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Snoozle : Design and Development of an IoT based Smart Cradle

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Abstract - Infant care requires continuous attention, which can be challenging for caregivers, especially in busy or working environments. To address this, this paper presents an IoT-based Smart Cradle System that enables real-time monitoring and automated assistance for infant care.The system integrates multiple sensors to monitor parameters such as sound, temperature, humidity, moisture, and movement. A microcontroller processes this data and performs necessary actions when required. Key features of the system include automatic cradle swinging, toy activation, and a user-controlled lullaby system, allowing caregivers to remotely soothe the infant as needed.Additionally, the system incorporates a camera module for live video monitoring along with face detection capabilities, enabling enhanced safety and awareness of the infant's condition. A web-based interface provides remote access for monitoring sensor data and controlling cradle operations in real time.The proposed system offers a reliable and efficient solution that improves infant safety, comfort, and caregiver convenience through smart automation and intelligent monitoring.

Keywords - IoT, Smart Cradle System, Infant Monitoring, Sensor-Based Automation, Real-Time Monitoring, Baby Safety, Cry Detection, Remote Control

I. INTRODUCTION

In recent years, digital technologies and intelligent automation have started influencing many areas of daily life, especially those that require continuous monitoring and care. Infant care is one such area where constant observation is necessary to ensure a baby's safety, comfort, and healthy development. Newborns cannot communicate their needs clearly, so caregivers must regularly check conditions such as crying, sleep behavior, environmental temperature, and wetness. In modern lifestyles, however, parents are often busy with professional responsibilities, making continuous manual supervision difficult. This creates a practical challenge in maintaining consistent infant monitoring [1].

Traditional cradles have been used for many generations to comfort babies through gentle rocking motion. While they help soothe infants, these cradles function only as mechanical devices and do not include any monitoring or intelligent control features. Parents must manually respond whenever the baby cries, check the surrounding conditions, and ensure that the baby remains comfortable. This dependency on manual observation increases physical workload and can lead to delayed responses, especially during nighttime or in healthcare environments where a caregiver may be responsible for multiple infants simultaneously [7].

Despite these advancements, existing solutions still exhibit several shortcomings. Many systems focus on a limited number of parameters and operate on predefined thresholds without offering adaptive or integrated responses. Some implementations provide monitoring without sufficient automation, while others automate cradle motion but lack reliable notification or remote accessibility. In several cases, the absence of intelligent response mechanisms can reduce system efficiency, as delayed or inappropriate actions may fail to comfort the infant effectively. Furthermore, fragmented system designs increase complexity and reduce usability, particularly for non-technical users [28].

The impact of these limitations becomes more severe in healthcare environments such as maternity wards and neonatal care units. Nurses and healthcare staff are often required to monitor multiple infants at the same time, making continuous manual observation impractical. Frequent handling of infants may also increase the risk of infection. Smart cradle systems with continuous monitoring, automated soothing, and minimal physical intervention can significantly reduce caregiver workload while enhancing infant safety and comfort.

The motivation behind integrating IoT and automation into smart cradle systems lies in addressing these real-world challenges. A well-designed smart cradle should not only detect infant discomfort but also respond intelligently by initiating appropriate soothing actions and alerting caregivers in real time. Remote monitoring through mobile applications further enhances usability by allowing parents to stay connected with their infants regardless of location. When such intelligent systems are absent, caregiving efficiency decreases, caregiver stress increases, and infant comfort may be compromised.

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To address these challenges, modern research has explored the use of embedded systems and the Internet of Things (IoT) to create intelligent baby monitoring solutions. By integrating sensors, microcontrollers, and wireless communication, it becomes possible to continuously observe infant conditions and automatically respond when required. Sensor inputs such as cry sound, motion, temperature, and moisture can be treated as system variables. Using simple classification or threshold-based algorithms, the system can detect abnormal conditions and trigger automated soothing actions. Remote connectivity through mobile applications further enables caregivers to monitor the baby in real time and receive instant notifications.

In this work, we developed an IoT-based Smart Cradle System that combines sensing, automated control, and remote monitoring within a single platform. The system uses multiple sensors to monitor parameters such as crying sound, environmental temperature, moisture level, and baby movement. Cry detection acts as a key trigger signal in the system. When the sound level crosses a predefined threshold, the algorithm interprets it as a cry event and activates soothing mechanisms. These include a motor-driven cradle swinging system that generates a rhythmic motion similar to traditional rocking, as well as lullaby playback through a wireless speaker and activation of a toy mechanism [29].

The system architecture includes embedded controllers that collect sensor data, process signals, and communicate through wireless networks. A camera module is integrated to provide live video streaming so that parents can visually monitor the baby from a remote location. A mobile application acts as the main user interface where caregivers can view real-time sensor readings, receive alerts, and manually control cradle functions if required. The data collected by the system can also be stored on a cloud platform, allowing simple analysis of sleep patterns and behavioral trends over time.

In summary, the proposed smart cradle system transforms a traditional cradle into an intelligent monitoring and response system. By combining IoT connectivity, sensor integration, automated control algorithms, and remote monitoring, the system reduces manual workload while improving infant safety and comfort. Such a solution supports both parents and healthcare professionals by ensuring faster response times, continuous observation, and reliable caregiving in modern environments.

II. METHODOLOGY

The proposed smart cradle system is developed to provide automated infant care along with remote monitoring by integrating sensing, actuation, and wireless communication technologies. The system architecture is divided into three primary sections: the Live Video and Music Streaming Unit, the Sensing and Driving Unit, and the Monitoring and Controlling Mobile Device. The sensing and driving unit forms the core of the system, where the cry detection unit and temperature and humidity sensing unit continuously monitor the infant's condition and surrounding environment. The collected data is transmitted to the controlling unit, which processes the inputs using predefined logic to determine appropriate actions. Based on this decision, control signals are sent to the toy motor driver and cradle motor driver to activate the toy unit and cradle swing unit, respectively, ensuring the infant is comforted through motion and engagement. In parallel, the live video and music streaming unit enables continuous visual and audio interaction. The baby face capturing unit streams real-time video to the mobile device via Wi-Fi, allowing caregivers to monitor the infant remotely. The lullaby playing unit receives audio signals from the mobile device through Bluetooth to provide soothing sound. The monitoring and controlling mobile device acts as the central user interface, facilitating real-time observation and remote control of system operations through wireless communication. Overall, the methodology follows a structured sequence of sensing, data processing, decision-making, and actuation, ensuring efficient, responsive, and reliable infant monitoring and care.

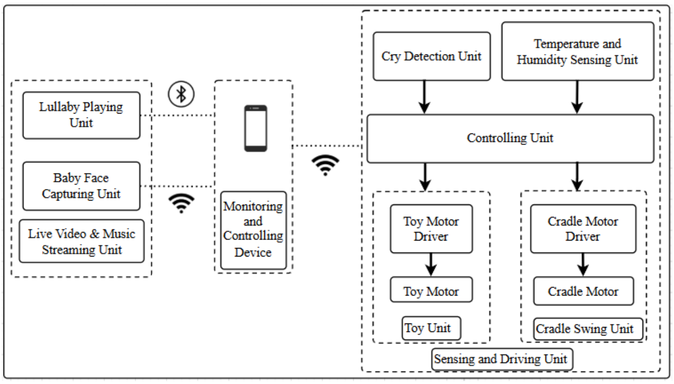

Figure 1: Block Diagram of the Smart Cradle

Figure 1 represents the block diagram of the smart cradle system, which is structured into three main sections: the Live Video and Music Streaming Unit, the Monitoring and Controlling Mobile Device, and the Sensing and Driving Unit. These sections operate together to provide automated cradle functionality along with remote monitoring capabilities.

A. Live Video and Music Streaming Unit: The Live Video and Music Streaming Unit is designed to handle visual observation and audio interaction with the infant. It includes the Baby Face Capturing Unit and the Lullaby Playing Unit. The Baby Face Capturing Unit utilizes a camera module to continuously record the infant's activities. The captured video is transmitted wirelessly to the mobile device through a Wi-Fi connection, enabling real-time supervision. The Lullaby Playing Unit is responsible for generating soothing audio. It receives sound signals from the mobile device via Bluetooth and plays lullabies or calming music to comfort the infant.

B. Monitoring and Controlling Mobile Device: The Monitoring and Controlling Mobile Device serves as the central interface for the user. It establishes wireless communication with other system units using Wi-Fi and Bluetooth technologies.Through Wi-Fi, the device receives live video data from the camera unit and exchanges control signals with the controlling unit. Additionally, it sends audio signals to the lullaby unit via Bluetooth. This allows caregivers to monitor the infant's condition, access system information, and remotely control functions such as audio playback and cradle operation.

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C. Sensing and Driving Unit: The Sensing and Driving Unit is responsible for detecting conditions and performing physical actions accordingly. It comprises sensing modules, a central controlling unit, and motor-driven subsystems. The Cry Detection Unit monitors sound intensity levels to identify when the infant is crying. When the sound exceeds a predefined threshold, a signal is forwarded to the controlling unit. The Temperature and Humidity Sensing Unit measures environmental conditions around the cradle to ensure a comfortable and safe atmosphere.The Controlling Unit acts as the decision-making component of the system. It processes inputs from all sensing modules and determines the required response based on programmed logic. Depending on the processed data, the controlling unit activates the following subsystems:

Toy Unit: This unit includes a Toy Motor Driver and a Toy Motor. The driver regulates the electrical supply to the motor, which operates a toy mechanism to engage the infant and reduce distress. Cradle Swing Unit: This unit consists of a Cradle Motor Driver and a Cradle Motor. The motor driver enables controlled operation of the cradle motor, producing a smooth swinging motion that helps soothe the infant.

III. ALGORITHM

The algorithm of the proposed smart cradle system illustrates the step-by-step operational logic followed by the system to detect a baby's cry and respond with suitable soothing actions

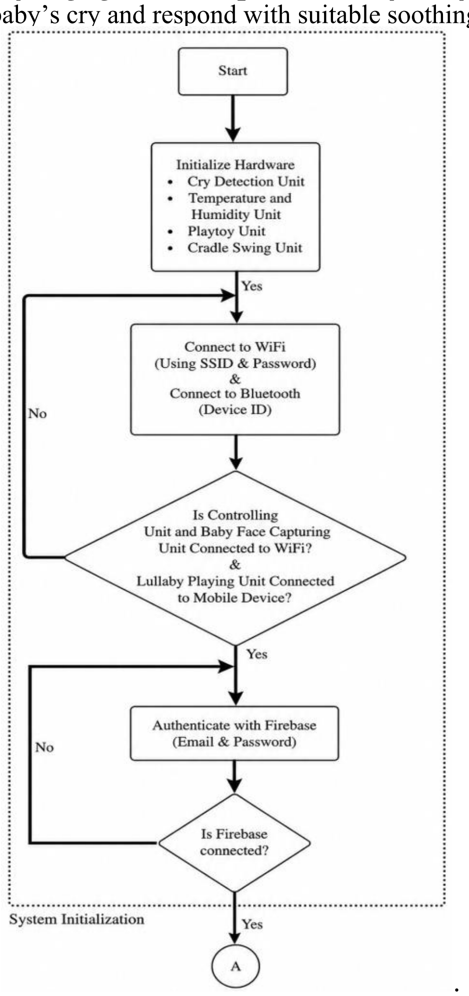

Figure 2. System Initialization of Smart Cradle

Figure 2 represents the overall system initialization process of the smart cradle, where all essential hardware units such as the cry detection module, temperature and humidity sensor, play/toy unit, and cradle swing unit are configured. The system then establishes communication through Wi-Fi and Bluetooth to connect the controlling unit, monitoring unit, and mobile application. Further, user authentication is performed via the cloud server (Firebase) to ensure secure data exchange. Once all connections are successfully established, the system transitions to operational mode for real-time monitoring and control.

In addition, the initialization stage ensures synchronization between different system modules to enable seamless data flow. The connectivity checks verify whether all units, including the baby monitoring and control units, are properly linked to the network and mobile device. Any failure in connection triggers a reattempt mechanism, ensuring system reliability before entering the operational phase. This structured initialization process minimizes communication errors and guarantees that all functionalities such as real-time monitoring, alert generation, and remote control operate efficiently.

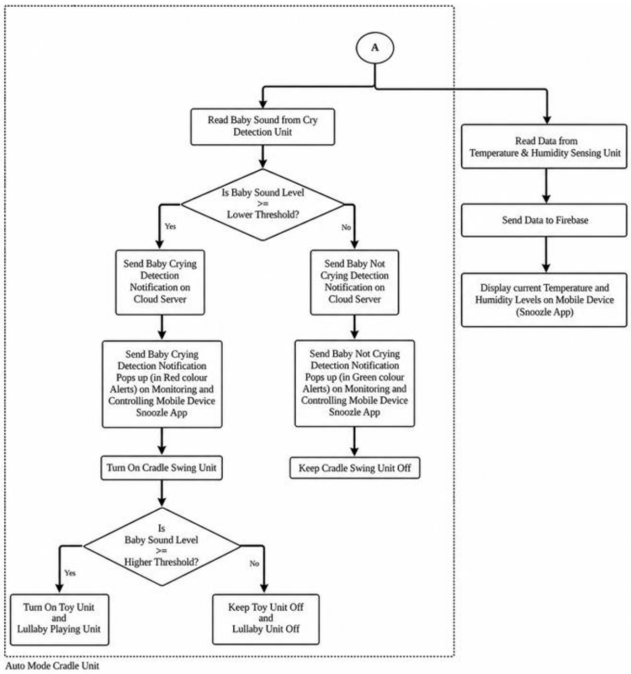

Figure 3. Automated Cradle Operation

Figure 3 illustrates the automatic operation of the smart cradle system based on real-time baby monitoring. The cry detection unit continuously analyzes the baby's sound level and compares it with predefined threshold values to determine whether the baby is crying. Based on this evaluation, notifications are transmitted to the cloud server and further displayed on the mobile application to alert the user. When the sound level exceeds the lower threshold, the cradle swing mechanism is activated to soothe the baby, while lower sound levels keep the system in an idle state.

In addition, if the sound intensity crosses a higher threshold, auxiliary soothing mechanisms such as the toy unit and lullaby playing unit are triggered to provide enhanced comfort. Simultaneously, environmental parameters including temperature and humidity are monitored and updated to the cloud server, enabling real-time visualization on the mobile application. This integrated approach ensures automated response, continuous monitoring, and improved infant care without requiring constant manual intervention.

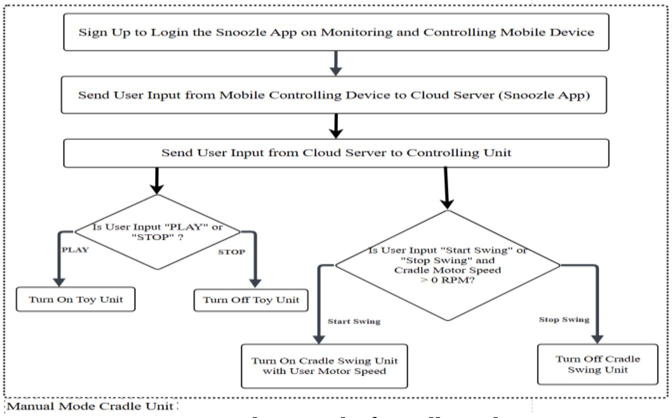

Figure 4. Manual Control of Cradle and Toy Unit

Figure 4 illustrates the manual control functionality of the smart cradle system through the mobile application. User inputs are transmitted from the mobile device to the cloud server and further relayed to the controlling unit, enabling remote operation. Based on the selected commands, the user can control the toy unit by initiating play or stop actions, allowing interactive engagement with the infant.

Additionally, the cradle swing mechanism can be manually operated by specifying start or stop commands along with the desired motor speed. The system processes these inputs in real time, ensuring precise control over the cradle movement. This manual mode provides flexibility to the user, allowing direct intervention and customization of cradle behavior beyond automated responses.

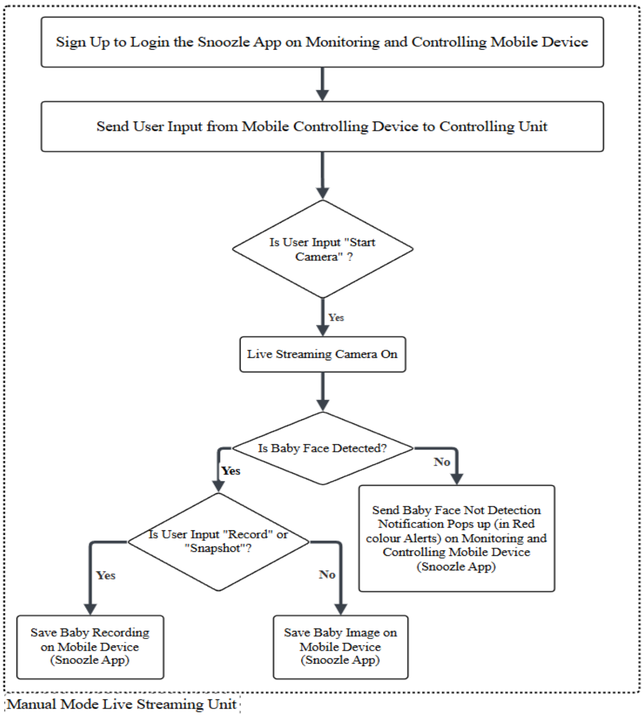

Figure 5. Live Streaming and Baby Monitoring

This figure 5 illustrates the live streaming and baby monitoring functionality of the smart cradle system through the mobile application. Upon receiving the user command, the camera module is activated to provide real-time video streaming of the baby. The system continuously processes the captured frames to detect the presence of the baby's face, ensuring effective monitoring.

If the baby's face is not detected, an alert notification is generated and displayed on the mobile application to notify the caregiver. In cases where the baby is successfully detected, the user is provided with options to either capture an image or record a video. The captured media is then stored on the mobile device for future reference.

This feature enhances remote monitoring capabilities by allowing caregivers to visually track the baby's condition in real time. It also adds an additional layer of safety and convenience by enabling instant alerts and media capture, making the system more reliable and user-friendly.

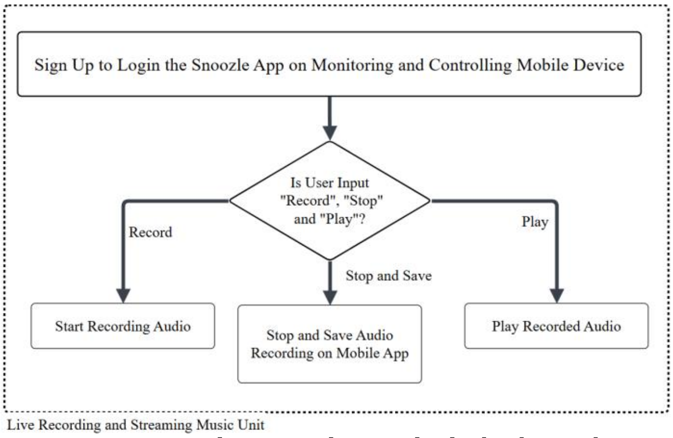

Figure 6. Audio Recording and Playback Mechanism

This Figure 6 presents the audio recording and playback functionality integrated within the smart cradle system through the mobile application. The user can initiate recording, stop and save the audio, or play previously recorded audio based on the selected input. The recorded audio is stored within the application, allowing it to be accessed and replayed when required.

This feature enables parents or caregivers to record personalized audio, such as lullabies or voice messages, which can be played to comfort the baby. The simple control mechanism ensures ease of use while enhancing interaction and providing a soothing environment for the infant. The use of wireless communication protocols enhances flexibility by allowing remote monitoring and control without physical intervention.

V. RESULTS

The proposed smart cradle system was successfully designed, implemented, and tested to evaluate its performance in real-time infant monitoring and automated soothing. The experimental setup consists of a fully functional cradle integrated with sensors, actuation mechanisms, an ESP32-based controller, and a mobile application interface. The hardware prototype, as shown in the results image,

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demonstrates stable mechanical construction, safe cradle suspension, and proper integration of electronic components.

During testing, the system effectively detected infant crying using the sound sensor and responded by initiating automated actions such as cradle swinging, play toy activation, and lullaby playback based on the predefined control logic. The swinging mechanism produced smooth and stable oscillatory motion without sudden jerks, confirming the reliability of the link mechanism and DC motor control. This ensured infant comfort while maintaining operational safety.

A. Smart Cradle Hardware Structure

Figure 7. Photograph showing the actual physical implementation of various smart cradle units

Figure 7 shows the physical implementation of the proposed smart cradle system along with the placement of all hardware components used for monitoring and automation. The arrangement of each device is carefully selected to ensure accurate sensing, effective monitoring, and smooth mechanical operation of the cradle. Proper positioning of sensors and modules allows the system to collect reliable data and perform actions efficiently based on the microcontroller's control logic.

At the top section of the cradle frame, the toy motor is mounted on the horizontal support bar. This position allows the motor to rotate or move a toy placed above the baby's view. The placement is important because toys positioned above the cradle naturally attract the baby's attention. When the system detects crying through the sound sensor, the microcontroller sends a signal to activate the toy motor. The moving toy acts as a visual stimulus that may help calm the baby or distract them from crying.

Near the toy motor, a camera module is installed facing downward toward the cradle bed. The direction of the camera is carefully adjusted so that it captures a clear view of the baby and the surrounding area inside the cradle. This placement ensures that parents can monitor the baby's movements, posture, and activities in real time through the monitoring application. Positioning the camera above the cradle also minimizes obstruction and provides a wide field of view for continuous observation.

On the left side of the cradle frame, a wireless speaker is attached. This component is responsible for playing lullabies or voice messages when the system detects that the baby is crying. The speaker is positioned close enough to the baby so that the sound can be heard clearly, but not too close to avoid discomfort due to high volume levels. When the microcontroller determines that additional soothing is required, it sends a command to the speaker to play calming audio.

On the right side of the cradle frame, the temperature and sound sensor module is installed. This placement allows the sensor to accurately measure the environmental conditions around the baby while also detecting the baby's cry. The sensor is directed toward the cradle area so that it can capture sound signals effectively and measure the ambient temperature near the infant. These readings are continuously transmitted to the microcontroller, which analyzes them and decides whether an action is required.At the lower right side of the cradle frame, the cradle motor is mounted and mechanically connected to the cradle structure. This motor is responsible for generating the rocking motion of the cradle. Its placement near the base of the cradle frame provides mechanical stability and allows controlled oscillation of the cradle without affecting the mounted sensors or monitoring devices. When the microcontroller receives a cry signal from the sound sensor, it activates the cradle motor to initiate gentle swinging, which helps soothe the baby.

Overall, the hardware arrangement shown in Figure 3 follows a systematic design where sensing, monitoring, and actuation components are positioned based on their functional requirements. Sensors are placed close to the baby for accurate data acquisition, monitoring devices are positioned above the cradle for clear observation, and motors are mounted on structural points to ensure stable mechanical motion. This coordinated placement enables the smart cradle system to operate efficiently by continuously sensing the baby's condition, processing the data through the microcontroller, and activating the appropriate comforting mechanisms when necessary.

B. Web Application Interface for Smart Cradle System

The web-based application interface developed for monitoring and controlling the smart cradle system. The web application acts as the communication layer between the caregiver and the cradle hardware. Through this interface, users can observe the baby's status, receive sensor updates, and manually control different system features. The design of the interface follows a structured layout so that each function of the smart cradle can be accessed easily.
The interface is kept simple so that even first-time users can navigate it without confusion. All the main features are clearly visible, which reduces the time required to operate the system. The design also focuses on smooth interaction, so users can quickly check the baby's status and control the cradle when needed. This makes the overall system more practical for daily use.In addition, the interface is designed to work smoothly across different devices such as mobile phones and laptops, making it convenient for users to access it anytime. The

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response time of the system is kept minimal so that actions like starting or stopping the cradle happen without noticeable delay. Clear labels and simple controls also reduce the chances of user error. Overall, the interface supports efficient monitoring and control while keeping the user experience straightforward.The system also maintains consistency in how information is displayed, so users do not get confused while switching between different features. Basic feedback is provided for user actions, which helps in understanding whether a command has been executed or not. This makes the interaction more reliable and easy to follow. Over time, such a simple and clear interface helps users become comfortable with the system without needing much guidance.

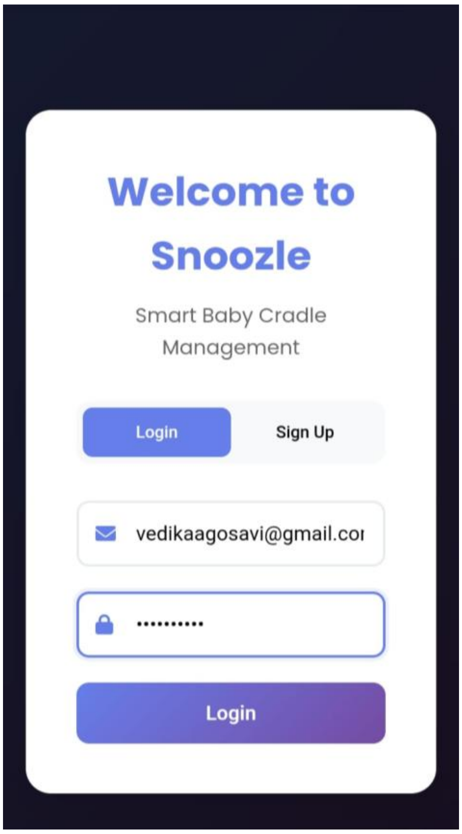

Figure 8. Login Interface

Figure 8 shows the Login Interface of the Web Application. This screen is the first interaction point for users accessing the system. At the top of the interface, the title "Welcome to Snoozle – Smart Baby Cradle Management" introduces the application and its purpose. Below the title, the interface provides two main options: Login and Sign Up. The login option allows registered users to access their existing accounts, while the sign-up option enables new users to create an account. The login process requires two main input fields: the email field and the password field. The email field is used to identify the registered user, while the password field ensures secure authentication. Once the correct credentials are entered, the user presses the Login button, which sends the authentication request to the backend system (Firebase). The system then verifies the credentials and grants access to the main dashboard if the information is valid. This authentication step ensures that only authorized caregivers can monitor and control the cradle system.This improves the overall user experience and ensures that access to the system remains secure and reliable.

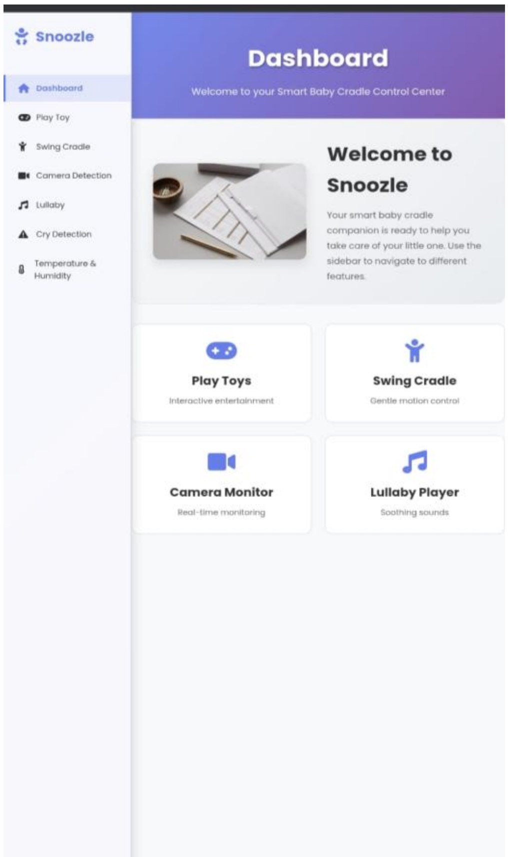

Figure 9. Dashboard Interface

Figure 9 illustrates the Dashboard Interface of the Web Application, which appears after successful login. The dashboard acts as the central control panel for the smart cradle system. On the left side of the screen, a navigation panel is displayed. This panel provides quick access to different modules such as Play Toy, Swing Cradle, Camera Detection, Lullaby, Cry Detection, and Temperature and Humidity Monitoring. Each option represents a specific functionality connected to the hardware components of the cradle system. For example, selecting the toy option triggers the toy motor, while the swing cradle option activates the cradle motor.

The main section of the dashboard contains a welcome panel that briefly describes the purpose of the application and guides the user in navigating different features. Below this section, the interface displays multiple functional control blocks, each representing a particular system operation. The Play Toys block allows the caregiver to activate the toy mechanism connected to the cradle. The Swing Cradle block enables manual control of the cradle's rocking motion. The Camera Monitor block provides access to the live video feed captured by the camera module installed above the cradle. This feature allows parents to observe the baby in real time. The Lullaby Player block allows the caregiver to play soothing music or recorded lullabies through the wireless speaker to calm the baby.

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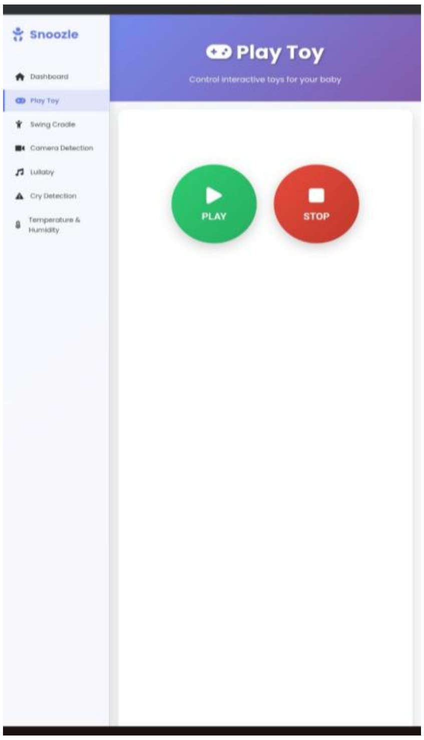

Figure 10. Play Toy Control Interface

In Figure 10, the Play Toy Control Interface shows a simple control panel with two buttons: Play and Stop. When the user presses the Play button, a command is sent from the web application to the cloud server, which then forwards it to the IoT controller. Based on this command, the controller activates the toy mechanism.

Similarly, when the Stop button is pressed, a signal is sent to the controller to stop the toy immediately. This allows the user to control the toy at any time and ensures safe operation.

Overall, this module helps in providing smooth and real-time interaction between the user and the toy through the web-based interface.This design keeps the control process simple and user-friendly, reducing any delay in response. It also ensures that the toy can be started or stopped instantly based on user input. Such real-time control improves safety and reliability during operation.

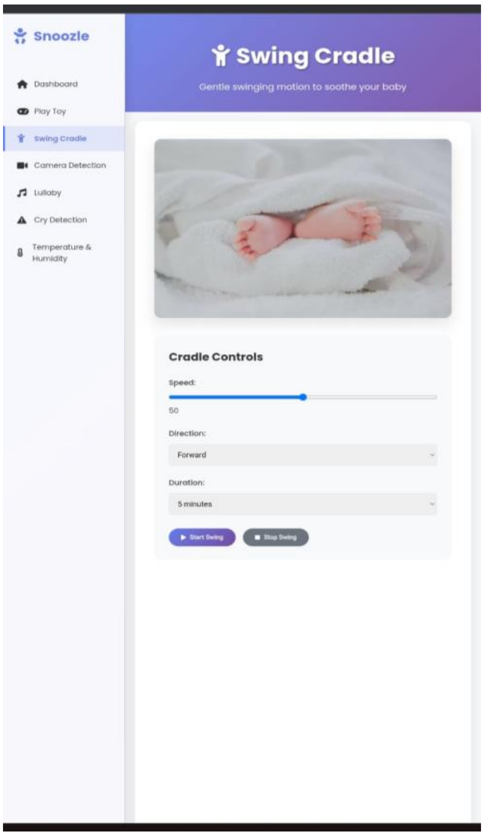

Figure 11. Cradle Swing Control Interface

In Figure 11. Swing Cradle Control Interface**,** The Swing Cradle interface enables automated control of the baby cradle through the web application. It allows users to adjust motion parameters such as speed, direction, and duration to provide a gentle swinging motion that helps soothe the baby.The interface includes a header and a visual display representing the cradle module, which improves user understanding of the system functionality. The main control panel provides configurable parameters including speed control, direction selection, and duration setting.

The speed of the cradle is adjusted using a slider that sends a control signal to the motor controller. The system regulates motor speed using Pulse Width Modulation (PWM), allowing smooth and adjustable swinging motion.Direction selection allows the cradle to swing either forward or reverse by changing the motor rotation through the motor driver circuit. The duration parameter defines the time for which the cradle will operate, after which the system automatically stops the motor using a timer mechanism. Additionally, the interface provides Start Swing and Stop Swing buttons. The Start Swing button activates the cradle based on the selected parameters, while the Stop Swing button immediately stops the cradle motion, ensuring safe and manual control of the system.

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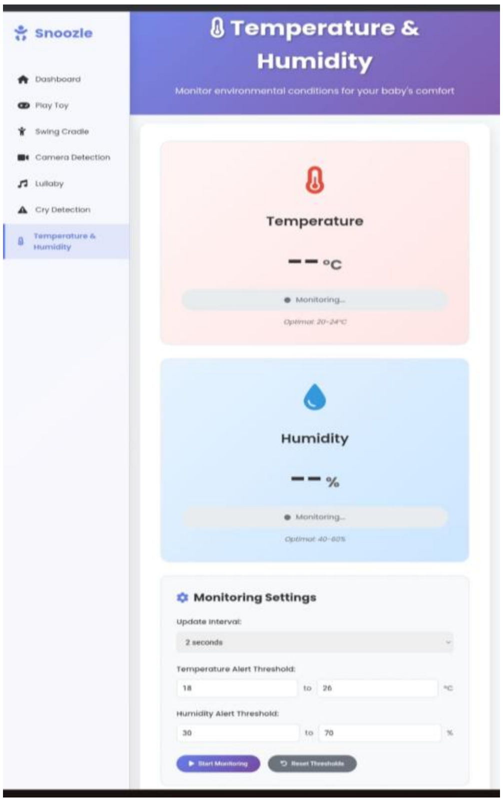

Figure 12. Temperature and Humidity interface

Figure 12. represents the Temperature and Humidity interface which monitors the surrounding environmental conditions of the baby in real time using sensors. It displays the current temperature in °C and humidity in percentage on the web application.

The system reads values from the sensors and sends them to the server, where they are displayed on the interface and updated at regular intervals. The Monitoring Settings block allows users to set the update interval and define temperature and humidity threshold limits. The system continuously compares the sensor values with these limits, and if the values exceed the predefined range, an alert can be generated to ensure a safe environment for the baby.This feature helps parents keep track of the baby's surroundings without checking manually every time. It also makes it easier to take quick action if the room becomes too hot, cold, or humid. By maintaining proper environmental conditions, the system adds an extra layer of comfort and safety for the baby.In addition, the interface is designed in a way that the readings are easy to understand at a glance. The regular updates ensure that the displayed values remain accurate and reliable. This reduces the chances of missing any sudden changes in the environment. It also supports better decision-making for maintaining a comfortable space for the baby. Overall, this module improves the usability of the system by providing continuous and clear environmental feedback.

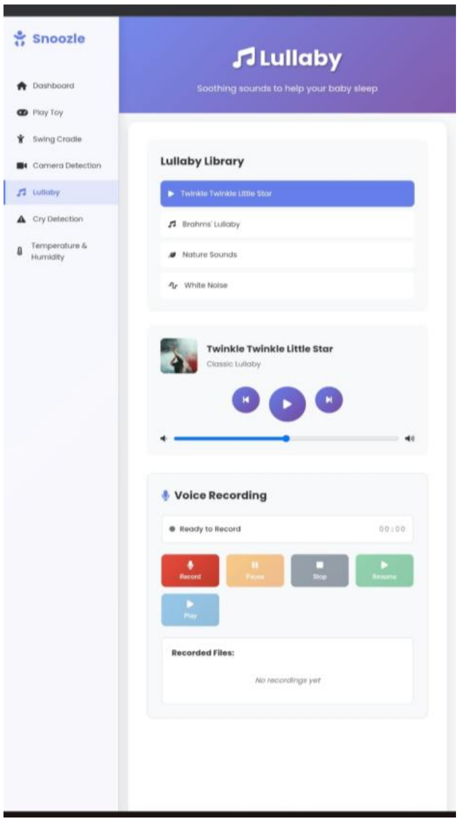

Figure 13. Lullaby interface

In Figure 13 The Lullaby interface provides an audio playback feature designed to help soothe the baby using calming music or recorded voice messages.

The audio player block provides controls such as Play, Pause, Next, and Previous, along with a progress slider that allows users to manage the playback easily. The system responds to user commands by starting, pausing, or switching between tracks while continuously updating the progress bar during playback. Additionally, the interface includes a voice recording block that allows users to record personalized voice messages using the device microphone. Users can record, pause, resume, and stop recordings, which are then saved and stored in the recorded files section. These saved recordings can be accessed and played later, enabling parents to use custom voice messages to comfort the baby.

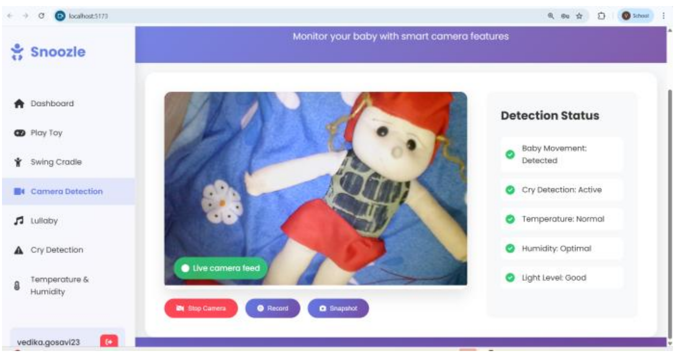

Figure 14. Face Detection Interface

In Figure 14, the Camera Detection Interface provides a live view of the cradle area using the camera module, allowing users to monitor the baby in real time. This feature helps in keeping track of the baby's presence and basic movements without needing to be physically near the cradle. The system continuously performs face detection to check whether the baby is properly visible in the frame.

If the face is not detected for a certain period, the system generates an alert notification, which is highlighted in red on the interface. This draws immediate attention and helps the user take quick action if required. The use of visual alerts makes it easier to notice such situations without constantly observing the screen.Overall, this module improves the reliability of monitoring by combining live video feed with simple detection logic, making the system more responsive and useful in real-life conditions.

In summary, the experimental results validate that the proposed smart cradle system operates reliably and efficiently. The combination of automated soothing, environmental monitoring, cloud-based data storage, and mobile application control successfully enhances infant comfort, caregiver convenience, and system responsiveness. These results confirm the feasibility of the smart cradle as a practical solution for modern infant care in both home and healthcare environments.

VI. CONCLUSION AND FUTURE SCOPE

The proposed IoT-based smart cradle system focuses on improving infant monitoring and caregiving by integrating multiple sensors and real-time response mechanisms. The system is capable of tracking environmental conditions such as temperature and humidity, along with detecting baby movements and crying patterns. Experimental observations show that the system provides reliable performance, with environmental sensing achieving around 99% accuracy, while the cry detection module responds quickly to identify infant distress. These features help in ensuring timely actions such as activating the cradle or notifying the caregiver.

The system also offers a user-friendly web interface, allowing caregivers to monitor the baby's condition and control different functions with ease. Feedback from users indicates that the interface is simple to understand and supports efficient monitoring in day-to-day usage. By combining automation with manual control, the system ensures both flexibility and safety during operation.

Although the current system provides continuous monitoring and basic automation, there is scope for further improvement. In future, AI-based techniques can be integrated to make the system more intelligent, such as analyzing baby behavior patterns and improving response decisions over time. This can help the system become more adaptive and responsive based on real usage. In addition, integrating advanced wetness detection using sensors embedded within the cradle fabric can further improve hygiene monitoring. Materials like polyester can be considered due to their durability and compatibility with embedded sensing elements.

Overall, the smart cradle system provides a balanced approach by combining safety, comfort, and automation. It reduces the need for constant manual supervision and helps caregivers respond more effectively to the baby's needs. With further improvements, the system has the potential to evolve into a more intelligent and adaptive solution for infant care in both home and healthcare environments.

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