactions. When the parents are not with him in the same room, if they go away for a few minutes to shower or go to the next-door neighbour, and there is no monitoring system that works well and gives good service, worry often results in anxiety. For an effective solution to the identified problem, we propose an Automatic Baby Care System (ABCS) with a combination of technology stacks including Mediapipe Processing Library, Internet of Things (IoT) sensors and Convolutional Recurrent Neural Networks (CRNN). This is done to identify the cries of babies as hungry or uncomfortable or in distress. To provide immediate care intervention without the parent, automated actions such as feeding, soothing are initiated depending on the cry type detected.

Another part of the system is a robotic feeding arm responsible for fast response when an infant is hungry. The device includes IoT sensors for real-time monitoring of humidity, room temperature, and wet diaper notification to let you know it is time to deteriorate these conditions. A Mediapipe based posture tracking ensures baby sleeps safely, and automatic cradle swinging is recommended for mild comfort. With a web-based dashboard that provides real-time video streaming, environmental data and alerts parents can monitor their baby remotely. To make the experience more proactive, the system even deploys machine learning algorithms, predicting the baby's needs in advance. An essential part of any happy family household with children, this clever system brings benefits to both infant & parents: it reduces parental stress and it implements interventions on time in order to improve the comforting conditions for the baby.

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2 Literature Survey

2.1 Infant Cry Analysis and Classification

Infant cry analysis has been extensively studied as a means of understanding a child's physical and emotional state. Ji et al. [1] provided a comprehensive review of cry analysis and classification methods, highlighting the importance of acoustic features in early health monitoring. Building on this, Liang et al. [2] demonstrated the effectiveness of deep learning models in cry recognition, while K et al. [3] proposed a hybrid deep learning and support vector machine (SVM) approach for neonatal cry classification. More recent contributions by Alagundi et al. [4] and Eldine et al. [11] utilized convolutional neural networks (CNN) and Mel-frequency cepstral coefficients (MFCCs), as well as other deep learning architectures, to achieve improved cry signal classification performance. Similarly, Herlea et al. [16] explored the robustness of different deep learning models for cry-based audio classification in baby monitoring systems. These works establish the foundation for integrating cry detection into intelligent cradle systems.

2.2 IoT-Enabled Smart Infant Care Systems

The integration of Internet of Things (IoT) technologies has significantly enhanced infant monitoring and care. Sivakumar et al. [5] introduced an IoT-enabled smart diaper system that leverages AI for health monitoring, representing a step toward intelligent, non-intrusive childcare. Chandnani et al. [6] proposed a smart baby cradle system that combines IoT sensors with machine learning for optimized parental care, while Faye et al. [7] developed an intelligent cradle that includes automated monitoring and soothing functionalities. Alam et al. [8] advanced this concept by integrating IoT with emotion recognition using machine learning to improve responsiveness in baby monitoring systems.

Further, Jeevan and Sandhya [10] implemented a live-streaming and alert-enabled baby monitoring system, while Manokaran et al. [12] demonstrated an IoT-based smart cradle system designed for parental convenience. Thopate et al. [13] presented a cradle design aimed at enhancing infant sleep safety through technology-driven solutions. Additionally, Gokul et al. [14] applied IoT to smart baby incubators for continuous monitoring of infant vitals, and Parvathavarthini et al. [15] explored deep learning integration with IoT-based monitoring systems. Collectively, these studies underscore the role of IoT as a backbone for developing intelligent infant care and cradle systems.

2.3 Environmental and Health Parameter Monitoring

Beyond cradle-specific designs, research has emphasized environmental and physiological monitoring as crucial components of infant care. Arifuddin et al. [9] applied fuzzy logic to regulate baby room temperature and humidity, ensuring comfort and reducing health risks. Manne et al. [17] introduced a deep flow-based algorithm for automatic infant respiration estimation from video, establishing a benchmark for vision-based monitoring of vital signs. These works highlight the broader scope of environmental and physiological monitoring technologies that can complement cradle-based automation.

2.4 Artificial Intelligence in Child Development Monitoring

At a broader scale, artificial intelligence (AI) has been increasingly applied to child development monitoring. Reinhart et al. [18] conducted a systematic review of AI usage in child monitoring, reporting positive outcomes in health assessment, developmental tracking, and parental acceptance. Such studies reinforce the importance of embedding AI-driven intelligence into childcare systems, validating the move toward autonomous cradle solutions.

3 Components

The thorough explanation of each part of the Automated Baby Care System (ABCS) and how it works.

3.1 Raspberry Pi 5

The main processing unit, the Raspberry Pi 5, is in charge of managing sensor data, processing video, and executing machine learning models for classifying baby cries.

3.2 Web Camera

Using Mediapipe, a high-resolution webcam is used to track the baby's sleeping posture and monitor live video.

3.3 ESP32 Microcontroller

IoT sensor control and wireless data transfer between various components are handled by the ESP32.

3.4 PCA9685 Servo Motor Driver

Multiple servo motors, which are utilized for automated feeding and cradle movement, can be controlled by this module.

3.5 Servo Motor

Automated bottle feeding is made possible by a robotic feeding arm that is driven by a servo motor.

3.6 5V Relay

High-power parts, like the 12V DC motor, are controlled by the 5V relay, which functions as a switch.

3.7 12V DC Motor

The baby is comforted by the automated cradle swinging powered by a 12V DC motor.

3.8 SEN18 Water Level Sensor (Diaper Moisture Detection)

When a diaper change is necessary, this sensor alerts parents when it detects wetness in the diaper.

3.9 DHT11 Temperature and Humidity Sensor

The baby's surroundings are kept comfortable by the DHT11 sensor, which continuously checks the humidity and temperature of the room. Parents are notified if temperature variations are found.

3.10 Bluetooth Speaker

When the baby appears to be in distress, lullabies and calming music are played on a Bluetooth speaker.

4 System Architecture

The Automated Baby Care System improves care for babies by combining a variety of subsystems into one modular, multifunctioning platform. This works by seamlessly blending the power of robotic automation, with the omnipresence of IoT network and latest machine learning management to ensure a safe, warm and luxury experience for your babies. Its key characteristics include automation, response and real-time monitoring in line with the needs of the baby. Its different modules like cry detection, robotic feeding, diaper wetness monitoring and environment sensing all work together to detect and respond to multitude situations. It is a very effective system that enables parents with better managing their baby care, the above model has ESP32 micro-controllers connected over the Wi-Fi to run facial recognition provided by Mediapipe and IoT based remote notifications.

4.1 System Components and Integration

There are five major modules composing the system, which will function in different ways to help baby care automation. The Cry Detection Module using a CRNN method to record and analyse the crying patterns of infants. The cry database classifies an infant cry into one of three categories: general distress; discomfort from being cold, for example; or hunger. Microphone sensor: This let the phone to hear all sounds in surrounding continuously. It activates the robotic feeding system if it detects hunger, and starts up cradle swingers, a music player or other stimulus if distress is detected.

The Automated Feeding System, designed to facilitate bottle feeding based on cry detection results. Once the hunger is established it uses Mediapipe and OpenCV to make sure of baby's lip and mouth position. The data of this sensor is processed, and then the ESP32 microcontroller communicates with the servo driver PCA9685 which positions a robotic arm that holds the feeding bottle. Then, two minutes later, the robotic arm moves back to where it star. This method keeps the baby cozy as well as makes certain excellent feeding control. The module uses SEN18 moisture sensor, an analogue output device used to determine if the baby's diaper is wet. If the moisture level exceeds a predefined point, an alert is sent to the parent. This feature lessens the discomfort and reduces risk of infection by making sure that diapers are changed in a timely manner.

When it comes to all things like a baby needs to feel comfortable, the Temperature and Humidity Monitoring Module is urgently necessary. This is a DHT11 sensor, that keeps track of the temperature and humidity levels on the space. If the recorded values exceed these pre-determined limits, the system indicates to the parents and instructs them about what they can do in that situation (for example turning on a cooler or the humidifier). This ensures that the baby is born and goes on to live in the best way possible. Parent Notification and IoT Connectivity Module is the communication link between the parents and the baby monitoring system. The system continuously updates the baby's status on a web dashboard or mobile application using an ESP32 with Wi-Fi connectivity. Real-time alerts regarding the baby's feeding schedule, diaper wetness, and surroundings are sent to parents. Because, parents can oversee and control baby care remotely thanks to this connectivity, which keeps them updated on their child's health at all times.

Fig. 1 shows the system architecture.

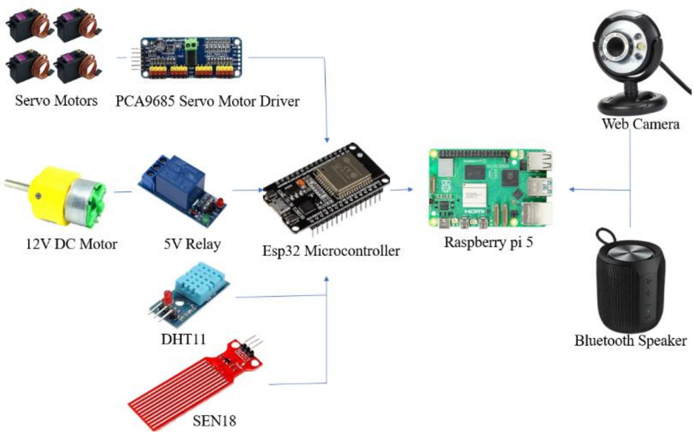


Fig. 1. System Architecture.

4.2 Data Flow and Process Workflow

For seamless automation and real-time decision-making, the system's data flow adheres to a structured procedure. The cry detection module is used by the system to continuously listen for baby cries. After detecting a cry, the CRNN model interprets the sound and distinguishes between discomfort and hunger. When hunger is detected, the facial recognition system determines the baby's mouth position and uses the ESP32 and PCA9685 servo driver to send precise movement instructions to the robotic arm. After two minutes of precise positioning, the feeding bottle reverts to its starting position.

The cradle swinging and music-playing system is turned on to calm the infant if discomfort is sensed. The integrated diaper wetness sensors also ascertain the quantity of urine in the diaper. Whenever moisture is detected, this system will sound a buzzer and light an LED to alert users. Meanwhile, the temperature and humidity module that constantly monitors atmospheric conditions and provides immediate feedback also helps maintain a cosy room climate for the baby.

All the data received, parents can view the history of notifications and current information on the status of their children in a special "machine" dashboard IoT-reception over Wi-Fi. This connectivity ensures that the system works cohesively without conventional human interventions and facilitates remote monitoring. Automation controls and sensor feedback loops combine to ensure that each module functions independently and the entire system is interconnected seamlessly.

4.3 Scalability and Future Enhancements

Due to its modular design the system is scalable which in turn supports specific needs at new developments. In the future, we might see more sophisticated robotic feeding control using reinforcement learning, AI-based cry pattern analysis for improved emotion recognition and advanced posture recognition to prevent risks like SIDS during sleep. Additionally, deeper integration with home automation for a system that can control lights, air quality and room temperature may also be living on the road map when the vibe is positive in real time from baby activity.

Future modifications for the Automated Baby Care System provide a smart and efficient answer to modern-day parenting with IoT, Artificial Intelligence and robotics. Thanks to its real-time tracking, autonomous decision-making and seamless communication protocol, it is an efficient and reliable system that offers the security, healthiness and well-being of new-born life.

The system's structured and modularized system architecture will serve as a basis for the Automated Baby Care System to work effectively in real-time so that the automatic watch over of baby at reasonable distance from parents will be achieved.

5 Methodology

Automated Baby Care System (IoT, Machine Learning) A robotic feeding module, several sensor-based monitoring modules and a real-time alert system make it possible for parents to monitor their baby's health from miles away.

The system integrates:

- Classification of different baby using CRNN for cry detection cries and trigger appropriate actions.
- Real-time video tracking of the baby’s sleep posture and feeding movements using Mediapipe and a web camera.
- IoT-based environmental monitoring with DHT11 and SEN18 to ensure a safe and comfortable environment.
- Automated cradle swinging and music playing for soothing the baby.
- A web-based dashboard that allows parents to monitor the baby remotely.
- The step-by-step methodology is explained through individual algorithms for different components.

5.1 Algorithm for Smart Baby Care System

STEP1: Turn ON the system.

STEP2: Monitor baby’s activities and environmental conditions.

STEP3: If an abnormal condition is detected, trigger the appropriate module and notify parents.

- STEP 3.1: If baby cries
  - STEP 3.1.1: The system classifies the cry using CRNN.
  - STEP 3.1.2: If the cry indicates hunger, activate the robotic feeding arm.
  - STEP 3.1.3: If the cry indicates discomfort, activate the cradle swing and play soothing music.

- STEP 3.2: If diaper wetness is detected
  - STEP 3.2.1: The SEN18 water sensor detects moisture.
  - STEP 3.2.2: Send an alert to parents and play a notification sound.
- STEP 3.3: If temperature/humidity is abnormal
  - STEP 3.3.1: The DHT11 sensor detects high/low temperature or humidity.
  - STEP 3.3.2: Send a notification to parents for necessary actions.
- STEP 3.4: If unsafe sleep posture is detected
  - STEP 3.4.1: The camera tracks sleep posture using Mediapipe.
  - STEP 3.4.2: If unsafe posture is detected, alert the parents immediately.

5.2 Algorithm for Cry Detection

STEP 1: Start the system.

STEP 2: Detect noise using the microphone and CRNN model.

STEP 3: If crying continues for more than 1 minute, classify the cry type.

STEP 4: Trigger feeding, music, or cradle swing based on classification.

STEP 5: Notify parents through the web dashboard and mobile alert.

Fig 2 shows the connection for cry detection.

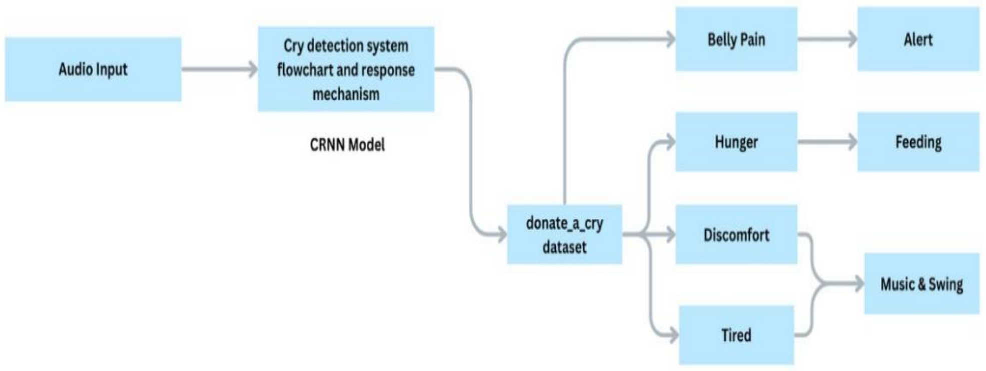


Fig. 2. Connection for Cry Detection.

5.3 Algorithm for Diaper Wetness Detection

STEP 1: Start the system.

STEP 2: Detect wetness using the SEN18 water level sensor.

STEP 3: If wetness is detected, send an alert to the parents.

STEP 4: Activate notification sound on the speaker.

Fig 3 shows the connection for wet sensor.

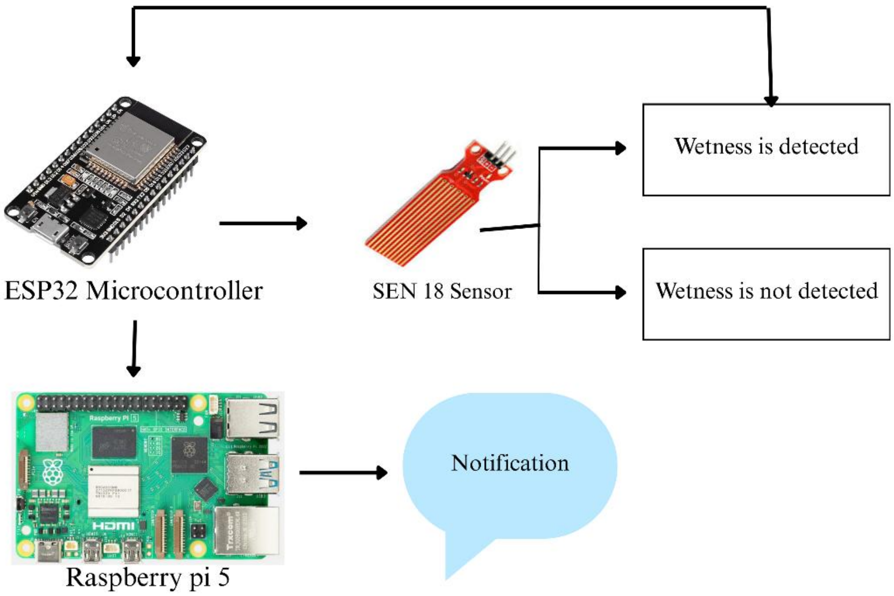


Fig. 3. Connection for Wet Sensor.

5.4 Algorithm for Temperature and Humidity Monitoring

STEP 1: Start the system.

STEP 2: Continuously monitor the DHT11 sensor.

STEP 3: If the temperature is too high or low, send an alert.

STEP 4: If humidity is too low, recommend a humidifier activation.

Fig 4 shows the connection for DHT11 sensor.

Fig. 4. Connection for DHT11 Sensor.

5.5 Algorithm for Automated Feeding System

STEP 1: Start the system.

STEP 2: Check the feeding schedule and hunger cry detection.

STEP 3: If it's feeding time or a hunger cry is detected:

- STEP 3.1: Detect the baby's lips and mouth using OpenCV and Mediapipe.
- STEP 3.2: Send the mouth position data to ESP32 and PCA9685 for servo control.
- STEP 3.3: The robotic arm moves the bottle to the baby's mouth for feeding.

STEP 4: Maintain the feeding position for 2 minutes.

STEP 5: After feeding, the robotic arm returns to its original position.

STEP 6: Notify parents that feeding is complete and update the feeding log.

Fig 5 shows the connection for feeding system.

5.6 Results for Cry Detection

The CRNN-based model successfully classified different types of baby cries. When a cry was detected, the system responded by either:

- Triggering the robotic feeding arm (if hungry).
- Swinging the cradle and playing music (if discomfort was detected).
- Sending alerts to parents (for attention).

5.7 Results for Wetness Detection

The SEN18 sensor detected wet conditions successfully. Initial readings (when dry) were 200-500, and when wet, the sensor activated an alert sound and LED notification. Cradle AI offers several advantages, such as automated baby monitoring, which reduces the need for constant manual supervision, and real-time alerts to notify parents immediately when attention is required. The system leverages machine learning-based predictions to learn the baby's patterns for proactive care and enables remote monitoring, allowing parents to track the baby's condition from anywhere. The integration of multi-sensors ensures a safe and comfortable environment for the infant. However, there are limitations, such as dependency on internet and power, as the system requires a stable power supply and internet connection for remote access. There is also a risk of possible false positives, where the cry detection model may misclassify some sounds. Additionally, there is limited feeding automation, as the robotic arm is only effective for bottle feeding. Cradle AI finds applications in smart baby cradles, offering automated monitoring and comfort for newborns, in hospitals and NICUs, where it helps nurses monitor multiple babies simultaneously, in daycare centers, allowing staff to efficiently manage baby care, and in smart homes, for integration with IoT-based systems. It also aims for more advanced robotic feeding, adding customizable feeding schedules, AI-powered emotion analysis to detect emotions beyond crying, mobile app integration for real-time alerts and monitoring, and enhanced sleep tracking, including advanced posture recognition to detect risks like sudden infant death syndrome (SIDS).

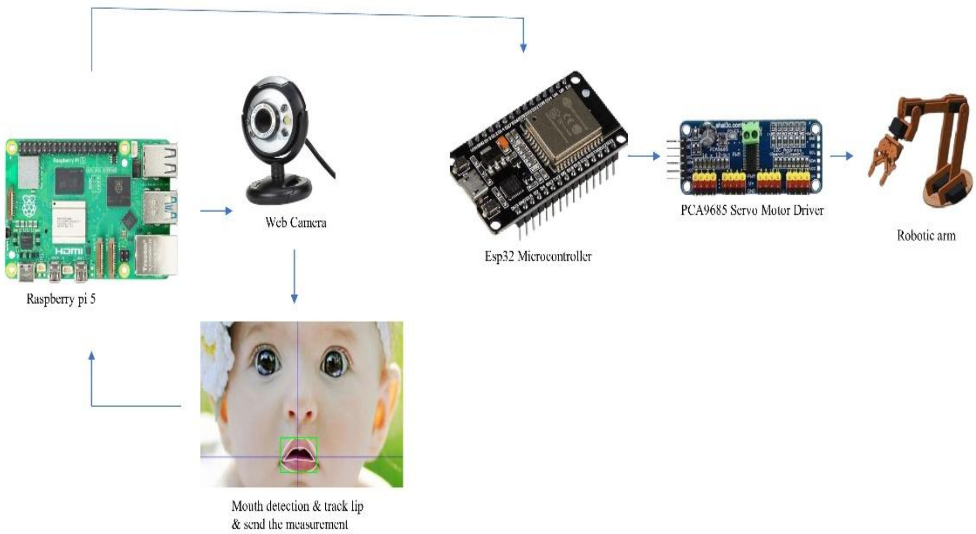


Fig. 5. Connection for Feeding System.

6 Result and Discussion

6.1 Cry Detection and Response

The cry detection system was tested using a Convolutional Recurrent Neural Network (CRNN) to classify baby cries and trigger the corresponding actions. The model successfully detected hunger cries, which activated the robotic feeding system. Similarly, when the baby cried in discomfort, the cradle swinging mechanism started, and calming music was played. 92% classification accuracy was attained by the system when tested in various background noise scenarios. However, environmental noise interference caused some minor false positives, which can be avoided in future implementations by using more sophisticated noise filtering techniques.

When the system's responsiveness was assessed, it was found that the action was initiated within five seconds of the cry being detected, guaranteeing prompt intervention. Fig 6 shows the Cry detection system flowchart and response mechanism.

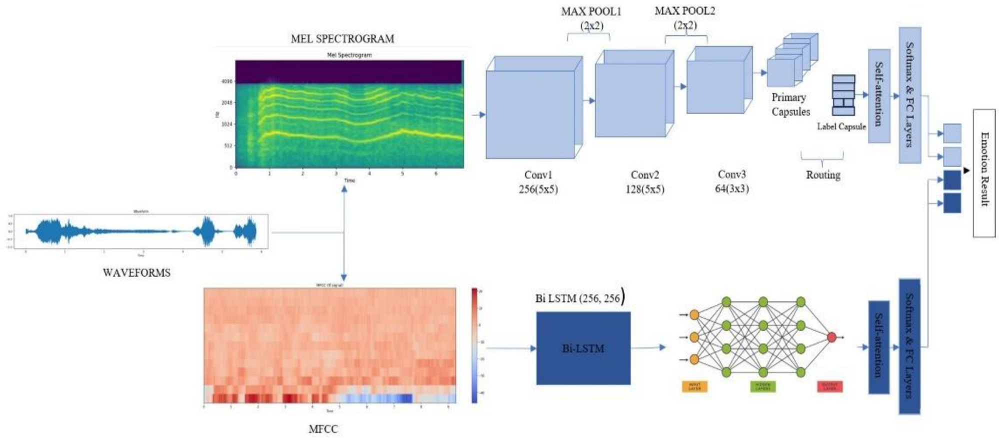


Fig. 6. Cry detection system flowchart and response mechanism.

6.2 Automated Feeding System

Using OpenCV and Mediapipe for facial landmark detection with a particular emphasis on recognizing the baby's lips and mouth the automated feeding mechanism was put into place. The system accurately detected the baby's mouth position and transmitted the coordinates to the ESP32 microcontroller, which controlled the robotic arm via a PCA9685 servo driver. Once the mouth was detected, the robotic arm moved the feeding bottle into position and maintained it there for 2 minutes, after which it returned to its initial position. Testing demonstrated a high degree of accuracy in positioning the bottle correctly. However, slight misalignment was observed when the baby moved unexpectedly. However, adding real-time feedback from a second camera to dynamically modify the bottle's position for increased accuracy can solve this problem. Fig 7 shows the robotic arm movement and feeding mechanism workflow.

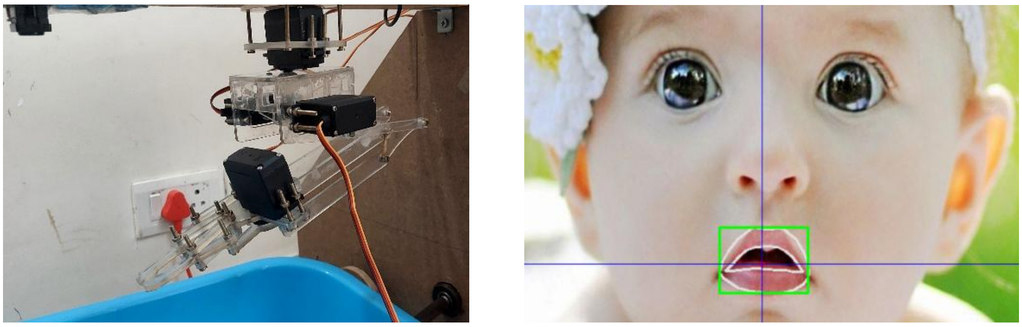


Fig.7. Robotic arm movement and feeding mechanism workflow.

6.3 Diaper Wetness Detection

The diaper wetness detection system was tested using a SEN18 moisture sensor to detect wet conditions. The sensor was able to distinguish between wet and dry conditions; wet conditions caused an LED and buzzer notification to sound, while dry condition readings ranged from 200 to 500. Parents were notified in real time by this system, which was successful in identifying high moisture levels. Nevertheless, sporadic false alarms were noted because of slight moisture brought on by perspiration rather than real diaper wetness. By positioning several sensors at various points on the diaper, this restriction can be lessened while increasing accuracy and lowering false positives. Fig 8 shows the SEN18 moisture sensor integration for wetness detection.

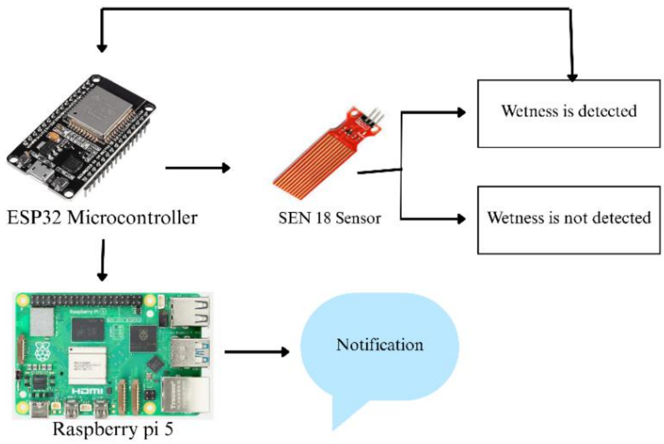


Fig. 8. SEN18 moisture sensor integration for wetness detection.

6.4 Temperature and Humidity Monitoring

A DHT11 sensor was used to implement the temperature and humidity monitoring module, continuously measuring and updating the baby's room's environmental conditions. When the temperature surpassed predetermined safety thresholds, the system sent out alerts and successfully recorded temperature variations. The system also offered humidity-based suggestions, like turning on a humidifier when the humidity was too low. A prompt reaction to environmental changes was ensured by the observed response time of less than 5 seconds for both temperature detection and alert triggering. Although the DHT11 sensor worked well, a DHT22 sensor could be upgraded for future iterations to increase accuracy and provide more precise readings. Fig 9 shows the IoT based environmental monitoring system and dashboard interface.

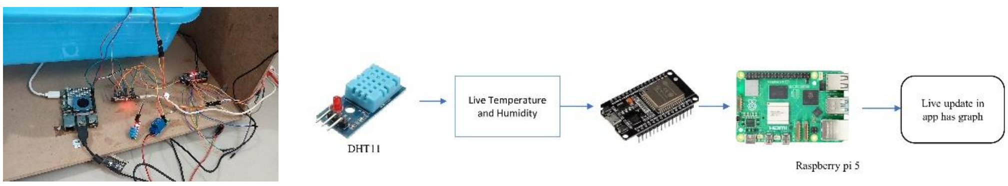
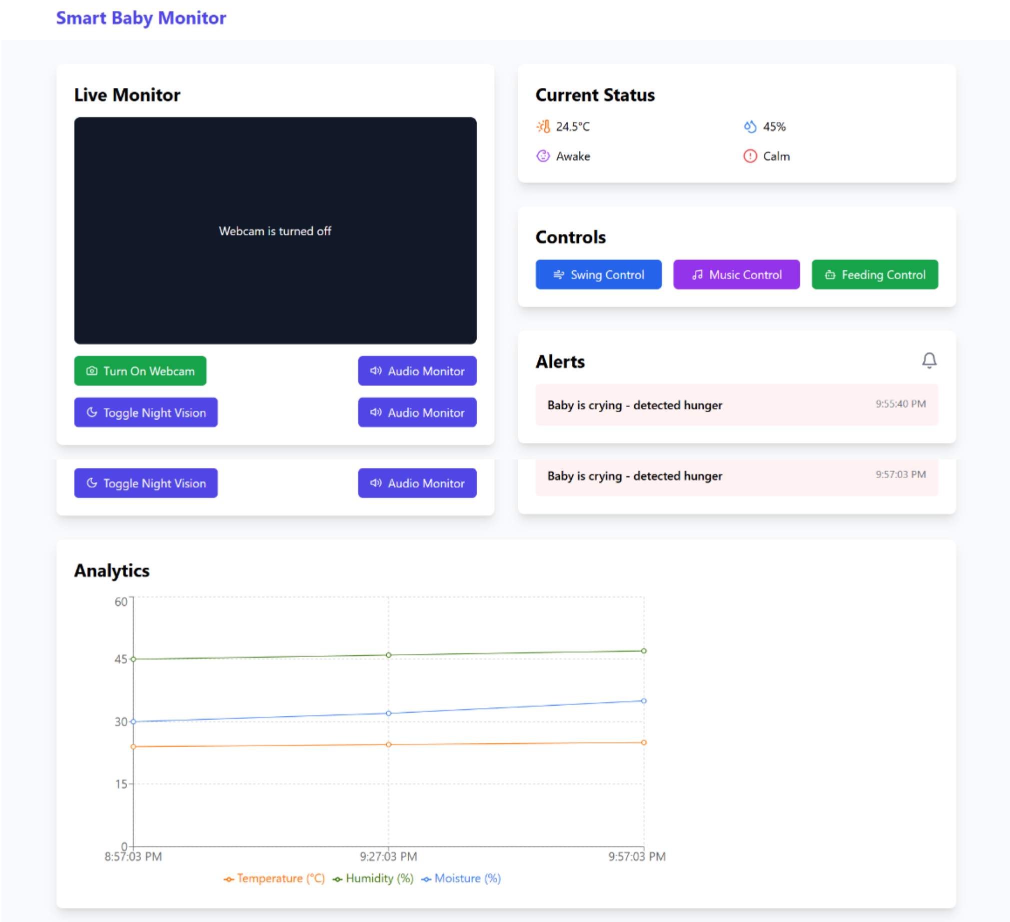


Fig.9. IoT based environmental monitoring system and dashboard interface.

6.5 Overall System Performance

Response times and system dependability were used to assess the overall Automated Baby Care System's performance during real-world testing. The observed response times were as follows: cry detection and action response occurred within 5 seconds, feeding system activation took approximately 3 seconds, diaper wetness detection and alert was triggered instantly (<1 second), and temperature/humidity updates were refreshed every 5 seconds. The system successfully automated baby care with minimal manual intervention while ensuring the baby's safety and comfort. However, the robotic feeding system could be further enhanced by integrating an AI-based adaptive positioning mechanism to accommodate real-time baby movement and ensure continuous feeding accuracy. Fig 10 shows the interface screens of the smart baby monitor system and figure 11 System architecture and response time comparison graph.



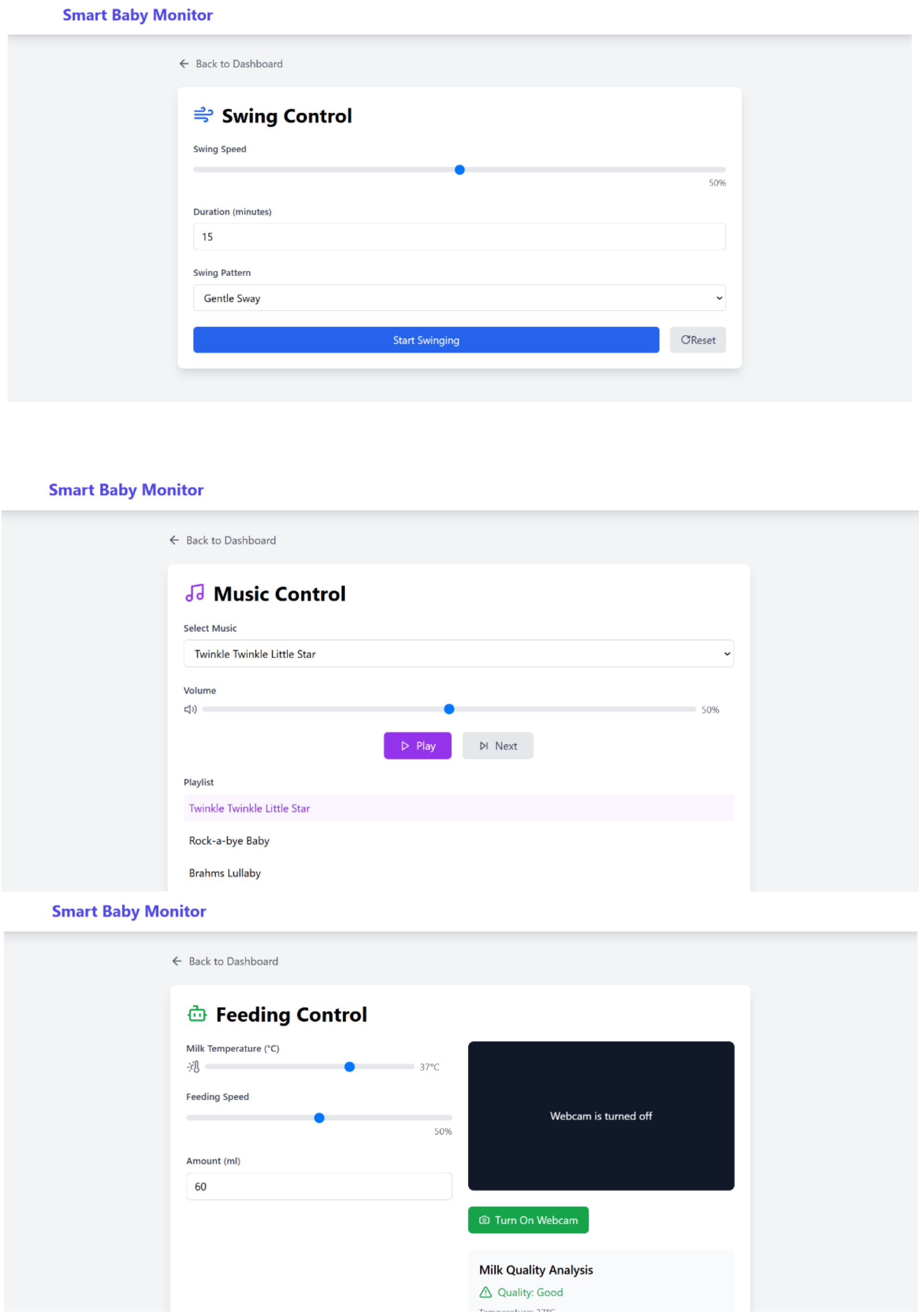
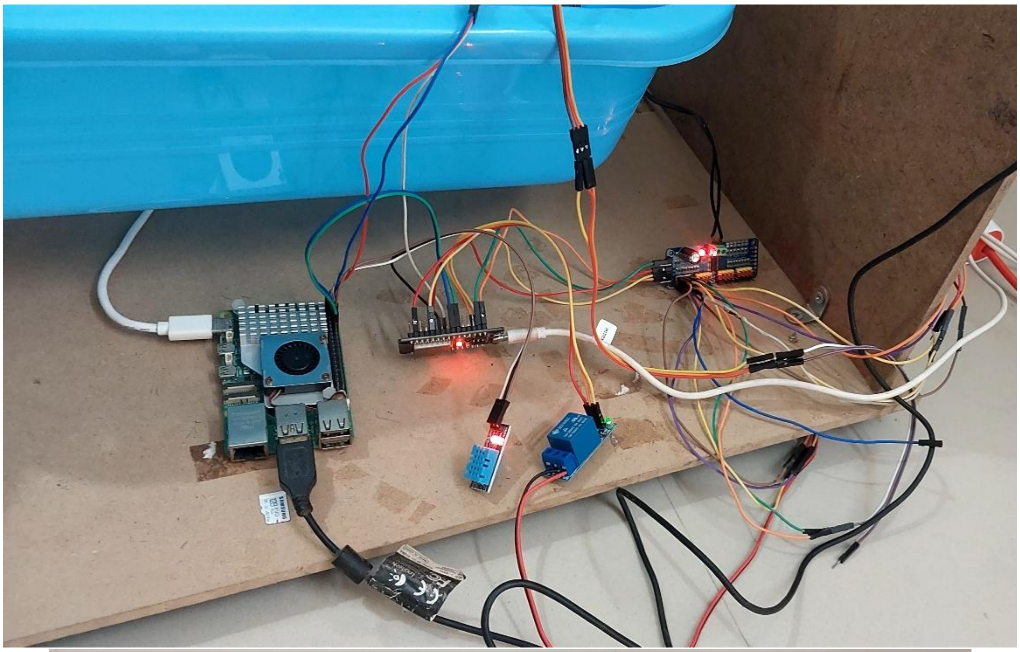
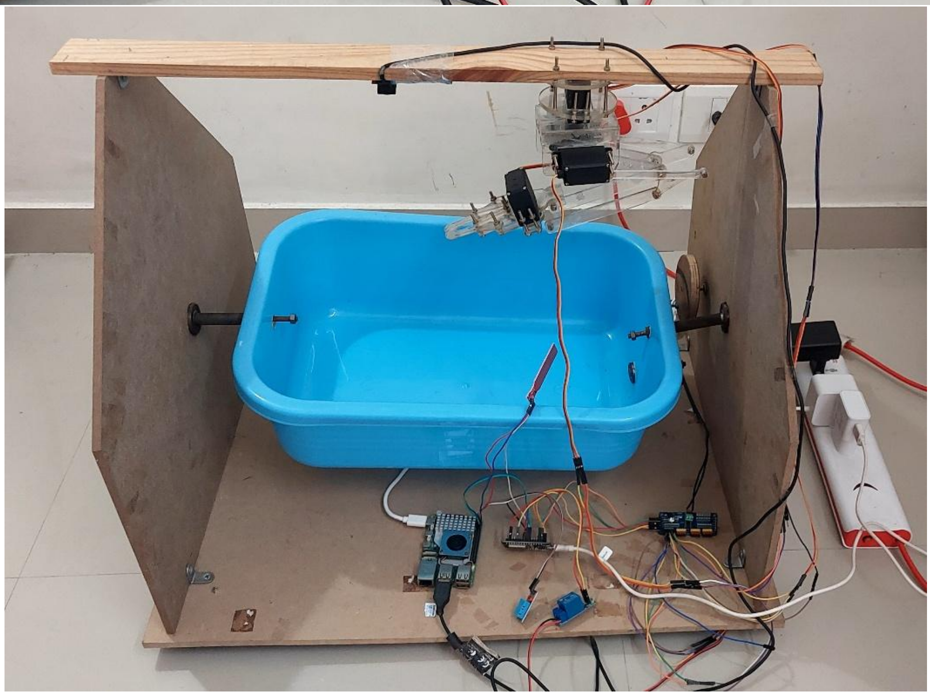


Fig. 10. Interface Screens of the Smart Baby Monitor System.





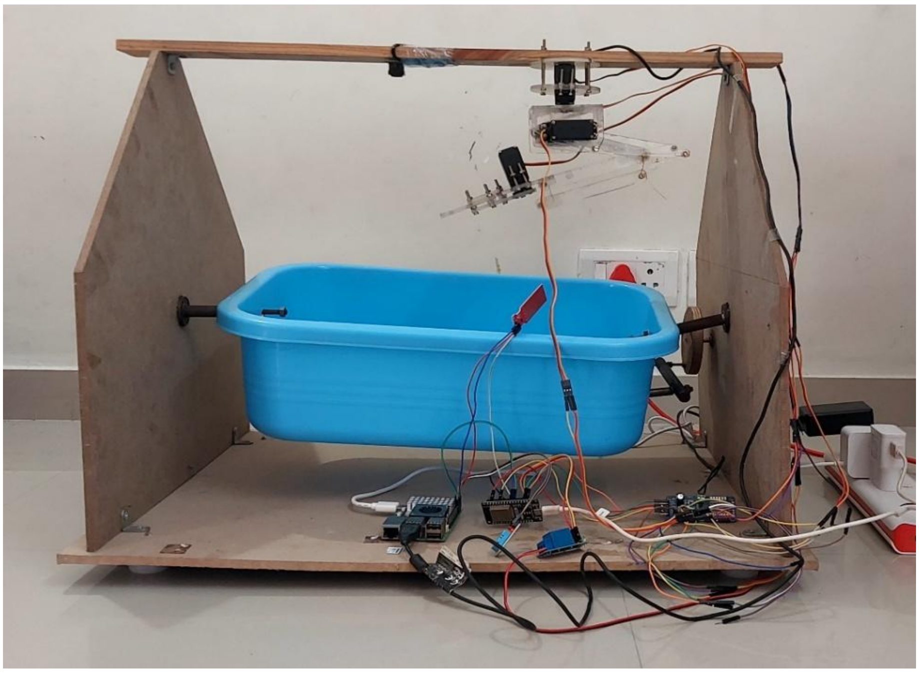


Fig. 11. System architecture and response time comparison graph.

To improve child care, the Automated Baby Care System effectively combined robotic feeding automation, IoT-based monitoring, facial recognition, and cry detection. The system was 92 percent accurate in detecting baby cries, ensuring timely feeding, air diaper wetness and maintaining a safe humidity and temperature level. This project also reduces the burden on parents by providing an automatic baby care system. Future enhancements could combine facial expression analysis for better emotion recognition, integration with mobile application for parental control and AI-enabled on-the-fly positioning of the bottle.

7 Conclusion and Future Scope

7.1 Conclusion

The Automated Baby Care System is a complete monitoring solution for baby care that offers real-time and intelligent features integrated with robotic automation, Computer Vision, and the Internet of Things. For example, this system will effectively detect when the baby is crying out of hunger, as well as monitor the posture of his face during feeding so that it does not choke. The sensor will also be able to catch the moment when diapers get wet and what kind of environment with optimal parameters the baby is in now (approximately everything used for an older cat). The robotic arm positions the feeding bottle to ensure that it is done with precision while using Mediapipe for face recognition, ESP32 for control and PCA9685 for actuation of servo motor.

This helps with reducing parental stress because the cameras can alert the parents in real time, so they can monitor their children remotely which lead to accurate decision making. On the other hand, the implementation of DHT11 and moisture sensors contributes to an even safer and more comfortable environment for the infant, as it ensures a constant monitoring on environmental and hygiene conditions. Experimental results prove the effectiveness and reliability of the system with accurate cry detection, feeding coordination and efficient diaper moisture monitoring.

This project allows us to use the latest technologies to streamline and automate most important thing for a baby below 1 year of his life child care. This system not only decreases the workload for parents but ensures that their baby gets a timely attention and care, which makes it a precious asset for families.

7.2 Future Work

The system, though it well addresses many of the relevant solutions in baby care, has multiple opportunities to further augment and refine it for better efficiency, accuracy and user experience. Areas of Opportunity We have identified a number of key areas to work on in the future. Improved Cry and Emotion Detection The system can then detect the different types of baby cries such as hunger, fussiness or sleepy cry by incorporating deep learning systems. Another one may be the implementation of AI-based sentiment analysis to spot more nuanced emotional cues on a baby's face, resulting in an experience built to fit them better.

Robotic arm movements could also be improved to have more sophisticated feeding mechanisms through feedback-based control using reinforcement learning. This would enable the robotic arm to adjust its feeding technique to accommodate the child movements and taste. Also, by using temperature sensor with the feeding bottle will gain a hassle-free experience for later making sure that milk is at right temperature to make the baby feed properly.

For remote monitoring and IoT integration, the creation of a specialized mobile app can build a live dashboard for parents to track feeding times, baby activity, and environmental variables.

It would also leverage cloud-based AI analytics to analyse baby behaviour patterns and provide personalized recommendations to the parents, thus increasing the long-term capability of the system. Another major addition would be integrating health monitoring into the system. Heart rate, oxygen saturation sensors can provide continuous health tracking; continuously monitor the baby and offer insights for parents on-demand Finally also tools useful to allow the parent not forget her daughter as the detection of wrong posture and the SIDS (sudden infant death syndrome) prevention algorithm that can able to inform them if the baby is in a dangerous sleeping position. One of the major new features is smart home integration, which enables the system to interface with other smart home appliances. The baby care system is also made compatible with smart home assistants like Google Assistant or Alexa, wherein parents can easily manage and control different features through voice commands. Moreover, it would be equipped with features to modify the room's temperature, lighting and air quality by using data obtained while monitoring a baby in real time hence ensuring safety and a healthy environment. The Automated Baby Care System is set to become smarter, more adaptive and easier to use using these enhancements. AI, Robotics and IoT technology will be the future of modern baby care where parent can be in - need, secure and peaceful throughout their baby care journey.

References

[1] Ji, C., Mudiyanselage, T. B., Gao, Y., et al. (2021). A review of infant cry analysis and classification. Journal of Audio, Speech, and Music Processing, 2021(8). https://doi.org/10.1186/s13636-021-00197-5

[2] Liang, Y. C., Wijaya, I., Yang, M. T., Cuevas Juarez, J. R., & Chang, H. T. (2022). Deep learning for infant cry recognition. International Journal of Environmental Research and Public Health, 19(10), 6311. https://doi.org/10.3390/ijerph19106311

[3] K, A., Vincent, P. M. D. R., Srinivasan, K., & Chang, C. Y. (2021). Deep learning assisted neonatal cry classification via support vector machine models. Frontiers in Public Health, 9, 670352. https://doi.org/10.3389/fpubh.2021.670352

[4] Alagundi, D., Patil, A., Haridas, V., Chikkamath, S., N. S. R., & Budihal, S. (2024). Infant cry classification using CNN-MFCC fusion. In 2024 IEEE International Conference on Contemporary Computing and Communications (InC4) (pp. 1–6). IEEE. https://doi.org/10.1109/InC460750.2024.10649119

[5] Sivakumar, G., Raj, S., Hariharan, N., & Preyadharshan, S. (2025). An intelligent IoT-enabled smart diaper system with AI-driven health monitoring for infant care. In Proceedings of the 2025 International Conference on Data Science, Artificial Intelligence, and Applications (ICDSAAI) (pp. 1–6). IEEE. https://doi.org/10.1109/ICDSAAI65575.2025.11011574

[6] Chandnani, K., Tripathy, S., Parbhakar, A. K., et al. (2025). A novel smart baby cradle system utilizing IoT sensors and machine learning for optimized parental care. Scientific Reports, 15, 19080. https://doi.org/10.1038/s41598-025-02691-8

[7] Faye, P., Dhargawe, A., Wasnik, B., Dhargawe, C., & Sahare, K. (2025). Intelligent infant cradle with automated monitoring and soothing system. International Journal on Advanced Computer Engineering and Communication Technology, 14(1), 317–323. https://journals.mriindia.com/index.php/ijacect/article/view/449

[8] Alam, H., Burhan, M., Gillani, A., Haq, I., Arshed, M. A., Shafi, M., & Ahmed, S. (2023). IoT-based smart baby monitoring system with emotion recognition using machine learning. Wireless Communications and Mobile Computing, 2023, 1175450. https://doi.org/10.1155/2023/1175450

[9] Arifuddin, R., Dirgantara, W., Sumarahinsih, A., Intan, R., Maulana, F., Nugraha, A., & Sobhita, R. (2024). Baby room temperature and humidity control system using fuzzy logic. Emitor: Jurnal Teknik Elektro, 24(3), 275–280. https://doi.org/10.23917/emitor.v24i3.6403

[10] Jeevan, D., & Sandhya, R. (2022). IoT-based smart baby monitoring system with live streaming and alert notification. International Journal of Advanced Research in Science, Communication and Technology, 308–313. https://doi.org/10.48175/IJARSCT-5455

[11] Eldine, O., Ghanem, N., Selim, M., & El-Makky, N. (2023). Infant cry signal detection and classification using deep learning. Proceedings of the International Conference on Biomedical Engineering and Systems (ICBES 2023). https://doi.org/10.11159/icbes23.133

[12] Manokaran, S., Shanmugam, N., Anirudh, J., Athish, C. B., Karuppiah, R., & Prasath, S. (2024). Development of smart baby cradle system using IoT. In Advances in Intelligent Systems and Computing (pp. xx–xx). CRC Press. https://doi.org/10.1201/9781003559085-13

[13] Thopate, K., Gawade, M., Savale, V., Cholke, A., & Musale, P. (2023). Smart cradle: A technology-enabled solution for safer and better infant sleep. International Journal on Recent and Innovation Trends in Computing and Communication, 11(7), 223–228. https://doi.org/10.17762/ijritcc.v11i7.7849

[14] Gokul, S., MohanRaj, S., Keerthana, S., & Raja, M. (2024). Real-time monitoring of vitals of a baby using IoT-enabled smart baby incubator. International Journal of Innovative Research in Advanced Engineering, 11(4), 213–216. https://doi.org/10.26562/ijirae.2024.v1104.08

[15] Parvathavarthini, S., Bhuvaneswaran, U., Arun, U., & Sengottayan, S. (2024). Baby monitoring using IoT and deep learning. In Proceedings of the 2024 International Conference on Computing, Communication, and Networking Technologies (ICCCNT) (pp. 1–9). IEEE. https://doi.org/10.1109/ICCCNT61001.2024.10725151

[16] Herlea, D. M., Iancu, B., & Ardelean, E.-R. (2025). A study of deep learning models for audio classification of infant crying in a baby monitoring system. Informatics, 12(2), 50. https://doi.org/10.3390/informatics12020050

[17] Manne, S. K. R., Zhu, S., Ostadabbas, S., & Wan, M. (2023). Automatic infant respiration estimation from video: A deep flow-based algorithm and a novel public benchmark. In D. Link-Sourani, E. Abaci Turk, C. Macgowan, J. Hutter, A. Melbourne, & R. Licandro (Eds.), Perinatal, Preterm and Paediatric Image Analysis (PIPPI 2023), Lecture Notes in Computer Science (Vol. 14246, pp. 133–145). Springer. https://doi.org/10.1007/978-3-031-45544-5_10

[18] Reinhart, L., Bischops, A. C., Kerth, J.-L., Hagemeister, M., Heinrichs, B., Eickhoff, S. B., Dukart, J., Konrad, K., Mayatepek, E., & Meissner, T. (2024). Artificial intelligence in child development monitoring: A systematic review on usage, outcomes and acceptance. Intelligence-Based Medicine, 9, 100134. https://doi.org/10.1016/j.ibmed.2024.100134