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Vision Cradle: AI-Based Smart Baby Comfort System Using Husky Lens

Vivek G.[1]**, Harshith Royal A.**[2]**, Varshika B.**[3]**, Midhun B.**[4]**, Rajavardhan Reddy D.**[5]

[1]Assistant Professor, [2,3,4,5]Student, Department of Electronics and Communication Engineering, Kuppam Engineering College, Kuppam, Andhra Pradesh, India.

E-mail: [1]vivekg@kec.ac.in, [2]alamchintu2000@gmail.com, [3]h787813@gmail.com, [4]midhunyadav809@gmail.com, [5]rajavardhan600@gmail.com

Abstract

Vision Cradle is an AI-driven smart baby comfort system that allows infant monitoring and automated caregiving by leveraging the power of vision, IoT, and edge computing. Vision cradle makes use of HuskyLens AI vision sensor to detect the presence of babies and categorize their behavior (e.g., whether the infant is sleeping or crying). The processed data are analyzed by an ESP32 microcontroller which triggers actions according to detected conditions such as swinging of the cradle and audio soothing. To detect the presence of wet diaper, moisture sensor is used. In addition, remote monitoring is made possible by using the cloud computing capabilities of the Thingspeak platform and instant alerting via Telegram and SMS services. Evaluation was conducted experimentally where 98.4%, 96.8% and 95.6% accuracy rates were recorded for detecting infant presence, crying and sleeping state respectively.

Keywords: Smart Cradle, Infant Monitoring, Artificial Intelligence (AI), Internet of Things (IoT), Embedded Systems, Husky Lens, ESP32, Edge AI.

1. Introduction

Infant care requires continuous monitoring due to the inability of newborns to express discomfort explicitly. Caregivers typically rely on indirect indicators such as crying, movement, or sleep patterns, which can lead to delayed responses or misinterpretation. Existing

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baby monitoring systems primarily provide video or audio feeds, requiring constant human supervision and lacking autonomous response capabilities. This work proposes Vision Cradle, an AI-enabled smart infant monitoring and comfort system that integrates edge-based visual intelligence, sensor fusion, and automated actuation. The system is designed to provide real-time detection, decision-making, and response without relying heavily on cloud-based computation, thereby improving reliability and reducing latency.

This research focuses on creating a real-time infant monitor based on Artificial Intelligence, Sensor and IoT (Internet of Things) technologies utilizing a system called "Vision Cradle". The goal is to detect if an infant is present in the indoor environment, detect if the child is crying, determine if the child is asleep, and detect the dampness of the diaper. In the event of prolonged crying or no infant present in the vision cradle, alerts will be sent immediately to the caregivers. Activity that occurs in the vision cradle during a certain time period can be monitored live or historically via a monitoring dashboard. Data related to the behaviour of the infants observed occurs within the vision cradle will be archived for analysis and prediction. Caregivers can interact with the infants from remote locations via a talkback feature. All of the above will help provide greater protection and comfort for infants along with continuous caregiver assistance.

An AI-based baby monitoring solution (Husky Lens vision sensor) for intelligent observation of new-borns was created as a key outcome of this project. An ESP32 microcontroller enables effective control and wireless communication; an automatic cradle swinging mechanism using a servo motor to comfort baby is included. The system includes a moisture sensing unit to detect when a diaper is wet and uses a TFT (Thin-Film Transistor) display for real time status display. Cloud-based data logging and remote monitoring will be facilitated by the use of the ThingSpeak platform. Overall, the project produced a low-cost, practical user-friendly prototype for home-based infant care.

2. Literature Review

The Innovations of infant monitoring have been primary focus on developing both automated childcare aid and real time infant safety monitoring solutions. Smart cradle systems have focused on providing automatic crib rocking movements as well as basic infant comfort mechanisms. Elmas et al. [1] proposed a smart swing cradle automation system to model rocking motion of the cradle in order to achieve a level of comfort for the infant. Liu et al. [2]

offered a smart crib control system based on sentiment analysis, which has limited control logic and offered only a single level of multi-sensor integration in their design.

The Anish et al. [3] developed an infant cry detection system based on an artificial neural network which will be useful in intelligent cradle application. The system recognized infant's cries very effectively, but it did not have automatic cradle functionality, so it couldn't able to monitor sleep states to alert caregivers when the infant needs any assistance. Chang et al. [18] infant's cry classification using extreme gradient boosting and group support vector networks helped to achieve greater accuracy in classification. Ji et al. [20] had analyzed data and classified infant cries and discussed the necessity of having a strong feature extraction and intelligent classification methods

Monitoring of babies has undergone many stages of development such as monitoring of babies remotely and communication between caregivers using IoT (internet of things) technology Jabbar et al. [4] where access to the internet and data is accessed through sensors to monitor the baby remotely, generate alerts to caregivers and send data to caregivers. Prusty et al [7] also used IOT sensors in IOT enabled smart cradle. They developed a smart cradle for tracking real-time activity and providing information to the caregivers about the baby. Duman and Aydin [8], created an IOT enabled monitoring IOT cloud connected cradle that provide data and didn't have any type of automatic response feature. Smart Cradle devices were developed for their relevance to the use of IOT connected furniture. These devices were primarily hardware specific and did not include AI capabilities or automation, such as Shahadi et al. [9].

Embedded vision technology and artificial intelligence integration enabled another advance in the system's overall performance. An embedded vision system that can monitor infants is the Baby Behaviour Monitoring System proposed by Husain et al [5]. This system used computer vision techniques to increase accuracy in observing the activities and behaviours of babies. The internet of things based smart baby monitoring system created by Alam et al [14] had identify babies' emotions, but was primarily dependent on cloud processing and lacked an automated cradle feature. Singh et al [15] designed an infant monitoring system that utilised computer vision technology and artificial intelligence but it did not fully address issues related to wetness detection, automating the activation of cradles and communication with caregivers.

Nasimsha et al [6] developed an automatic cradle with incubator which supports infant's healthcare. This system was intended for clinical environments but not suitable for home deployments. Kumar et al [12] proposed an IoT cradle system that include machine learning and android app technology into an infant monitoring system. They improved the ability to monitor an infant remotely; but the process was largely dependent on mobile and cloud computing, thus creating a high level of computational dependency. The IoT-based smart infant cradle described in WJARR [13] had cry detection and urine monitoring capability with alert functions, but the system did not provide for analysis of sleep states or AI-based vision systems.

3. Methodology

The Vision Cradle follows an event-driven monitoring methodology consisting of sensing, decision making, actuation, communication, and cloud logging stages. Initially, the Husky Lens AI camera continuously captures infant visual information and classifies the detected state into baby present, crying, or sleeping categories. Simultaneously, the moisture sensor monitors diaper wetness conditions.

The components include Husky Lens AI camera, ESP32 processor, moisture sensor, servo motor, audio module, and cloud interface as illustrated by Figure 1. The Vision Cradle is an intelligent system for infant monitoring that incorporates AI technology in order to provide real-time monitoring as well as automation of certain activities related to taking care of an infant. The ESP32 processor plays the role of a central processor making calculations and decisions based on the information obtained from other parts of the device. The HuskyLens AI vision sensor becomes the key element of the visual monitoring system that constantly monitors the presence of an infant in the cradle and classifies his state using AI recognition of images. Being able to process images locally makes it possible to take quick decisions without involving cloud computing in the process of working with the image data. Information about the visual state is sent to the ESP32 which also evaluates and stores the data. Besides, the data is uploaded into the ThingSpeak cloud service via Wi-Fi.

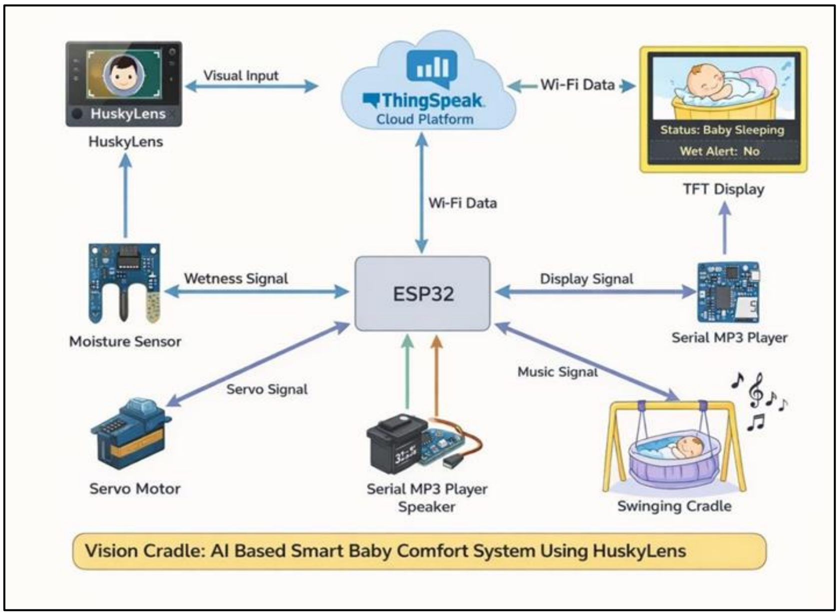


Figure 1. Block Diagram of the Proposed Vision Cradle System

The process of monitoring the hygienic state of infants will require the installation of a moisture sensor into the beddings of the baby. The moisture sensor collects moisture data from the baby's bedding or diaper monitor and sends a signal whenever the diaper gets wet. The wetness signal is immediately transmitted to the ESP32 for analysis in relation to threshold level. Whenever there is an excess level of moisture, the condition will be flagged as a case of wet diaper and appropriate measures taken by notifying the caregivers. ESP32 acts as the core controller in this infant monitoring and comfort system. The ESP32 takes the input signals from the sensor Huskylens and moisture sensor, analyzes the collected data using the preset monitoring algorithms and determines the course of action to take. The controller facilitates cloud interaction, monitor update, triggers comfort features and alerts generation.

The IoT-based remote monitoring capability is facilitated by the ThingSpeak cloud platform. Data captured by the ESP32 concerning the status of infants in terms of their presence, crying time, sleeping time, and wetness data are sent periodically through the cloud using Wi-Fi connectivity. This facilitates a means of accessing the live data, historical data, and analysis of behavioural patterns by caregivers through the ThingSpeak dashboard interface on the web. TFT screen inclusion will facilitate instant and visual monitoring of the conditions surrounding the infant. The ESP32 will consistently transmit data signals that contain current status of the system in terms of the infant presence, sleep status, cry alert and wet alert to facilitate quick assessment of the infant’s status by caregivers nearby without going to the cloud dashboard. The Serial MP3 Player module facilitates audio transmission in response to distress detected among the infants. Upon detection of constant crying for a set amount of time by the ESP32, control command will be relayed to the serial MP3 Player module which will play the recorded lullabies and calming music.

The speaker serves as the sound reproduction unit of the system and acts as the speaker for producing the relaxing music produced by the MP3 player. This process of sound reproduction is done automatically when there is crying and thus ensures effective usage while creating a soothing ambiance for the baby. A servo motor is used to automate the cradle rocking process in the system. If the crying continues for more time than set in the system, the microcontroller sends a PWM signal to control the operation of the servo motor, which makes the cradle rock in a way that relaxes the baby. As soon as the crying ends, the servo stops working.

Continuous monitoring of the baby is carried out using the vision and sensors powered by artificial intelligence technology in the Vision Cradle device. Husky Lens software is responsible for identifying if the baby is within the cradle as well as recognizing his/her behavioral patterns like sleeping and crying. Upon recognizing that the baby is continuously crying for 10 seconds, an alarm system is automatically activated and sends out an alert message on both SMS and Telegram platforms. On detecting that the baby is within the cradle, an affirmation is communicated through the Telegram app and website pop-ups. Upon detecting that the baby is missing from the cradle, a red alert message is triggered on the dashboard with a notification issued to the caregiver. A moisture sensor is used to detect diaper wetness, and once wetness is detected, instant alerts are sent through SMS and Telegram. The system also stores daily activity data and provides a summary report through Telegram when requested from the dashboard. In this way, the system not only monitors the infant but also ensures fast caregiver awareness and improved baby safety.

Algorithm: AI-Based Infant Monitoring and Comfort Decision Logic

```
Initialize ESP32, HuskyLens, Moisture Sensor, Servo Motor,
Audio Module, Wi-Fi, Telegram and SMS Services
Set:
Cry_Threshold = 10 seconds
Wetness_Threshold = 700 ADC value
Presence_Confidence = 80%
WHILE System Active DO
   Read HuskyLens Output
   Read Moisture Sensor Value
```

```
  IF Presence Confidence > 80% THEN
      Baby_Status = PRESENT
  ELSE
      Baby_Status = ABSENT
      Send Telegram Alert
      Display Dashboard Warning
  ENDIF
  IF Baby_Status = PRESENT THEN
     IF Crying Detected THEN
         Start Cry Timer
         IF Cry Timer ≥ 10 seconds THEN
            Alert_Level = HIGH
            Send SMS Alert
            Send Telegram Alert
            Activate Servo Swinging
            Play Soothing Audio
         ENDIF
     ELSE
         Reset Cry Timer
         Stop Servo Swinging
         Stop Audio Playback
     ENDIF
     IF Sleeping Detected THEN
         Alert_Level = LOW
         Log Sleeping Activity
         Maintain Passive Monitoring
     ENDIF
  ENDIF
  IF Moisture_Value > Wetness_Threshold THEN
     Alert_Level = CRITICAL
     Send Wet Diaper Alert
     Update Dashboard Status
  ENDIF
  Upload Status to ThingSpeak
  Log:
    Presence State
    Cry Duration
    Sleep Duration
    Wetness Status
    Timestamp

END WHILE
```

4. Results and Discussions

The proposed Vision Cradle hardware prototype is presented in Figure 2. The proposed prototype utilizes the mentioned above hardware including HuskyLens AI vision sensor, ESP32 microcontroller, moisture sensor, servo motor, audio module, TFT display, and components that provide cloud connectivity as shown in Table 1.

Table 1. Hardware Components and its Specifications

Component	Model / Type	Key Specifications
AI Vision Sensor	HuskyLens AI Camera	Built-in AI processor, face/object recognition, UART/I2C communication, 3.3–5 V operation
Microcontroller	ESP32 DevKit V1	Dual-core 240 MHz processor, Wi-Fi and Bluetooth connectivity, 520 KB SRAM
Moisture Sensor	Capacitive Moisture Sensor Module	Real-time wetness detection, analog output, low power consumption
Servo Motor	SG90 Micro Servo	4.8–6 V operation, PWM control, 0–180° rotation for cradle swinging
Audio Module	DFPlayer Mini MP3 Module	MP3 playback from microSD card, serial communication interface
Speaker	Mini 8 Ω Speaker	Audio output for lullabies and soothing sounds
Display Unit	TFT LCD Display	Real-time display of infant status, alerts, and system information
Cloud Platform	ThingSpeak	Cloud-based data logging, visualization, and remote monitoring
Power Supply	Regulated DC Power Supply	Provides stable 5 V and 12 V outputs for system operation
Voltage Converter	LM2596 Buck Converter	Adjustable DC–DC step-down converter for voltage regulation
Communication Services	Telegram Bot and SMS Gateway	Remote alert generation and caregiver notification services

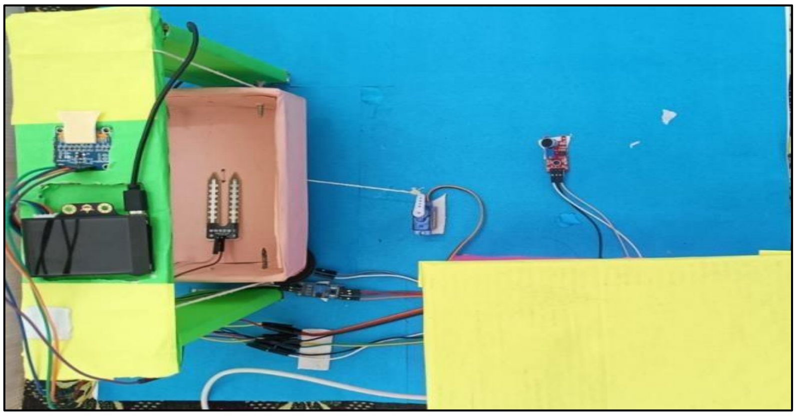


Figure 2. Developed Hardware Prototype of the Vision Cradle

This system proved successful in carrying out real-time infant monitoring, cradle automation, and remote alerts creation. The AI vision sensor HuskyLens module was programmed to detect presence, crying and sleeping of infants. Crying and sleep detections are demonstrated in Figure 3 and Figure 4 accordingly.

Figure 3. Infant Cry Detection Using HuskyLens AI Vision Sensor

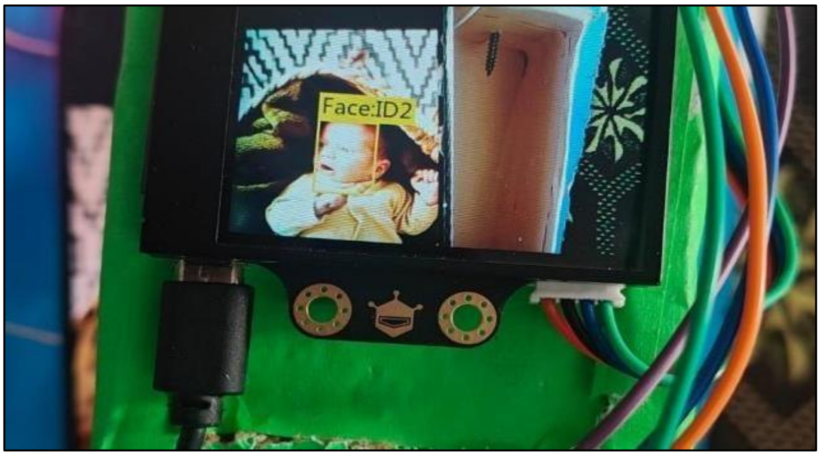


Figure 4. Infant Sleep Detection Using HuskyLens AI Vision Sensor

Table 2. Performance Evaluation of AI-Based Infant State Detection

Parameter	Value
Presence Detection Accuracy	98.40%
Cry Detection Accuracy	96.80%
Sleep Detection Accuracy	95.60%
Average Processing Time	0.42 s
False Positive Rate	2.10%
False Negative Rate	3.40%

In case of prolonged crying of an infant (over 10 seconds), ESP32 triggered the process of cradle movement and soothing sounds as demonstrated in Figure 5. Detection efficiency of the implemented approach was tested using 500 test samples representing infant presence, crying and sleep. As shown in Table 2, high accuracy of recognition was achieved as 98.4% for detecting presence, 96.8% for cry and 95.6% for sleeping. Average processing time was calculated as 0.42 s; at the same time, false-positive rate and false-negative one were 2.1% and 3.4% respectively.

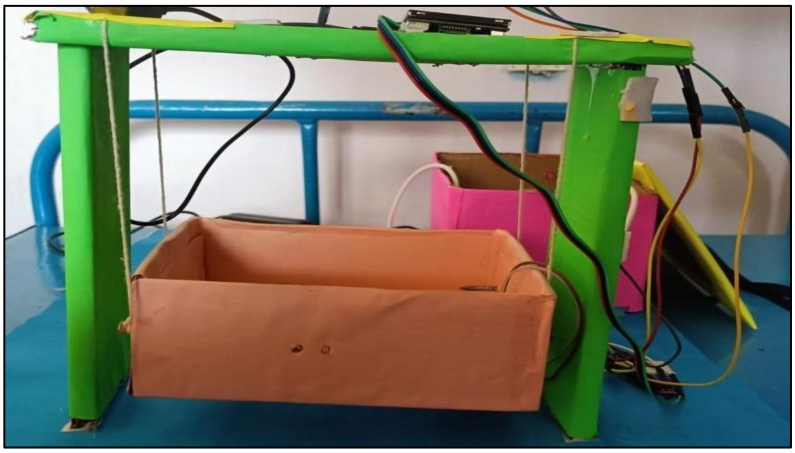
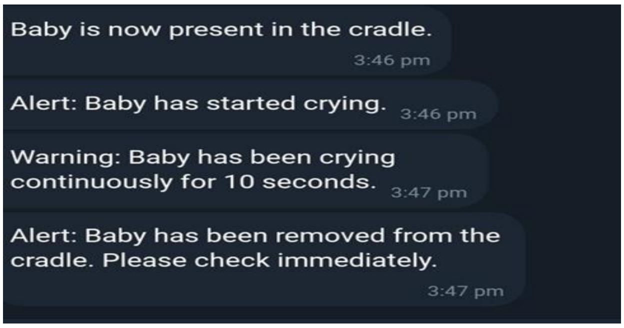


Figure 5. Automated Cradle Swinging Activated During Cry Detection

The notification module was tested by utilizing Telegram and SMS service providers. Some examples of the generated notifications for detection of infants' presence, excessive crying time, wet diaper, and baby removal are depicted in Figure 6 to Figure 9.



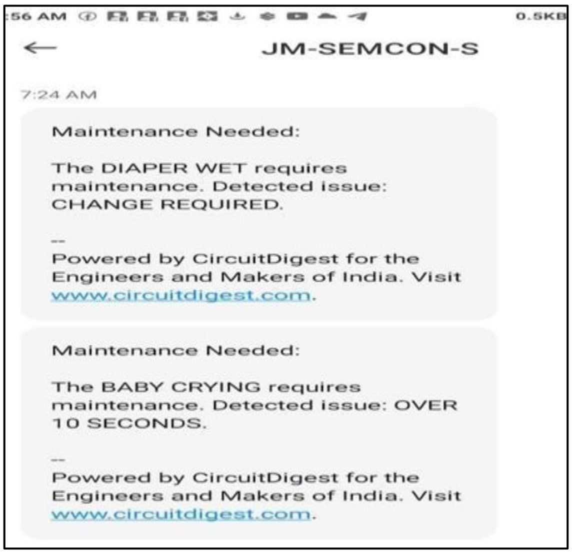
Baby is now present in the cradle. 3:46 pm

Alert: Baby has started crying. 3:46 pm

Warning: Baby has been crying continuously for 10 seconds. 3:47 pm

Alert: Baby has been removed from the cradle. Please check immediately. 3:47 pm

Figure 6. Telegram-Based Infant Monitoring and Alert Notifications



7:24 AM

Maintenance Needed:

The DIAPER WET requires maintenance. Detected issue: CHANGE REQUIRED.

--
Powered by CircuitDigest for the Engineers and Makers of India. Visit www.circuitdigest.com.

Maintenance Needed:

The BABY CRYING requires maintenance. Detected issue: OVER 10 SECONDS.

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Figure 7. SMS Alerts for Cry Detection and Diaper Wetness Events

12 March

/start 11:41 am

Hello 11:41 am

hello 11:44 am

/start 11:45 am

hello 11:45 am

New Messages

16 March

Alert: Baby has been removed from the cradle. Please check immediately. 12:06 am

Figure 8. Telegram Notification Generated for Infant Removal Detection

The system efficiently created notifications when the specific criteria were recognized, which helped the care provider to know about the condition of the baby instantly. The communication module results are represented in Table 3. The Telegram notifications were delivered with an average delay of 1.8 seconds, while SMS notifications took 4.2 seconds on average. 99.1% of successful Telegram notification delivery and 97.5% of SMS delivery were observed.

Alert: Baby has been removed from the cradle. Please check immediately. 12:06 am

Warning: Baby has been crying continuously for 10 seconds. 12:45 am

Warning: Baby has been crying continuously for 10 seconds. 12:45 am

Daily Baby Summary:
Total crying time: 23m
Total sleeping time: 0m
Urine count today: 0
Cry count today: 0
Diaper wet status: Wet 12:45 am

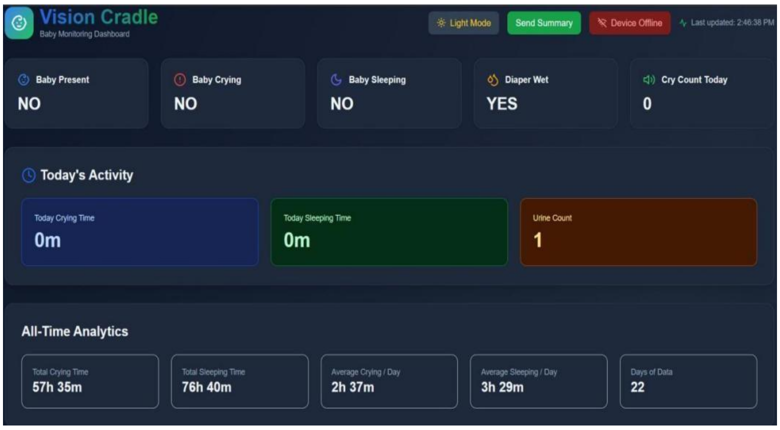
Warning: Baby has been crying continuously for 10 seconds. 12:45 am

Figure 9. Messaging Platform Alerts and Daily Activity Summary

Table 3. Communication Performance of Telegram and SMS Alerts

Parameter	**Telegram**	**SMS**
Average Delay	1.8 s	4.2 s
Delivery Success Rate	99.10%	97.50%
Packet Loss	0.60%	1.80%
Alert Reliability	98.90%	97.20%

The cloud based monitoring dashboard presented in Figure 10 allows real time visualization of activities performed by babies, whereas the historical data summary dashboard in Figure 11 permits behavioral analysis over a period of time. Data was collected continuously through ThingSpeak platform for 22 days, during which system sent data to cloud server every 30 seconds with 98.7% success rate. Dashboard refresh latency remained less than 1 second with average update rate of 0.84 seconds. A total of 63,360 entries were successfully stored during the experiment.



Last updated: 2:46:38 PM

Baby Present: NO
Baby Crying: NO
Baby Sleeping: NO
Diaper Wet: YES
Cry Count Today: 0

Today's Activity

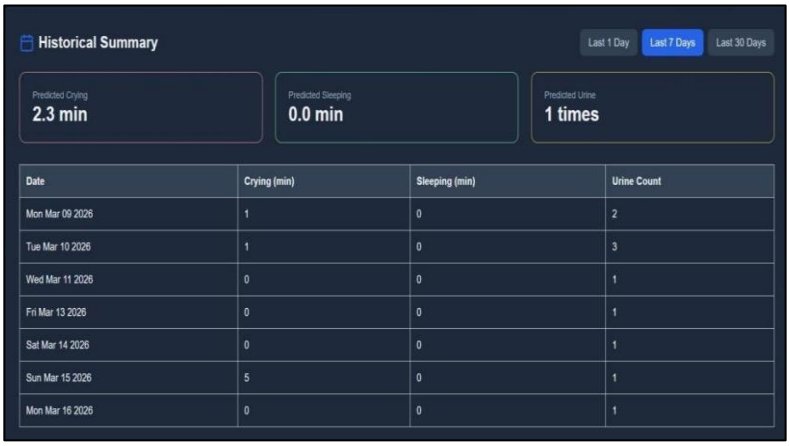
Today Crying Time: 0m
Today Sleeping Time: 0m
Urine Count: 1

All-Time Analytics

Total Crying Time: 57h 35m
Total Sleeping Time: 76h 40m
Average Crying / Day: 2h 37m
Average Sleeping / Day: 3h 29m
Days of Data: 22

Figure 10. Real-Time Infant Monitoring Dashboard

Behavioral analyses from the collected data are presented in Figs. 12 and 13. It is evident that there were variations in crying duration, sleeping duration and number of wet diapers over the time. From the analysis of stored data, an average crying duration of 42.6 minutes per day, an average sleeping duration of 11.8 hours per day, and an average number of wet diapers of 5.4 per day was observed. Maximum crying duration observed was 78 minutes, whereas minimum crying duration recorded was 18 minutes. Trend prediction analysis provided estimation accuracy of 92.3%.



Predicted Crying: 2.3 min
Predicted Sleeping: 0.0 min
Predicted Urine: 1 times

Date	Crying (min)	Sleeping (min)	Urine Count
Mon Mar 09 2026	1	0	2
Tue Mar 10 2026	1	0	3
Wed Mar 11 2026	0	0	1
Fri Mar 13 2026	0	0	1
Sat Mar 14 2026	0	0	1
Sun Mar 15 2026	5	0	1
Mon Mar 16 2026	0	0	1

Figure 11. Historical Summary of Infant Behavioural Data

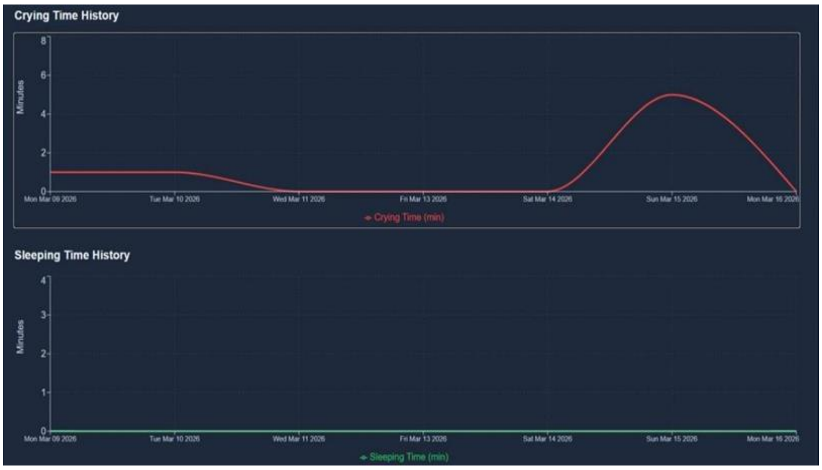
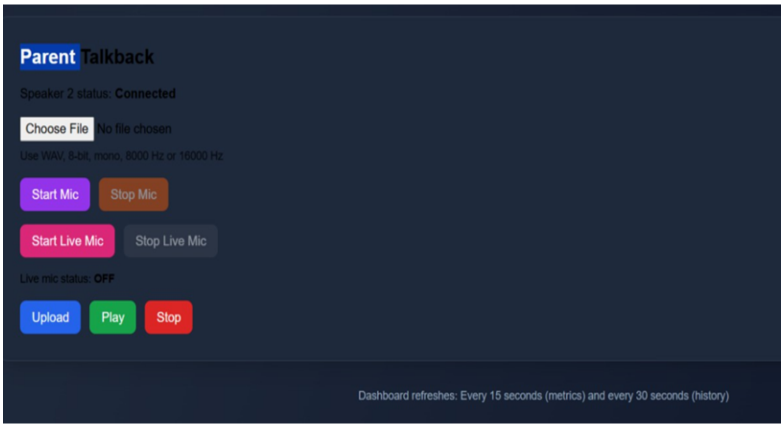


Figure 12. Daily Crying and Sleeping Duration Analytics

The parent talkback interface, presented in Figure 14, allowed for remote communication through audio playback capability and microphone input features. In addition, the multi-parameter monitoring dashboard presented in Figure 15 proved simultaneous monitoring of baby's presence, crying state, and diapers wetness.

Figure 13. Multi-Parameter Behaviour Analytics for Crying, Sleeping and Wetness Events


Parent Talkback

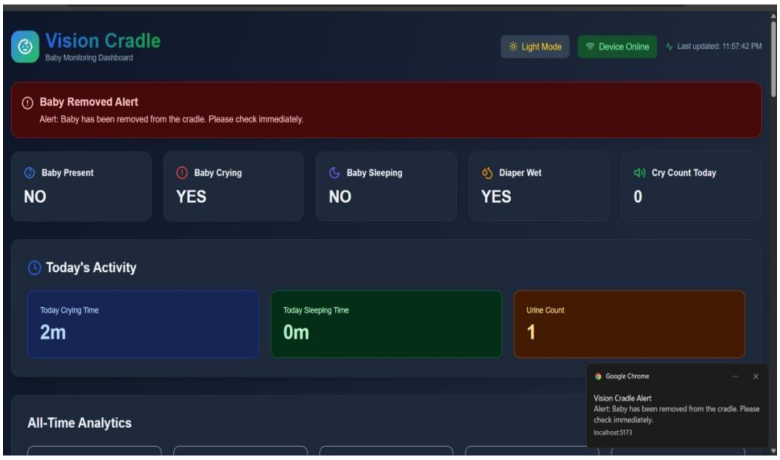
Speaker 2 status: Connected

Use WAV, 8-bit, mono, 8000 Hz or 16000 Hz

Live mic status: OFF

Dashboard refreshes: Every 15 seconds (metrics) and every 30 seconds (history)

Figure 14. Parent Talkback Interface for Remote Caregiver Communication



Baby Removed Alert

Alert: Baby has been removed from the cradle. Please check immediately.

Baby Present: NO
Baby Crying: YES
Baby Sleeping: NO
Diaper Wet: YES
Cry Count Today: 0

Today's Activity

Today Crying Time: 2m
Today Sleeping Time: 0m
Urine Count: 1

Vision Cradle Alert
Alert: Baby has been removed from the cradle. Please check immediately.

Figure 15. Multi-Parameter Monitoring Dashboard with Real-Time Alerts

Performance testing on 200 multi-events resulted in 97.1% accuracy level, 0.78 s average delay time and 95.8% of simultaneous events handling capabilities. The whole system had been working properly with the average power consumption of 2.8 W in an idle mode and 7.4 W in a cradle active and audio mode. On average, the network performance has proven to be 1.2 Mbps. Latency time has stayed under 2.5 s. Therefore, the results show that the presented Vision Cradle system is able to monitor infants, provide automated comfort support, analyze information in the cloud environment, and inform parents instantly.

5. Conclusion

In this paper, Vision Cradle was proposed as a smart infant comfort solution based on the use of AI, where Vision Cradle combines the functions of HuskyLens vision sensing, ESP32 microcontroller, IoT connection, and actuator to monitor the infants. This solution was successfully developed such that the infant presence, crying, sleeping states, and wet diaper can be detected. It was able to provide instant alert using Telegram and SMS services when required. From experimental result analysis, it was found that there is high accuracy in detection such as infant presence at 98.4%, crying sound detection at 96.8%, and infant sleeping state detection at 95.6%. Moreover, low processing latency enables the use of real-time operations. It was also found that cloud synchronization and remote monitoring could be successfully implemented in this prototype. This prototype is able to swing the cradle automatically as well as play soothing music to enhance infant comfort when crying. In conclusion, a simple, cost-effective, and functional prototype was developed in this work.

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