IntelliCradle: IoT-Enabled Infant Care System

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***Abstract*— This research presents the "Smart Infant Cradle Care System" an innovative application of Internet of Things (IoT) technology in infant care sector. Designed to assist working parents, the cradle integrates sensors, including a DHT11 for environmental status and a CCTV camera for monitoring, controlled by an Arduino Uno microcontroller. Coupled with Python-based software on a Linux server, it offers real-time infant monitoring through a web application. Testing in awake and asleep scenarios demonstrated effective monitoring and response, showcasing IoT's potential in enhancing infant care sector. While successful, the project also highlighted challenges in sleep pattern data analysis, suggesting directions for future research.**

Keywords- Baby cradle, Sleep pattern, IoT.

I. Introduction

The modern world has dramatically changed what it means to be a parent, especially for working couples who are responsible for taking care of their infant while maintaining their professional responsibilities. Because newborns are at risk for conditions like immunodeficiency and breathing difficulties which necessitate close observation even after they have been released from the hospital, they may require additional care.

The advent of Internet of Things (IoT) technology has revolutionized infant care with the development of sophisticated monitoring systems. With the development of advanced monitoring systems, the introduction of Internet of Things (IoT) technology has completely changed the way that newborn care is provided. These systems come with a wide variety of sensors and devices that track health data in real time and analyze newborn sleep patterns. Utilizing temperature, sound, and movement data, these Internet of Things (IoT) solutions can offer valuable information on an infant's sleep quality.

This research proposes an innovative Smart Infant Cradle, enhanced by IoT technology, that supports the sleep health of infants. It incorporates a suite of sensors and devices designed to monitor an infant's environment and physiological signs, thus facilitating interventions that promote healthier sleep patterns. The system offers a user-friendly interface for parents to receive updates and alerts on their infant's sleep, ensuring peace of mind even when they cannot be physically present. By simplifying complex circuitry and integrating remote monitoring capabilities, this Smart Cradle System represents a significant advancement in infant care.

II. Review of Literature

Several monitoring systems have been developed recently through developments in infant care technology. A notable study [1] developed a method for monitoring newborns in incubators and collected critical data for both immediate clinical use and long-term study. This system combines pulse and humidity sensors, sending data to a computer system via an Arduino microcontroller. These advancements hold the potential to improve the capabilities of remote monitoring, enabling medical practitioners to monitor newborn status through local networks and the internet.

In [2], a comprehensive system for remote supervision was proposed, and further integration of IoT in baby health monitoring was studied. By monitoring vital signs like body temperature, heart rate, and movement, the system's architecture sends alarms to caregivers through wireless connection. This approach allows for programmed alarm conditions, which not only gives parents peace of mind but also increases the accuracy of health monitoring.

Finally, another research effort examined the use of smart cradle systems [3]. A prototype that makes use of a cradle as a safe and effective place to keep an eye on a baby's activities was described in this study. Using Internet of Things components, the system notifies parents of baby's situation like wakefulness or urination by sending warnings straight to their mobile device. With sensors for moisture and light levels, the prototype guarantees a holistic approach to baby care.

These studies collectively highlight a trend towards more autonomous, precise, and user-friendly infant care solutions, capitalizing on IoT's potential to transform the care environment. Such technological progress underscores the potential for a significant shift in how parental care is administered, with a growing emphasis on connectivity and real-time data.

III. System Architecture

Traditional baby cradles, known for their simplicity and low cost, are manually operated and lack automation. To enhance the safety, security, and convenience for infants and parents, the need for automated solutions is increasingly evident. Recent research, as discussed in Section II, has explored various methods for automating child cradles, paving the way for innovative approaches in this domain. In this paper the cradle prototype built as the following.

A. Hardware Components

The Smart Infant Cradle's system features an Arduino Uno microcontroller for core operations, a DHT11 sensor for temperature and humidity control, and a CCTV camera for remote monitoring. Key components include an ESP Relay for power management, a servo motor for automated motions, and a buzzer. These hardware elements are outlined in the following Table 1.

Table 1: Hardware components

	Component	Function
1	Arduino Uno	Central microcontroller for managing sensors and actuators in the cradle, like automated swinging.
2	Linux Server (Dell Desktop)	Runs the Python code to determine the status of the infants and sending commands.
3	ESP Relay	Controls power to the cradle's mechanisms, like the servo motor or temperature sensor.
4	DHT11	Monitors the cradle's surrounding temperature and humidity.
5	off-shelf CCTV camera	Provides visual images of the infant, allowing remote viewing by parents via internet connectivity.
6	Servo motor	Operates the cradle's mechanical swing.
7	Buzzer	Play calming music

B. *Software Architecture*

The software architecture is designed to be a combination of Arduino microcontroller aligned with python running on a Linux server in my home lab. The code flowchart is shown in figure 1. The code was taken from an open-source website Github which was developed by Celeb Olsen and modified in this research in order to link it with the Arduino circuit [4].

C. *Communication Protocols Used*

To link between sensor and actuators the following protocols utilized:

- Real Time Streaming Protocol (RTSP)
- Hypertext Transfer Protocol (HTTP)
- Custom Transmission Control Protocol (Custom TCPP)

Tabulated in Table 2, and consisting of sources and destinations of each. In a communication protocol, the source is the sender of the message or data, while the destination is the receiver of that message or data.

Table 2: Communication Protocols Utilized

Protocol	Source	Destination	Description
RTSP	Python code	CCTV	CCTV is streaming live feed, captured by python code.
HTTP	Mobile Phone	Web app	Parents connect to get latest update and see the live feed.
	Python code	Arduino Cloud API	To fetch latest surrounding cradle's data
	Arduino IDE	Arduino Cloud API	Send latest data of cradle's surrounding
Custom TCP	Python code	ESP Relay	Python code control the relay using ESPHome API.

IV. METHODOLOGY

A. *Experimental Setup*

The experimental setup for the Smart Infant Cradle was carefully planned to ensure a realistic testing environment. The cradle was assembled with the Arduino Uno serving as its central processing unit, as illustrated in Figure 2. This unit was interconnected with the DHT11 and sound sensors, as well as a CCTV camera, for infant activity detection. A servo motor was installed for cradle motion, and an ESP Relay was used for power management. The software, primarily composed of Python scripts running on a Linux server, was customized to control these hardware components and to process the sensor data. Additionally, an open-source web application interface was developed to provide real-time monitoring of the infant's activity.

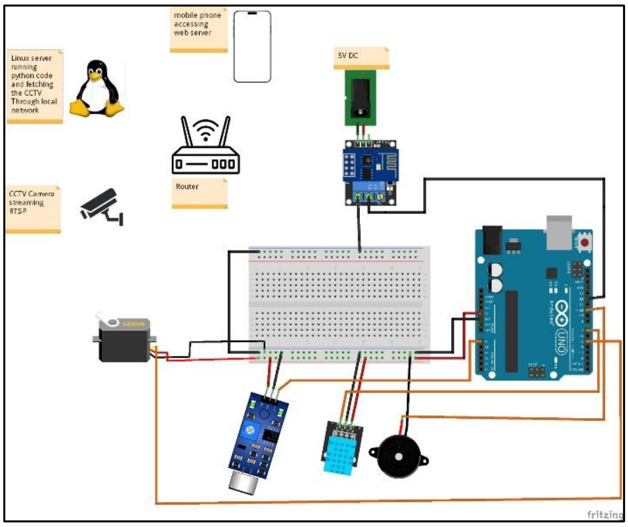

Figure 2: Circuit diagram

(Source: drawn using Fritzing app.)

Then the cradle prototype was built using foam board and wooden sticks. Divided into two parts, cradle holding by servo motor part and circuit box part.

B. *Testing and Validation*

The testing phase was conducted in two stages as follows:

1. Functionality Tests: Each component of the cradle was tested individually for operational integrity. The integration of the system was then tested to ensure the interaction between the hardware and software components. This included verifying the responsiveness of the servo motor to sensor inputs and the accuracy of data displayed on the user interface.

2. User Interface Test: The usability of the web app was evaluated by a selected users, mimicking potential parents. Feedback was gathered to assess the interface's reliability, and user-friendliness.

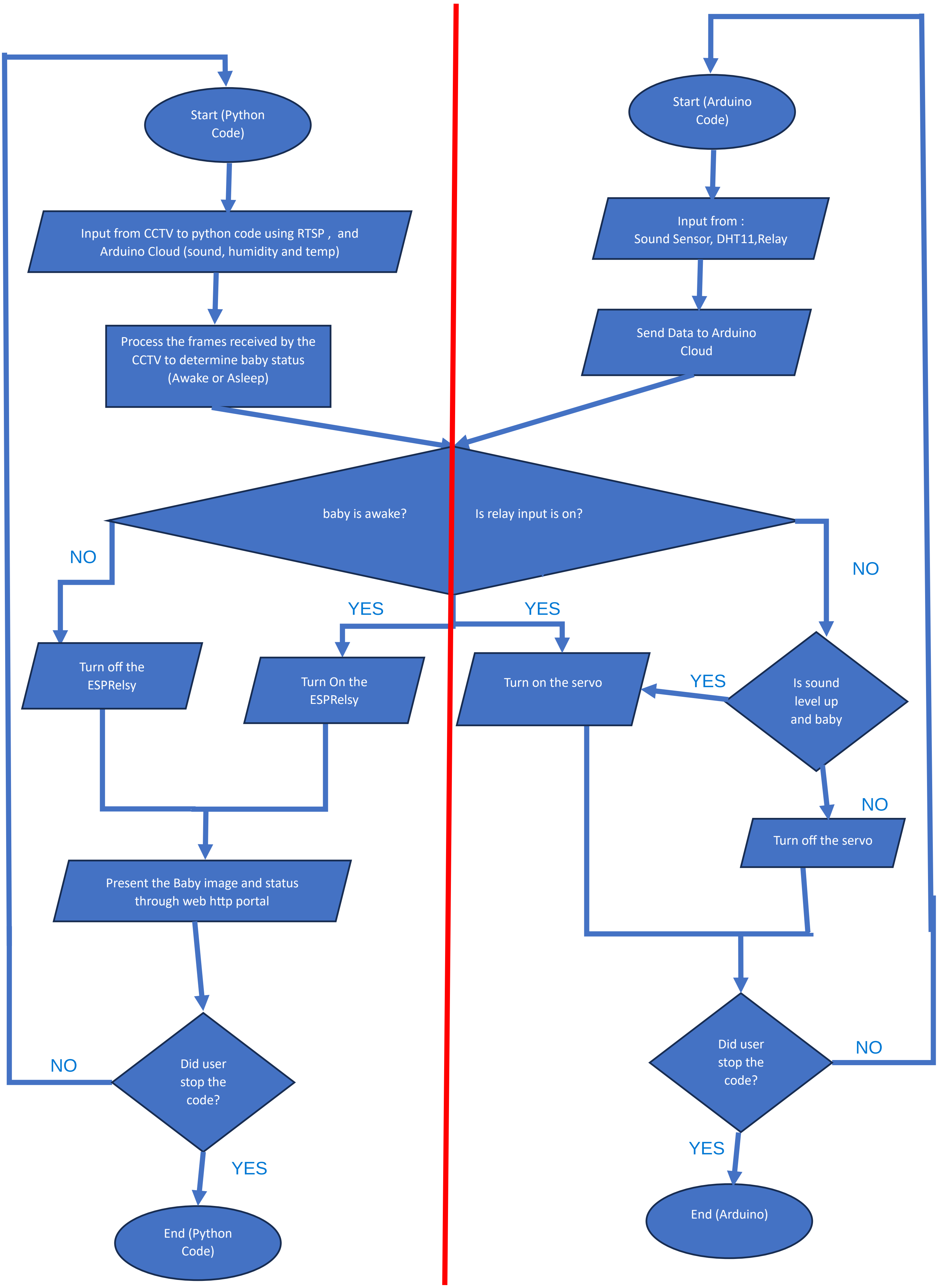

Figure 1: Flow chart of the system

V. RESULTS

The Smart Infant Cradle project was implemented successfully, as shown in figure 3 which shows how the hardware and software components integrated.

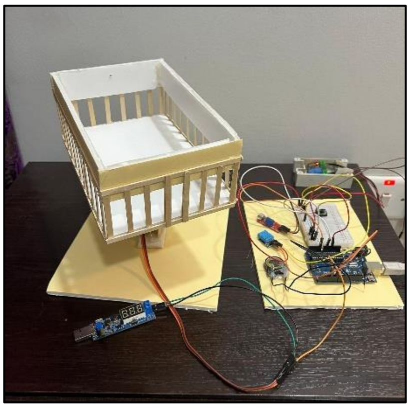

Figure 3: Final prototype

The data collected by the sensors is displayed in the web app and system's performance was evaluated under two primary scenarios: when the infant was awake and when the infant was asleep. In both scenarios, the cradle's automated responses, driven by sensor inputs, operated seamlessly, demonstrating the success of the design.

During the awake scenario, the system detected infant movements through the image processing. The servo motor, controlled by the Arduino Uno, initiated a gentle rotation motion in response to signs of awakeness. Concurrently, the real-time data was effectively captured and displayed on the web application interface, allowing for remote monitoring. This scenario can be seen in figure 4.

Figure 4: Web app interface during awakeness scenario.

In the sleeping scenario, as shown in figure 5, the cradle maintained a stable and conducive environment for the infant's sleep. The temperature and humidity levels monitored by the DHT11 sensor displayed on the web app to give parents the status of the cradle environment ensuring comfort. The CCTV camera provided continuous visual monitoring, which was accessible through the web application interface. This scenario demonstrated the system capability to reassure parents while the infant is sleeping.

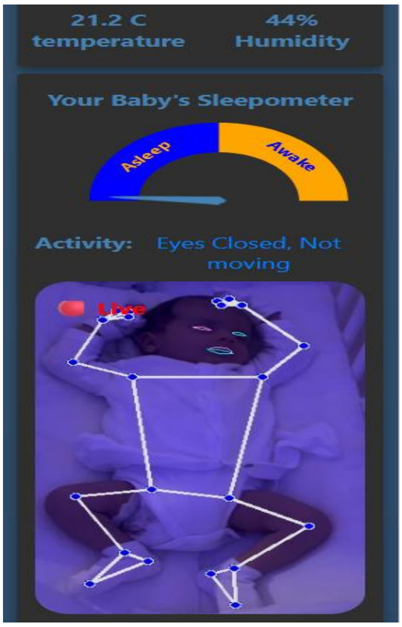

Figure 5: Web app interface during sleeping scenario.

However, challenges were encountered in gathering comprehensive data to statistically compare the infant's sleep patterns with published studies due to the need of long periods in order to have a dataset which can be compared. Despite these challenges, the preliminary results from the Smart Infant Cradle project are promising. The successful integration of hardware and software components and the operation of the system in both awake and sleep scenarios highlight the ability of IoT technology in enhancing infant care.

VI. CONCLUSION

The Smart Infant Cradle project successfully demonstrates the practical application of IoT technology in enhancing infant care. Integrating hardware like Arduino Uno and DHT11 with software components, the system effectively responded in scenarios of the infant being awake and asleep, though challenges in sleep pattern data collection were noted. This project not only highlights the potential of IoT in childcare but also opens up opportunities for further research, particularly in advanced data analysis and extended functionalities for comprehensive infant care.

REFERENCES

[1] N. Saude and P. A. H. Vardhini, "IoT based Smart Baby Cradle System using Raspberry Pi B+," 2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC), Aurangabad, India, 2020, pp. 273-278, doi: 10.1109/ICSIDEMPC49020.2020.9299602.

[2] N. L. Pratap, K. Anuroop, P. N. Devi, A. Sandeep and S. Nalajala, "IoT based Smart Cradle for Baby Monitoring System," 2021 6th International Conference on Inventive Computation Technologies

(ICICT), Coimbatore, India, 2021, pp. 1298-1303, doi: 10.1109/ICICT50816.2021.9358684. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[3] S. Joseph, A. Gautham.J, A. Kumar and M. K. Harish Babu, "IOT Based Baby Monitoring System Smart Cradle," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2021, pp. 748-751, doi: 10.1109/ICACCS51430.2021.9442022. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[4] Caleb Olson, “GitHub - calebolson123/ Baby Sleep Coach: DIY Baby Sleep Tracking,” GitHub. https://github.com/calebolson123/BabySleepCoach