ISSN 2278-3091
Volume 15, No.1, January – February 2026
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse021512026.pdf
https://doi.org/10.30534/ijatcse/2026/021512026

Smart Cradle: An Automated Soothing Baby Cradle Integrated with Mobile App for Remote Control and Assistive Features

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Received Date: December 13, 2025 Accepted Date: January 21, 2026 Published Date: February 06, 2026

ABSTRACT

Babies need quick attention and comfort when they cry. It is a struggle for caregivers to quickly respond in situations where they have multiple tasks to handle or during nighttime hours. Putting the baby into the cradle is the common way used to comfort the baby and help them fall asleep. Reviewing related studies, there are existing systems that offer automation in soothing and remote control of the cradle. We identified two major issues: relying on sound-level thresholds to detect infant cries and unreliable internet-based control. To bridge this gap, we design a system that automatically detects baby cry using a cry detection model to achieve high accuracy in the presence of background noise and local connectivity, to allow for remote control of the cradle. The system uses embedded systems for the smart cradle. It performs automatic soothing and integrates Android mobile application development for local cradle control. Even with background noise, the guided testing results reliably detected infant cries. The system started both swinging and lullaby playback. Manual control through the app also needs to be improved, especially in syncing the user interface and hardware. Testing in real-world situations and further refinement of the model, hardware, and software integration are recommended for system usability and reliability.

Key words : Android Application, Automatic Soothing, Baby Cry Detection, Smart Cradle.

1. INTRODUCTION

Parents nowadays, especially mothers with jobs and caregivers, usually face problems in handling their career and family duties [1]. A local survey done by the researchers with 60 parents from Zamboanga del Sur and Zamboanga Sibugay showed that 48.33% had to look after their babies while doing household tasks. Also, Milieu Insight survey found that six in ten working Filipino mothers find it hard to manage their jobs and family duties [2]. Taking on multiple tasks may cause increase time pressure and feelings of overwhelm among caregivers. About 20–30% of babies cry frequently and have sleep difficulties without a clear cause, and this associated with parental stress and, in a small number of cases, impulsive maltreatment [3]. Continuous and frequent crying is also said to have a strong emotional effect on caregivers, such as rising stress, burnout, and harm to mental health [4]. Since caregivers usually respond when babies cry too much by carrying, rocking or comforting their infants, these repeated efforts may cause tiredness and physical strain, making everyday caregiving harder. Traditional cradles like baby hammocks and rocking cradles, have long provided infants with a soothing and comforting sleep environment. Research demonstrates that the gentle rocking motion of these cradles entrains spontaneous neural oscillations, which benefits sleep quality and memory consolidation [5]. Additionally, soothing music or lullabies have been shown to calm infants and support cognitive development. Studies indicate that music exposure in premature infants enhances high-level cognitive brain networks, especially in regions associated with sensory, cognitive, and social-emotional processing [6]. Traditional methods are still common but require manual operation. This is time-consuming and physically demanding, especially for caregivers with many tasks. Many studies of automated cradles offer comfort for babies through automation. However, most systems use loud noise detection for cries, which makes them prone to background noise interference. Problems with internet connectivity also occur when monitoring and controlling the cradle remotely. These issues show the need for a system with high accuracy in detecting infant cries and the ability to provide both automatic and manual soothing responses.

This study presents the Smart Cradle. It integrates an Internet of Things (IoT) system with an Android mobile app for both automatic and manual soothing. The Smart Cradle aims to help parents and caregivers by providing temporary support when responding to an infant's needs is difficult. The application also helps manage other baby-related tasks.

2. PURPOSE AND DESCRIPTION

Taking care of a baby is usually handled by mothers, especially in families where fathers are the breadwinner. Homemakers, on the other hand, handle many other duties aside from caring for their baby, such as household chores, running small businesses or doing part-time jobs to earn extra income. For single parents and working mothers, handling these tasks can very be demanding. Activities like feeding, calming down and caring for the baby are important, yet they can be exhausting when added to work and home tasks. In such situations, having dependable help can really ease the load on caregivers, allowing them to focus on other task without affecting baby's health or comfort. The purpose of this study is to design and develop a smart baby cradle that offers short term help in attending to babies needs. This Smart Cradle will use IoT technology for remote control, which will allow users to move the cradle and turn on calming functions using an Android mobile application. Additionally, the system includes helpful features like health reminders, daily routines and breast and sleeping tracker to help caregivers for daily baby care. Through automation of baby care task, this project aims to lighten the loads for parents and caregivers, making sure infants get enough care and comfort while helping caregivers handle their other task.

3. SYSTEM PERSPECTIVE

The Raspberry Pi acts as the central processor that gets commands from the mobile application and takes over cry detection, as shown in Figure 1. It communicates with the ESP32 to activate the motor-driven swing mechanism, while the Bluetooth speaker is connected to the Raspberry Pi for music playback. The ESP32 is programmed to interface directly with the Raspberry Pi to receive and execute the commands processed by the central system. The mobile application connects to the Raspberry Pi's local network, which enables users to send control inputs such as swing activation or music playback. The Raspberry Pi handles these incoming commands and forwards the necessary actions to the ESP32, which drives the motor for cradle swinging. At the same time, a Bluetooth speaker connected to the Raspberry Pi enables audio playback, while the Pi also manages cry detection and other automated responses.

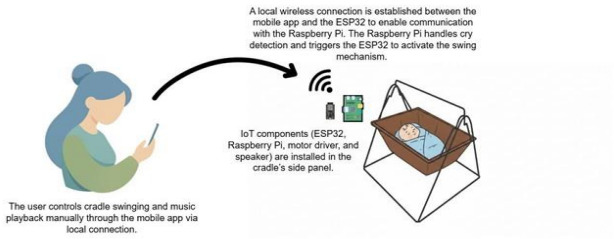

Figure 1: System Block Diagram

a. Flowchart

Figure 2 shows and describes the operational flow of the system. It starts by establishing the connection between the mobile application and the Smart Cradle System's Network. Once connected, the user selects whether to run the cradle in Automatic or Manual mode through the mobile application. If Manual Mode is chosen and manual control is selected, the system allows the user to operate the cradle directly through the app to enable activation of the swing mechanism and lullaby playback. Alternatively, if Automatic Mode is selected and auto-control is enabled, the system transitions into a real-time monitoring state in which the Raspberry Pi continuously receives and analyses audio input from the microphone to detect a baby's cry. When no cry is detected, the system remains in monitoring mode and loops back to reassess incoming audio. However, once a cry is identified by the cry-detection model, the Raspberry Pi signals the ESP32 to activate the swing mechanism and simultaneously triggers the Bluetooth speaker to play soothing lullabies. The operations will be stopped if the connection between the mobile application and the cradle system is lost. Regardless of the selected mode, the process runs in a continuous loop, either manual control or fully autonomous soothing based on the baby's detected crying behavior.

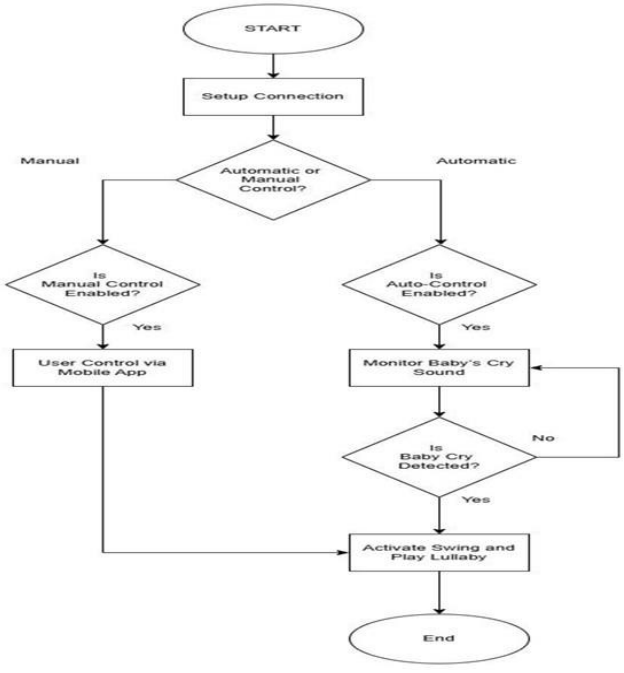

Figure 2: System Flowchart

4. SUMMARY, CONCLUSION AND RECOMMENDATIONS

4.1 Summary

This study developed a smart cradle that performs automatic soothing using Raspberry Pi and ESP32 upon cry detection and combines Android mobile application for cradle monitoring and control with an assistive task that helps parents or caregivers for their baby care tasks. The process involves selecting the suitable hardware components, creating the prototype and implementing algorithms using tools like Arduino IDE, Android Studio and Visual Studio Code. Pilot and Main Test are conducted to evaluate the system's functionality, responsiveness and its overall performance. The results showed that the system's features work as intended such as automatic swinging of cradle and playing of music, and manual control for the app. Due to limited size of the training dataset, cry detection is inconsistent in cases when the sound tested is solely a loud noise placed near the wireless microphone but it has high cry detection accuracy in the presence of a background noise. The swing command functioned properly, but the cradle moved slowly and had only one speed option. Overall, the system's core functionality works but still has room for improvement in future versions.

4.2 Conclusion

This study developed a smart cradle that performs automatic soothing using Raspberry Pi and ESP32 upon cry detection and combines Android mobile application for cradle monitoring and control with an assistive task that helps parents or caregivers for their baby care tasks. The process involves selecting the suitable hardware components, creating the prototype and implementing algorithms using tools like Arduino IDE, Android Studio and Visual Studio Code. Pilot and Main Test are conducted to evaluate the system's functionality, responsiveness and its overall performance. The results showed that the system's features work as intended such as automatic swinging of cradle and playing of music, and manual control for the app. Due to limited size of the training dataset, cry detection is inconsistent in cases when the sound tested is solely a loud noise placed near the wireless microphone but it has high cry detection accuracy in the presence of a background noise. The swing command functioned properly, but the cradle moved slowly and had only one speed option. Overall, the system's core functionality works but still has room for improvement in future versions.

4.3 Recommendation

This study developed a smart cradle that performs automatic soothing using Raspberry Pi and ESP32 upon cry detection and combines Android mobile application for cradle monitoring and control with an assistive task that helps parents or caregivers for their baby care tasks. The process involves selecting the suitable hardware components, creating the prototype and implementing algorithms using tools like Arduino IDE, Android Studio and Visual Studio Code. Pilot and Main Test are conducted to evaluate the system's functionality, responsiveness and its overall performance. The results showed that the system's features work as intended such as automatic swinging of cradle and playing of music, and manual control for the app. Due to limited size of the training dataset, cry detection is inconsistent in cases when the sound tested is solely a loud noise placed near the wireless microphone but it has high cry detection accuracy in the presence of a background noise. The swing command functioned properly, but the cradle moved slowly and had only one speed option. Overall, the system's core functionality works but still has room for improvement in future versions.

ACKNOWLEDGEMENT

We extend our gratitude to all who supported us in completing our thesis. Above all, we thank God, our families, friends, and colleagues for their steady support, financially, emotionally, and spiritually. Their encouragement and belief in us kept us motivated to finish this research. We are truly thankful to our mentor since our second year, and now our thesis adviser, Mr. Syril Glein T. Flores, for his steady support, guidance, and expertise. The authors would also like to thank Dr. Philipcris C. Encarnacion along with Mr. John Aaron G. Belza, Mr. Niel Patrick O. Neri, and Mr. Leomar F. Neovo, for their comments and suggestions. Their feedback and constructive criticism helped improve the study and made sure it met the required academic standards and guidelines.

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