



An Intelligent Robot for Monitoring and Protecting Toddlers.
Final Report

TMP-23-326


BSc (Hons) in Information Technology
Specializing in Computer Systems & Network Engineering

Department of Computer Systems Engineering
Faculty of Computing
Sri Lanka Institute of Information Technology

September 2023

DECLARATION

I declare that this is my own work, and this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to Sri Lanka Institute of Information Technology the non-exclusive right to reproduce and distribute my dissertation in whole or part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

| Date | Name | Student ID | Signature |
|------------|---------------|------------|---|
| 09/09/2023 | W. R. Lakshan | IT20093150 |  |

.....
Signature of the supervisor: Prof. Sanath Jayawardena

.....
Date

.....
Signature of the co-supervisor: Ms. Rangi Liyanage

.....
Date

ABSTRACT

In recent years, there has been a noticeable augmentation in the interest towards the construction of intelligent robots that could cater to an array of applications, ranging from monitoring to safeguarding toddlers. One of the significant applications in this domain is the monitoring and protection of toddlers. The objective of this article is to provide an elaborate description of the conception and development of an intelligent robot system, primarily aimed at surveilling and safeguarding children present in both households and daycare facilities. The main goal of the proposed robot system is to oversee children's activities in real-time. An intelligent robot was designed and built for this study to help parents and other caregivers watch over toddlers and ensure their safety. The robot can watch and record toddlers' motions and acts thanks to its array of sensors, which includes microphones, cameras, and motion sensors. Its functionality is further enhanced by its ability to adapt and learn from the behavior of toddlers over time, making it a valuable security and surveillance device. The robot also encompasses an intelligence algorithm that scrutinizes the surroundings for any potential hazards and promptly notifies the parents or guardians of any toddler who may be in danger. The robot has been furnished with a myriad of features, including an alert, navigational abilities, the ability to play lullabies automatically by detecting the toddlers' crying situations, and the capability to monitor toddler behavior. The primary goal of the robotic system is to furnish parents and caregivers with a feeling of comfort while simultaneously guaranteeing the child's safety and welfare. Parents and other caregivers can surely benefit from the intelligent robot that keeps an eye on and defends newborns and toddlers. The sophisticated attributes of this technology ensure that the young child is protected, stimulated, and appropriately taken care of. The implementation of this system lead to a transformation in the way we care for and interact with toddlers, thus offering a valuable complement to the overarching parenting framework.

ACKNOWLEDGEMENT

We would like to offer our sincere gratitude and appreciation to everyone who helped to make our senior project, "An Intelligent Robot for Monitoring and Protecting Toddlers. This project is the result of our perseverance, commitment, and the priceless assistance and advice we received from various people. First and foremost, we want to express our sincere gratitude to the following individuals.

Supervisor - Prof. Sanath Jayawardena

Co-supervisor - Ms. Rangi Liyanage

They guided us through the entire endeavor with their experience, insight, and steadfast support. Their wise counsel and important insights have played a crucial role in the development of our research, methodology, and implementation strategies. Also, we want to express our sincere gratitude to our other classmates and group members who worked tirelessly with us, contributing their knowledge, ideas, and expertise. The accomplishment of this project was greatly influenced by their contributions and teamwork.

TABLE OF CONTENTS

| | | |
|-------|--|----|
| 1. | Introduction..... | 1 |
| 1.1 | Background and literature survey | 3 |
| 1.2 | Research gap | 7 |
| 2 | Research problem..... | 9 |
| 3 | Research objectives..... | 11 |
| 3.1 | Main objective..... | 11 |
| 3.2 | Specific objectives..... | 13 |
| 4 | Methodology | 14 |
| 4.1 | Overall system architecture diagram..... | 14 |
| 4.1.1 | Crying Detection & Automate Lullabies Playing System | 16 |
| 4.2 | Requirements..... | 18 |
| 4.2.1 | Functional Requirement..... | 18 |
| 4.2.2 | Non-Functional Requirements | 19 |
| 4.2.3 | System Requirements..... | 21 |
| 4.3 | Commercialization Aspects..... | 22 |
| 4.3.1 | Market Opportunity | 22 |
| 4.3.2 | Target Audience | 23 |
| 4.3.3 | Demand | 24 |
| 4.3.4 | Marketing Strategies | 25 |
| 4.4 | Financials | 26 |
| 4.5 | Testing and Implementation | 28 |
| 4.5.1 | Software and Hardware Implementation | 28 |
| 4.5.2 | Testing..... | 29 |
| 5 | Result and discussion..... | 37 |
| 5.1 | Results | 37 |
| 5.2 | Research Findings | 38 |
| 5.3 | Discussion | 39 |
| 6 | Summary of personal contribution..... | 39 |

| | | |
|-----|--|----|
| 6.1 | Toddler Following and Obstacle Avoidance Robust Navigation System..... | 39 |
| 6.2 | Toddler Monitoring & Animal Detection System | 40 |
| 6.3 | Toddler behavior detection & alerting System..... | 40 |
| 6.4 | Toddler Crying Detection & Automate Lullabies Playing System | 41 |
| 7 | Conclusion | 42 |
| 8 | References | 43 |

LIST OF FIGURES

| | |
|---|----|
| Figure 1:Body, foot, hand, and facial key points of a baby sleeping in safe (a) and dangerous (b) positions detected by Openpose..... | 5 |
| Figure 2:Mel-spectrogram samples of baby crying sounds (x-axis: time, y-axis: frequency)..... | 6 |
| Figure 3:Types and Percentages of child abuse | 9 |
| Figure 4:Overall System Architecture Diagram | 14 |
| Figure 5:Component System Diagram..... | 16 |
| Figure 6: Implementation process of the system. | 28 |
| Figure 7: Sound testing through VLC player..... | 31 |
| Figure 8:Lullaby playing checking | 32 |
| Figure 9:Solid work sketch | 33 |
| Figure 10:Base of the robot..... | 34 |
| Figure 11:Speaker Implementation..... | 35 |
| Figure 12:Raspotify API Implementation..... | 36 |

LIST OF TABLES

| | |
|---|----|
| Table 1:Research Gap | 8 |
| Table 2:Functional Requirements. | 18 |
| Table 3:Non-Functional Requirements | 20 |
| Table 4:System Requirements..... | 22 |
| Table 5:Estimated Budget | 27 |
| Table 6:Component Estimated Budget | 27 |
| Table 7:Summary of the test cases | 30 |

1. INTRODUCTION

In recent years, the field of robotics has made great progress in building intelligent robots capable of performing a range of activities. These advancements have been made possible by the rise of artificial intelligence. In the field of childcare, where robots can be of tremendous aid to both parents and caregivers, they have demonstrated particularly promising results. The use of intelligent robots for the purpose of monitoring and protecting toddlers is a particularly important use of this technology since these robots can contribute to the protection and well-being of toddlers. Within the scope of this project is the design and development of an intelligent robot with the purpose of supervising and protecting toddlers.

In this fast-paced and demanding world, modern parents frequently have to balance various duties, such as rigorous job schedules, home responsibilities, and parenting issues. The aforementioned duties may incorporate tasks such as maintaining household cleanliness, tending to the needs of offspring, and managing financial obligations. These competing demands can make it difficult for parents to keep constant supervision over their energetic toddlers, which raises worries regarding both their safety and their toddlers' well-being. We propose the development of an intelligent robot that can act as a reliable and watchful companion for toddlers, remotely monitoring them and sending their parents real-time alerts when it is deemed necessary to do so. This innovative resolution not only aims to assuage the apprehensions of guardians of juveniles ranging from 2 to 5 years of age, but also harbors the capacity to be efficacious in various other settings such as childcare centers, recreational areas and preschools, among other potential avenues. The development of a sophisticated and effective method for monitoring children will be the focus of our project, which will make use of cutting-edge technologies.

The basis of this system shall be founded upon robotics, which shall render feasible the construction of a robot that is endowed with both physical aptitude and self-sufficiency. This said robot shall possess the ability to perceive and apprehend its environment, classify and categorize objects, and exercise sagacious judgments based on real-time data that has been integrated with artificial intelligence (AI) and machine learning (ML) algorithms. Complementary to this, image processing techniques, in conjunction with OpenCV (Open Source Computer Vision Library),

shall equip the robot with the ability to interpret visual information, recognize faces, discern potential risks or hazards, and effectively monitor the child's activity. The intelligent robot will have advanced navigational capabilities, which will allow it to safely follow the child while independently avoiding obstacles. This will allow the robot to fulfill its intended purpose. This function ensures that the child is under constant surveillance, even in settings in which the child may be exploring or moving rapidly. The robot will keep a watchful eye on the child because it is outfitted with advanced artificial intelligence algorithms and powerful picture processing skills. The utilization of real-time video analysis shall be employed to observe the child's location and undertakings so as to guarantee their well-being and safety. The monitoring system will have the capacity to identify illicit presences, like the presence of an unfamiliar individual in close proximity to the child, and shall expeditiously inform the child's parents or other authorized caregivers. The intelligent robot will be programmed to recognize scenarios in which specific animals pose a risk to the safety of children and to respond appropriately to those situations. Utilizing several techniques for picture identification and categorization. The machine is able to tell the difference between creatures that could be harmful and those that are safe. If the robot detects a potentially harmful animal in the vicinity of the child, it will either drive the animal away or make it avoid the youngster, ensuring the child's protection. As the intelligent robot learns to comprehend the requirements of a toddler, it will be outfitted with the ability to identify the crying and restlessness. When it recognizes these signs, the robot will begin to soothe the toddler by singing lullabies or playing other noises designed to put them at ease.

My contribution to the development of this research project is focused primarily on the creation of a system to detect cries and the concurrent automation of functionalities related to playing lullabies. This significant addition aims to improve the degree of help that is made accessible to parents and other caregivers, with the major purpose being the calming of toddlers when they exhibit signs of distress through the automated playback of lullabies. The lullabies that can be played by the robot can be completely customized, giving parents the opportunity to select tunes that they are confident will have a profoundly calming and relaxing effect on their children. This cutting-edge and intelligent robotic solution, built for the surveillance and protection of toddlers, has the potential to provide parents with a dependable and cutting-edge instrument for ensuring their child's safety and well-being. The solution was designed for the protection of toddlers and is intended to protect them from harm. The implications of this technology are even more far-

reaching because it has the ability to bring about a revolutionary new age in the field of childcare. It could do this by providing parents with an automated method of keeping an eye on and protecting their cherished toddlers.

1.1 Background and literature survey

The application of artificial intelligence (AI) and robotics in childcare settings has recently emerged as a potentially fruitful strategy for boosting the health and safety of infants and toddlers. This document provides a complete history and literature survey in order to contextualize the research project that is focused on "Cry Detection and Automated Lullabies in an Intelligent Robot for Monitoring and Protecting Toddlers."

Over the passage of time, a significant transition has occurred from traditional methodologies to more sophisticated technical solutions in the realm of childcare technology. The advent of cutting-edge innovations in robotics and artificial intelligence has created fresh avenues for enhancing and mechanizing the tasks that were previously undertaken by individuals in the childcare sector. Early childcare was mostly dependent on human intuition and care.

P. Ruthvi Raj Myakala and his coworkers claim that they have developed an advanced intelligent system that is able to reliably detect crying episodes in infants and monitor them continuously. The system sends a prompt notification to the parents in the form of a text message along with a photograph of the newborn whenever their infant is crying. The urgency of the call is taken into account while delivering the notification. A real-time monitoring system has been created with the help of this cutting-edge technology, which makes use of speech signal approaches and hardware components. The system analyzes the real-time audio inputs, extracts the relevant features, and intelligently recognizes the infant cry signals by applying various signal processing techniques. The technology sends a message to a human controller whenever it detects a cry signal. This human controller has the ability to control a smart robot from a remote location using a Wi-Fi connection. The controller will subsequently be able to monitor the baby's surroundings through live video streaming provided by the intelligent robot. Once more, the signal is captured by the microphone on the robot, which extracts characteristics to determine whether or not the sound was that of an

infant crying. Following the completion of the validation process, the system will send messages to the parents that are pertinent to the level of severity of the situation.[1]

According to the Matthew Kay and his team investigations, even while it is essential to keep a watchful check on infants at all times, it can be difficult for parents to do so. Standard CCTV is utilized by some parents in order to keep a watch on their children; however, this method is unable to notify them of any urgent situations. Additionally, many parents are concerned about the electromagnetic waves that are emitted through wearable technology, despite the fact that certain wearable equipment is designed to notify them. on addition, users of these systems are required to invest a significant amount of money on specialist hardware. [2]Because of the aforementioned concerns, we were able to design an automatic baby monitoring service that notifies parents of potential dangers such as crying and rolling over while simultaneously using less technology. The primary functions of the service are the recognition of the baby's emotions, the detection of the infant's screams through the use of EfficientNet, video streaming and voice transmission between the parents and the baby, and notification of detected events. Other capabilities include the ability to monitor potentially hazardous lying postures using OpenPose. OpenPose is a real-time system that uses open-source software to locate critical points on a person's body, feet, hands, and face in order to identify their 2D stance. This library provides estimation of a high quality that is suitable for usage in real-time applications. We decided to go with OpenPose and then updated it so that it could be run on TensorFlow. This allowed us to precisely identify the baby's body components and evaluate whether or not the baby's posture was immediately harmful. The illustration depicts the baby's skeletons in both safe and harmful sleeping positions, making it easy to compare the two.



Figure 1: Body, foot, hand, and facial key points of a baby sleeping in safe (a) and dangerous (b) positions detected by Openpose.

Researchers developed deep neural networks of EfficientNet specifically for crying identification by using mel-spectrograms of 3599 baby crying sounds ("crying") and 3607 environmental noises ("not crying") to train the networks. Transfer learning was applied in this process. [3] The sample sounds were taken from the "donateacry-corpus" and "ESC-10: Dataset for Environmental Sound Classification" sources on GitHub. After that, LibROSA is what's used to get the spectrograms out. In order to test the model, just 20% of the datasets were utilized, while the remaining 80% were utilized to train the model. Because EfficientNet-B3 performed the best with our datasets, we decided to modify it to incorporate a GlobalMaxPooling2D as well as a dense layer. The data for the classification report was produced with the help of Scikit-Learn's classification report. When we sliced and recognized the spectrogram at intervals of one second, the precision of the model for detecting crying was 0.96, and the accuracy was fairly good for certain specific crying patterns. They are constantly looking for ways to improve the precision of their work.[4]

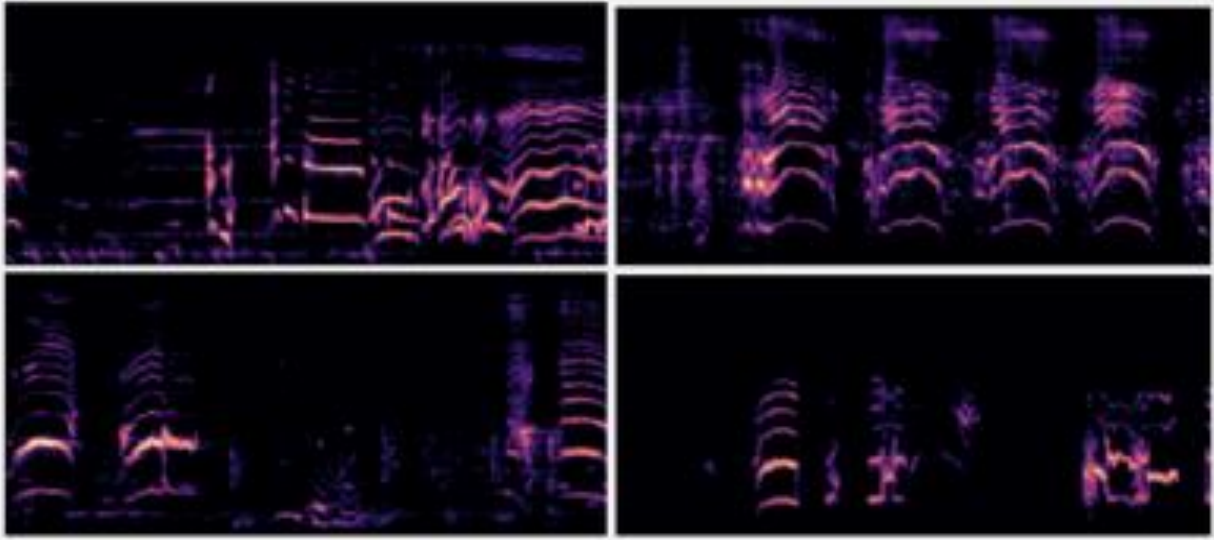


Figure 2: Mel-spectrogram samples of baby crying sounds (x-axis: time, y-axis: frequency)

There is a strong correlation between the environment of one's bedroom and the quality of sleep that they get. To ensure you have the most restful sleep possible, sleep experts recommend sleeping in a room that is at a comfortable temperature, is completely dark, is free from noise, and has no interruptions. [4] However, it can be difficult for an individual to understand which environmental circumstances might be contributing to disturbed sleep. In this study, we discuss the conceptualization, execution, and preliminary evaluation of a capture and access system known as Lullaby. Lullaby generates a comprehensive record of a person's sleep by combining an off-the-shelf sleep sensor with temperature, light, motion, audio, and photo sensors. This allows for the creation of a comprehensive sleep log. According to the findings of the study, environmental influences have been associated with poor sleep quality as well as sleep disruptions, both of which have been linked to daytime drowsiness and weariness. It may be especially challenging to have a good night's sleep in a room that is excessively warm, has inadequate lighting, is distractingly noisy, or has poor air quality. [5] Although some of these environmental influences are easily observable, others may be concealed or more difficult to identify. As a consequence of this, individuals whose quality of sleep is poor frequently have difficulty identifying the cause of their sleep issues or the degree to which they are affected by them.

We have been able to effectively include an automated lullaby feature into our system. This is the novelty part of this section. This feature is able to recognize when the child is crying and will then

automatically generate lullaby that are intended to comfort the toddler. When a parent is absent from their residence or otherwise unable to be in close proximity with their offspring, the availability of this feature can prove to be of immense aid to them. When compared to earlier systems, the automatic lullaby playing system that we have developed offers parents increased utility in the aforementioned circumstances.[6] Furthermore, guardians possess the capability to customize the selection of music to their offspring's distinct palate through the utilization of a specialized musical software, affording them a significant degree of authority over their progeny's auditory encounter.

1.2 Research gap

The growing investigation into the use of intelligent robotic systems in the monitoring and protection of toddlers constitutes a novel and intriguing frontier of research. This frontier is replete with the inherent potential to significantly improve the safety of children while simultaneously easing the burdensome responsibilities that are carried by caregivers. These extremely complex robotic beings claim an astonishing array of skills, ranging from the execution of alerting processes and flawless navigation to the seamless orchestration of automated lullabies and the comprehensive capture of toddler behavior patterns. These capabilities are only a few examples of the astounding array of capabilities that these highly sophisticated robotic entities possess. Nevertheless, it is of the utmost importance to identify the evident gaps that pervade the present corpus of scholarly work. This calls for meticulous investigation to determine the entire extent of practicality and efficacy inherent in the deployment of such robotic equivalents. The primary purpose of this study, which is committed to outlining the existing research gaps, is to precisely identify the key areas within this rapidly developing subject that call for additional in-depth research.

The performance of lullabies is one of the many potential jobs that these intelligent robots for toddlers could have, but it takes on a particularly prominent role when one considers the scenario of a toddler who is upset. However, there is a noticeable lack of thorough study in order to elucidate the complexities of creating the robot's lullaby-playing capabilities and guarantee that it will perform at its highest level of efficiency in emotionally charged scenarios. It is for this reason that

ongoing research attempts are so passionately dedicated to uncovering the complexities of song selection, taking into consideration variables such as the age of the newborn and individual tastes. In addition, the project aims to automate the lullaby system of the robot, with a particular emphasis on promoting interactivity and engagement. Furthermore, as a significant component of this, we included the option to personalize the lullabies in accordance with the preferences of the infant as well as the requirements of the guardians. This will result in the experience of being rich in facets and providing the child in question with a stimulating environment.

| Research | Real time input and output | Voice recognition | Crying detection | Automated lullabies playing | Customization of lullabies |
|--------------------------|----------------------------|-------------------|------------------|-----------------------------|----------------------------|
| Research 1 [4] | ✓ | ✗ | ✓ | ✗ | ✗ |
| Research 2 [1] | ✓ | ✓ | ✓ | ✗ | ✗ |
| Research 3 [7] | ✓ | ✓ | ✓ | ✗ | ✗ |
| Research 4 [8] | ✓ | ✗ | ✓ | ✗ | ✗ |
| Proposed System | ✓ | ✓ | ✓ | ✓ | ✓ |

Table 1: Research Gap

2 RESEARCH PROBLEM

The increasingly hectic lifestyles of modern parents have given rise to a whole host of issues in today's culture, which has resulted in a plethora of obstacles. Within the scope of our research project, our group has effectively identified a primary worry, which is the urgent requirement for parents to devote more time to the care of their toddlers. The fact that parents are expected to perform such a wide variety of commitments, which further reduces the amount of free time they have, is another factor that needs to be taken into consideration. It is extremely important to be aware of the fact that if a parent fails to provide adequate care for their child at critical junctures, this might unintentionally result in undesirable outcomes, creating an atmosphere in which the child and the parent may be subjected to physical or emotional abuse. In the course of our additional research on this topic, we came to the conclusion that the most common cause of abuses involving toddlers is the carelessness of their parents. The figure that is provided for us below can help us obtain a clearer picture of the situation.

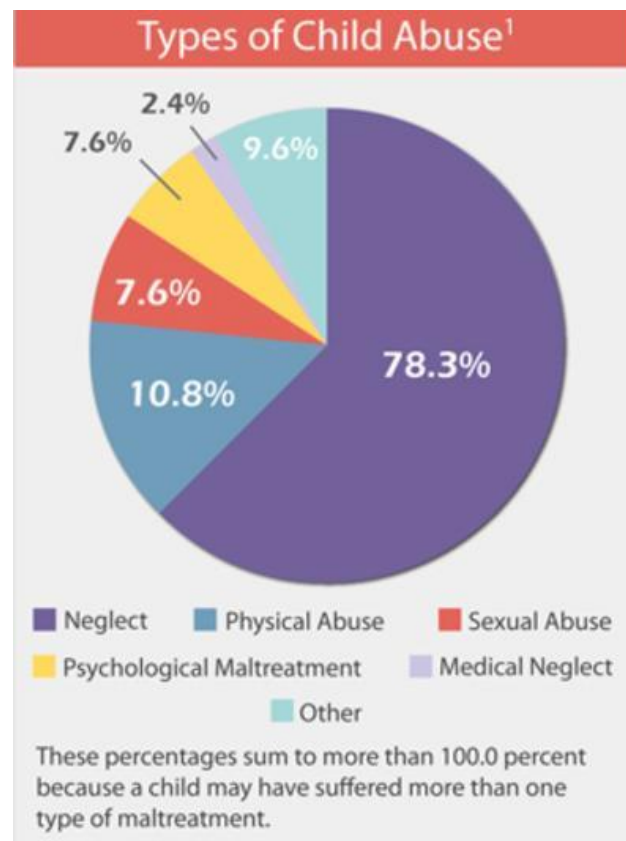


Figure 3: Types and Percentages of child abuse

Our research group has addressed this intricate problem by embracing a holistic perspective that factored in the wellbeing of both the parent and the child. When our cutting-edge solution is put into action, parents will be given the ability to monitor their children. This cutting-edge method gives parents the ability to recognize instances in which their children's actions call for instant attention while also fostering interaction by performing actions such as automatically playing lullabies. The strategy that we have opted to pursue entails the development of a mobile robotic device designed to offer aid to parents in fulfilling the needs of their offspring. This multipurpose robot has the capacity to explore the area immediately surrounding the toddler. In addition, the robot intends to monitor the child's activities by coordinating its actions with those of the toddler. In this way, even at times when the child's parents are physically absent, the robot remains vigilant and ensures that the child's needs and actions are comprehended and promptly reacted to it. Furthermore, our cutting-edge technology allows us to curate musical selections and automatically play lullabies according to the child's specific behaviors, especially crying situations, with the goal of contributing to the promotion of restful sleep and the mitigation of stress in toddlers.

As we embark on this trip, it is essential that we do not lose sight of the ethical and privacy issues that are related to the various technological interventions that we will encounter along the way. We make a solemn pledge to keep the greatest possible safety standards, as well as to respect the independence of both parents and children, as well as their inherent dignity. In spite of the fact that these methods show promise of being effective in boosting the overall well-being of toddlers, encouraging optimal sleep quality, and reducing stress levels, it is incumbent upon us to underline the essential need for rigorous scientific investigations. This investigation present a thorough depiction of the genuine impact that these interventions impose on the diverse facets of the life of toddlers, encompassing their crying, their levels of stress, and their overall perception of well-being.

In addition, we are aware of the importance of continuous scientific inquiry as well as thorough inspection. Through meticulous investigation, we intend to accumulate empirical evidence concerning the impact of our intervention on crucial components of juvenile growth and development, including but not limited to the level of stress experienced by the child, the caliber of rest they receive, and their overall state of well-being. This data will be employed to enlighten the creation and refinement of our intervention. We possess great expectations that, through such

actions, we shall be capable of making a substantial contribution to the corpus of knowledge surrounding efficacious methods of enhancing the well-being and contentment of toddlers who are inhabiting the rapidly changing world of present times. We are elated to proceed with this research investigation in partnership with parents, caregivers, and other members of the community with the aspiration that we shall ultimately be able to effectuate a positive transformation in the lives of families who are endeavoring to navigate the intricacy of contemporary parenting. We possess the capability to fabricate a prospective era in which progenies can flourish in societies that are distinguished by affection, attentiveness, and significant bonds. This future can be shaped by us.

3 RESEARCH OBJECTIVES

3.1 Main objective

The primary objective of the present research endeavor is to develop an ingenious robotic system that possesses a unique capability to deliver all-inclusive care and surveillance to toddlers in the absence of their parents or primary caretakers. This ambitious endeavor seeks to utilize innovative ideation and cutting-edge technological advancements to yield a significant impact in the sphere of safeguarding children. This project aims to support toddlers' emotional and cognitive development in addition to ensuring their physical well-being by fusing cutting-edge robotics and artificial intelligence. By providing parents and other caregivers with a deep sense of comfort and peace of mind about the well-being of their priceless children, this all-encompassing approach to childcare seeks to assuage their worries and anxiety. Overall system objective can be divided into 4 sub-objectives as follows.

Sub Objective 01: Designing a navigation system for the robot that will allow it to navigate around the child in a manner that is both effective and secure, taking into account both navigation and the safe mobility of barriers. This will enable the robot to move around the toddler in a way that is both efficient and safe. The robot able to be able to intelligently clean up the space, for example, in the event that the toddler interacts with it or destroys it, to have a friendly human-robot connection with a child who is under the age of three.

Sub Objective 02: Developing a system for the robot that will enable virtual surveillance of a child's surroundings in order to keep the child safe, and then designing and building that system. This was done in order to keep the child safe. It has the ability to identify any unauthorized presence in real time. In addition, it is possible to identify potential dangers to the child's safety. Moreover, it is imperative to eliminate any creatures that may potentially endanger the toddler while ensuring the safety of both the animal and the child.

Sub Objective 03: Developing a timely notification mechanism that has the capacity to precisely track the child's conduct and impart this data to the guardians. It is able to recognize the child's actions, such as when he runs, sleeps, or climbs into a hazardous area, and also that an animal invades the area and when the child is crying. It sends to the parents through this alerting system.

Sub Objective 04: Developing a system that would provide parents, who are preoccupied with their professional commitments, an opportunity to avail childcare services while they are away from their abodes. Specially in this system is able to avoid disruptions when the toddler is crying, by automatically playing the lullabies. Moreover, this methodology has the capability to grant mental release to both the offspring and their guardians.

3.2 Specific objectives

The crying detection and automatic lullaby-playing systems is one of the promising application of a toddler protecting robot. To obtain a accurate comprehension of the potential advantages and disadvantages linked with the utilization of this technology, it is imperative to ascertain particular research objectives that can evolution and application of these systems. The robot is able to recognize a child's crying and will then begin automatically playing lullabies for them. The utilization of lullabies, which are serene melodies intended to induce sleep in a child, can prove advantageous to the well-being and contentment of toddlers. A toddler can acquire the ability to unwind and doze off more effortlessly with the aid of lullabies, which also possess the additional benefit of diminishing stress levels. The reality that the robot has the capability to automatically play lullabies can serve as an exceedingly helpful solution for parents and caregivers who may lack the time or proficiency to do so themselves. Furthermore, the lullabies that can be played by the robot can be completely customized, giving parents the opportunity to select tunes that they are confident will have a profoundly calming and relaxing effect on their children. Presently, it is quite prevalent for parents to be engrossed in their professions and other obligations, resulting in their incapability to monitor their children's actions and demeanor while absent from the domicile. In view of these circumstances, the principal impetus underlying the creation of this robot is to furnish a resolution to the temporal limitations experienced by occupied parents, while likewise rendering the potential for both the offspring and the parents to experience cognitive emancipation.

4 METHODOLOGY

4.1 Overall system architecture diagram

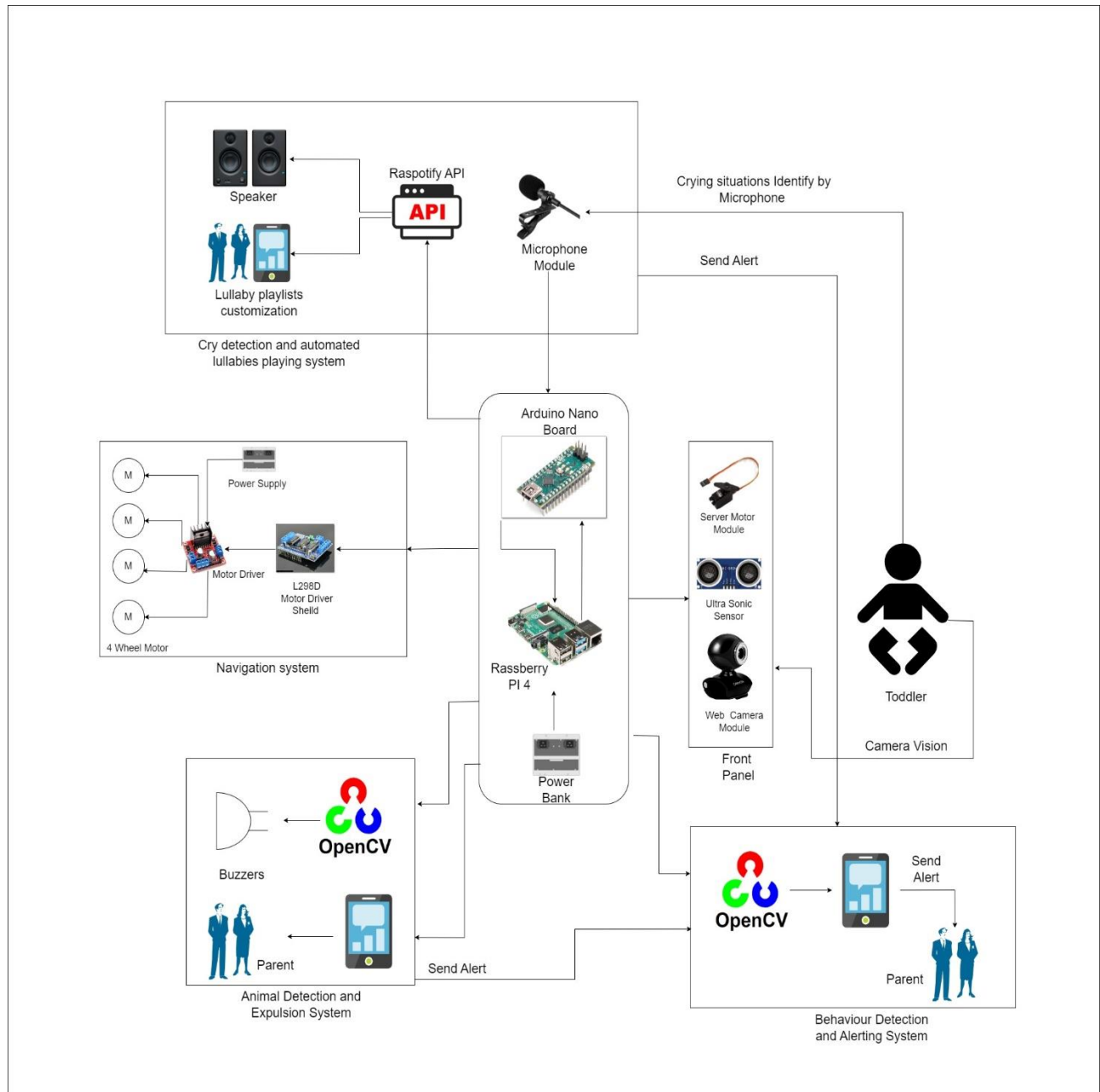


Figure 4: Overall System Architecture Diagram

The comprehensive system diagram that illustrates the design of this robot is displayed in above figure. We will now present a comprehensive and in-depth review of the entire project within this specific area. This overview has been painstakingly broken down into four separate sub-modules, which have been deliberately designed to assist a deeper and more intuitive comprehension. From the very beginning of the development of the system, each individual sub-module was designed with a distinct group of goals in mind. We begin our investigation by delving into the complexities of the robot's navigation system, which was painstakingly designed to assure the robot's unwavering ability to gracefully track the subtle motions of a toddler. [9] Secondly, an advanced animal detection mechanism has been ingeniously implemented into the system in order to quickly identify and preemptively respond to any possible risks that may be posed by animals. This astute preventative step has been ingeniously incorporated into the system.

In addition to these core components, we have developed a nuanced system dedicated to the accurate detection of the behavior of toddlers. This highly developed system has the extraordinary ability to recognize and react to a wide variety of behavioral signals and signs that are presented by the child. [10] As a result, it ensures the maximum possible degree of both engagement and safety for the child. Furthermore, an inventive automatic music-playing system has been seamlessly integrated into the surroundings. This system was created to offer the toddler a relaxing and comfortable aural experience during moments of heightened worry and stress, thereby cultivating a caring and calm environment.

4.1.1 Crying Detection & Automate Lullabies Playing System

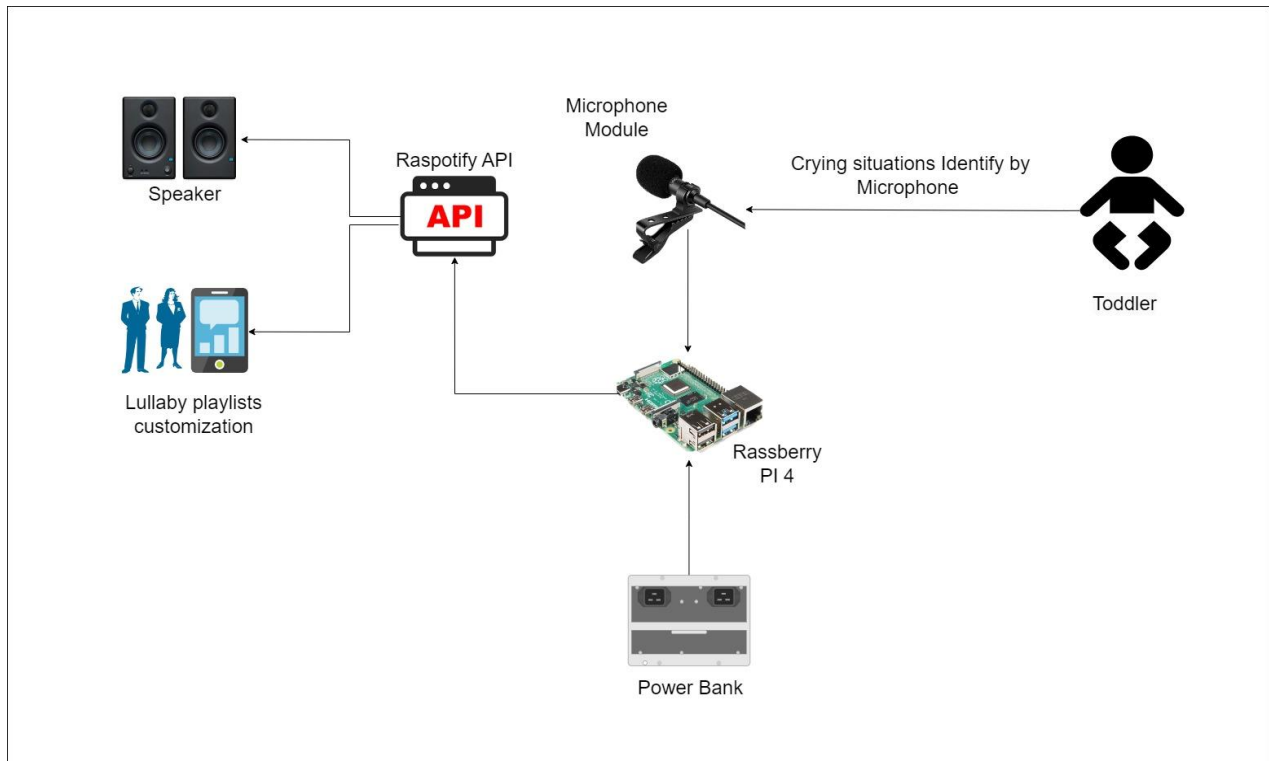


Figure 5: Component System Diagram

The above diagram shows the high-level view of the cry detection and automated lullabies playing system. The automated lullaby play section can be broken down into two independent and equally important components, namely the part that detects cries and the part that plays lullabies to the baby. Within this segment, the cry detection component takes on the role of utmost importance, functioning as the procedure's focal point in the process as a whole. [11] The application of machine learning turns out to be the most important strategy that is used to recognize instances of crying, and the utilization of a sound sample mechanism is the method that is selected. In the field of machine learning, the term "sound sampling" refers to the painstaking process of capturing and precisely recording audio data through the gathering of digital samples. This is done in order to train a computer to recognize sounds. When considered in this specific light, the acquisition of an exhaustive audio sample dataset that has been painstakingly curated becomes an absolute necessity. This dataset ought to include examples of weeping that span a broad spectrum, including changes in terms of intensity, duration, and ambient background noise. [12] The goal is to guarantee

that the dataset records every possible variation of a weeping sound that one can come across. A step of preprocessing is done to the audio data in order to ensure that it is in the best possible condition for analysis before that phase even begins. [13]This preliminary stage comprises a range of activities, including converting the audio recordings into an appropriate format, leveling the volume levels to establish uniformity, and eliminating any undesired noise or artifacts that might interfere with the accuracy of the following studies.[14]

During the process of cry detection, the microphone will conscientiously capture brief sound blocks representing instances of the baby's crying. [15]These sound blocks will last between two and three seconds. After that, a complex computational method is utilized to make an in-depth comparison of these sound blocks to the dataset that has already been established.[16] By making this comparison, the system is able to automatically generate a suitable and personalized lullaby response, which can be personalized to relieve the infant's pain and provide comforting solace. [17]A structure as complex as this one incorporates the fundamental mechanism that allows the cry detection component to function without issue, ensuring that the lullaby delivery system is both effective and receptive.[18]

Within the part that is solely devoted to the playback of lullabies, we have taken great care in deciding that the Spotify application will serve as our go-to choice for delivering a peaceful musical experience. [19]This decision was made in order to provide parents with an interface that is simple and straightforward to use, so that they can easily adapt and curate playlists to meet the requirements of their infant or toddler. We ensure a seamless and optimal interaction with the Spotify ecosystem by seamlessly connecting the raspotify API with the sophisticated Raspberry Pi 4 module. This allows us to ensure ideal integration. To begin, you will need to configure the system by entering the essential user credentials that are connected with a Spotify premium account. This will enable the Raspberry Pi module to have access to the necessary functions and will ensure that you have a premium listening experience. [20]Our cutting-edge solution is designed to effortlessly make lullabies that are exactly tailored to the collected weeping noises using the high-quality microphone that is an important element of the Raspberry Pi setup. This is made possible through the harmonious confluence of technology and empathy. [21]By utilizing sophisticated algorithms for sound analysis, the system is able to recognize and interpret the unique

voice patterns of a crying toddler. This enables the system to provide prompt and correct musical responses to the child's cries.[22]

We have given careful consideration to the incorporation of a dedicated speaker into the Raspberry Pi module in order to provide the child as well as the parent with an immersive auditory experience. This speaker, which is synergistically connected with the system, produces lullabies that are remarkably clear and rich, and they captivate the listener. Parents are strongly urged to take advantage of the flexibility and ease of use provided by the Spotify application, which can be quickly and easily downloaded to their mobile devices. [23]This gives parents the ability to further customize and fine-tune the lullaby playlists, allowing them to accommodate their child's specific interests while also ensuring a harmonious and pleasant environment for their child. Our system has been meticulously developed to recognize a baby's or toddler's cries with astounding accuracy by utilizing cutting-edge technology and user-friendly interfaces.

4.2 Requirements

4.2.1 Functional Requirement

| Requirement ID | Requirement | Description |
|----------------|--------------------------|--|
| 001 | Cry Detection System | The system must maintain the spacing between 1 and 5 meters with the toddler at all times. After that, the system would be able to recognize the toddler's cries and would respond by playing lullabies in response to such cries. |
| 002 | Lullabies Playing System | It is required that you have a Spotify account in order to use this system. The mobile application can be downloaded onto the parent's mobile device, and they will need to compile a playlist before it will begin playing lullabies automatically. |

Table 2:Functional Requirements.

4.2.2 Non-Functional Requirements

| Requirement ID | Requirement | Description |
|----------------|--------------|---|
| 001 | Accuracy | The outputs and validity checking results should be accurate as the whole component depends on the accuracy of the details and outputs it provides. |
| 002 | Performance | As the crying detection and automated lullabies playing system validates the toddler's crying periodically and automatically generate lullabies. All the components should be implemented based on high performances. |
| 003 | Availability | As this product of is a robot, it should be highly available throughout the whole process for all types of users where they can access to the system whenever they want. |

| | | |
|-----|-------------------|---|
| 004 | User-friendliness | Crying detection and automated lullabies playing system of this robot, all types of users the whole system the instructions and also user interface should be user friendly, understandable and easy to handle. |
|-----|-------------------|---|

Table 3:Non-Functional Requirements

4.2.3 System Requirements

| Requirement ID | Requirement | Description |
|----------------|-----------------------|--|
| 001 | Microphone | We would need a microphone that is highly sensitive to the frequency range of a baby's cry, which is normally between 300 Hz and 600 Hz, to distinguish a toddler's crying. A condenser microphone with a good frequency response and minimal noise would be ideal for this application. |
| 002 | Speaker | We included a speaker as a output source by developing the mechanism to automatically playing lullabies according to the captured crying situations. |
| 003 | Raspberry Pi 4 module | Building this crying detection and autonomous lullaby playing system in a toddler protecting robot using the Raspberry Pi module can be both flexible and affordable. It also offers substantial processing power and a wide range of communication possibilities. |

| | | |
|-----|-------------------------|---|
| 004 | Spotify Premium Account | We included raspotify API to developing the automated lullaby playing system. By using this API users can simply play and customize their playlist through the Spotify application. |
|-----|-------------------------|---|

Table 4: System Requirements

4.3 Commercialization Aspects

4.3.1 Market Opportunity

The development of an intelligent robot aimed at monitoring and ensuring the safety of toddlers presents a groundbreaking innovation for parents and caregivers who are in search of an improved approach to child supervision. With the inclusion of sophisticated sensors and advanced algorithms for intelligence, this robotic technology harbors the potential to revolutionize the manner in which we tend to and engage with toddlers.

Home Use - With the utilization of its highly developed sensors and cognitive capabilities, this particular automaton exhibits the possibility of revolutionizing the manner in which we provide care for and engage with infants.

Daycare Centers - This innovation can be utilized in preschools and day care centers for early childhood education to enhance the safety of children and elevate the standard of care offered by these establishments.

Special Needs Care - Intelligent robots can be adapted to meet the needs of children who have particular requirements, so opening up a niche market for products and services that aid families that have children who have special needs.

Subscription Services - It is entirely feasible for a product to generate recurrent revenue streams and enhance its viability over a long period by means of marketing the product in tandem with subscription-based services that encompass frequent upgrades, ongoing maintenance, and comprehensive customer support.

4.3.2 Target Audience

The intelligent toddler monitoring and safeguarding robot is developed to cater to a variety of consumer segments, each of which has a different set of requirements and preferences than the others. We will be able to adjust our marketing efforts, product features, and messaging to effectively reach and engage the target audience if we first identify and understand these different groups of the market.

Working Parents - This particular assemblage is comprised of individuals who fulfill the role of parental figures and concurrently hold either complete or partial employment positions that are situated away from their familial dwelling. Consequently, these individuals incessantly encounter temporal limitations that ensue from their occupational responsibilities. Hence, they may not be easily accessible to bestow constant supervision upon their offspring.

Single Parents - Single parents, who are individuals that are either divorced, separated, widowed, or never-married, frequently undertake the responsibility of being the solitary overseer for their offspring, necessitating them to simultaneously manage a diverse assortment of duties. As a result of their solitary status, it is plausible that these parents may not have access to supplementary childcare assistance, thereby exacerbating their already arduous task of raising their children.

Families with Multiple Children - This particular classification encompasses those familial units that possess a quantity of offspring exceeding the singular, thus resulting in a potentially cumbersome task for the parental figures in terms of overseeing and regulating the actions and behaviors of each individual child in a simultaneous manner.

Daycare Centers and Early Childhood Educators - Daycare centers, educational institutions catering to the needs of toddlers, along with preschools and other similar establishments, are widespread workspaces for professionals operating in this domain. These individuals are entrusted with the responsibility of ensuring the physical and mental wellness of a varied cohort of young and impressionable minds.

Families with Special Needs Children - This subset consists of families where at least one member of the household has a child with a unique requirement or special need, such as a disability.

4.3.3 Demand

To achieve a successful product launch, it is of utmost significance to possess a comprehensive comprehension of the requirement for the intelligent toddler monitoring and safeguarding robot so as to accurately evaluate the potential of the market. In light of this, the current study proffers an extensive and thorough inquiry into the demand for this innovative childcare solution and further expounds on the essential factors that are stimulating its adoption.

The exigency for the astute monitoring and safeguarding robot designed specifically for toddlers is influenced by a plethora of factors, encompassing but not limited to, shifting family dynamics, apprehensions of parents regarding the safety of their offspring and the progressive enhancements in technology. Upon scrutinizing and dissecting the aforementioned constituents, we will be in a better position to gauge and assess the extant demand for the product, along with the demand that is destined to be engendered in the future.

The demands for intelligent toddler monitoring and safeguarding robots is driven by a mix of causes, including parental worries for child safety, technology breakthroughs, changing lifestyles, and a need for increased childcare quality. Specifically, the demand for intelligent toddler monitoring and safeguarding robots is driven by these factors. Businesses have the opportunity to take advantage of a rising market and provide a valued solution for the protection and care of children if they take these factors into consideration and find effective ways to properly handle them.

4.3.4 Marketing Strategies

The intelligent toddler monitoring and safeguarding robot is an innovative way to address parental worries about the safety and wellbeing of their children. Implementing marketing methods that have been well prepared will assist in raising awareness, generating interest, and ultimately convincing prospective clients to utilize this crucial childcare solution.

Targeted Content Marketing - Creating informative contents and captivating material that imparts knowledge and insight to the intended audience with respect to the various and sundry capabilities and advantages of the robot. Developing blog posts, articles, videos, and highlighting real-life scenarios where the robot enhances child safety and simplifies childcare.

Social Media Campaigns - Making use of the various venues provided by social media in order to establishing a community, share consumer testimonials, and generate buzz. Maintaining a consistent posting schedule of compelling content, carry out live demonstrations, and operate targeted advertising campaigns on online platforms such as Facebook, Instagram, and YouTube.

Educational Webinars and Workshops - Inform potential buyers of the advantages and capabilities offered by the robot. Demonstrate the ways in which the robot may enhance childcare to working parents, single parents, and daycare providers through the hosting of online webinars and workshops.

Partnerships with Daycare Providers - The establishment of a sound and robust bond between parents and their offspring ought to commence at the earliest possible juncture. In order to enhance the availability of our robot to childcare professionals, it is vital to cultivate and foster beneficial associations with enterprises that offer daycare services. This can be achieved through the presentation of reduced pricing or alternative options for bulk procurements.

Product Demonstrations and Free Trials - Enable prospective clients to undergo a comprehensive and immersive firsthand interaction with the product by providing them with the opportunity to partake in live product demonstrations and avail themselves of free trial periods. This will, in turn, provide customers with the capacity to observe and appreciate the myriad advantages of the robot prior to committing to a purchase.

4.4 Financials

The implementation of the intelligent toddler monitoring and safeguarding robot represents a progressive and visionary approach towards reliable and effective childcare, which holds a significant potential for success in the contemporary market. It is of paramount importance for any prudent decision-making process to encompass a comprehensive and rigorous comprehension of the multifaceted financial implications associated with the various stages of product development, encompassing marketing strategies and revenue generation.

The below mentioned table shows the overview of the estimated budget required for the development and launch of the Intelligent Robot for Monitoring and Protecting Toddlers.

| Component | USD | LKR |
|--------------------|-----|--------|
| Raspberry Pi 4 | 106 | 35,000 |
| Web Camera | 24 | 8000 |
| Microphone | 15 | 5000 |
| Speaker | 5 | 1500 |
| Gear Motor | 15 | 5000 |
| Arduino Nano Board | 23 | 7500 |
| Power Bank | 30 | 10000 |
| Motor Drive | 3 | 800 |
| Ultra Sonic Sensor | 1 | 300 |
| Buzzer Module | 1 | 350 |
| SIM800L module | 3 | 1100 |
| Total | 226 | 74,550 |

Table 5: Estimated Budget

This report contrasts the individual component of an intelligent robot for monitoring and protecting toddlers called “Crying detection and Automated lullabies playing system”. This specific component can be deployed independently without depending on the other three components. Below table shows the estimated budget to deploy this specific component called “Crying detection and Automated lullabies playing system” as a service.

| Component | USD | LKR |
|----------------|-----|--------|
| Raspberry Pi 4 | 106 | 35,000 |
| Microphone | 15 | 5000 |
| Speaker | 5 | 1500 |
| Power Bank | 30 | 10000 |
| Total | 156 | 51,500 |

Table 6: Component Estimated Budget

4.5 Testing and Implementation

4.5.1 Software and Hardware Implementation

During this stage of development, we will discuss the hardware and software implementations of the system. Connecting the various parts of the system is necessary in order to create one that is operational. We connect the microphone to the Raspberry Pi 4 module so that we can identify when the toddler is in a state that causes them to cry. Lullabies can also be played via the speaker that is connected to the Raspberry Pi 4 module. Next, we need to work on the voice recognition component so that we can identify when someone is sobbing. We educated a data set by teaching it with a machine learning algorithm that uses sound sampling. Programming languages such as C and Python were utilized in order to successfully complete this task. In order to play the lullabies at the appropriate times based on the baby's crying, we made use of an API provided by Raspotify. Installing the Spotify app on a mobile device offers the user the ability to make playlists based on their preferences. This is useful for parents and other caregivers. The flow of the implementations is depicted in the diagram that may be found below.

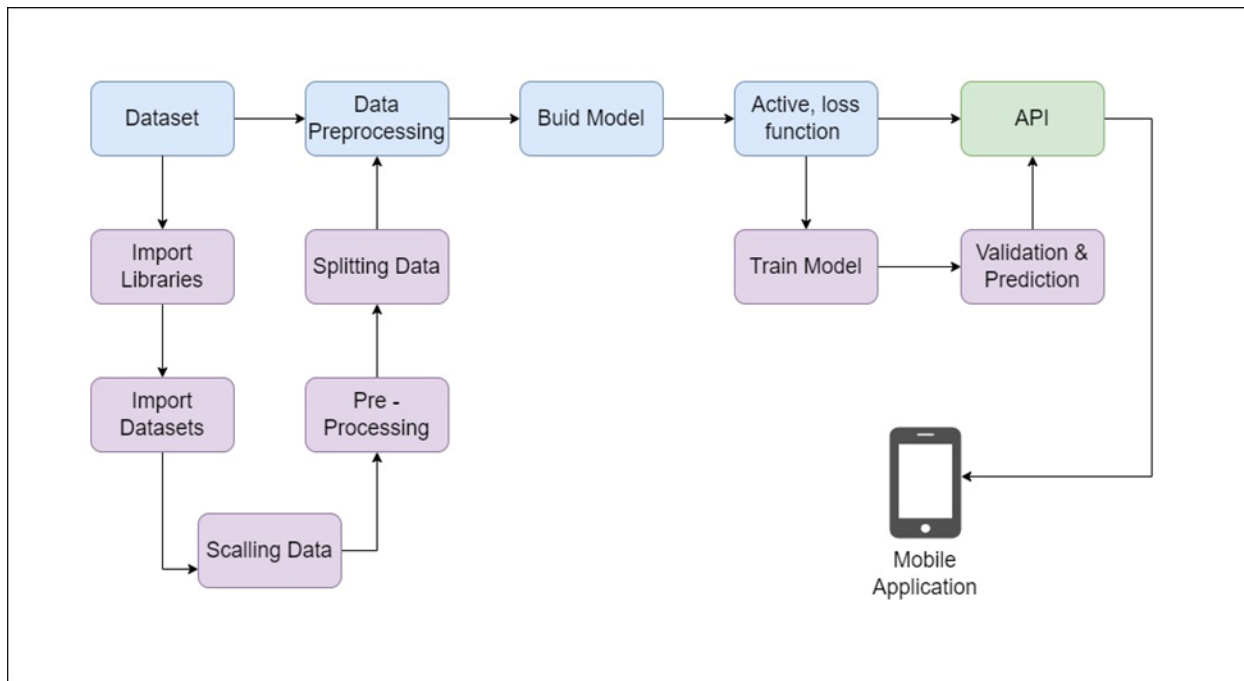


Figure 6: Implementation process of the system.

4.5.2 Testing

The successful testing and implementation of the intelligent toddler monitoring and safeguarding robot are critical to ensuring its functionality, safety, and acceptance by users. This document provides an overview of the strategies and considerations for testing and deploying this innovative childcare solution. Testing process has been conducted under several steps as follows,

- 1. Unit testing** – Each individual subcomponent has undergone testing on its own, separate from the other subcomponents.
- 2. Component testing** – After completing the unit testing, bug free components combined together to ensure the consistency of the system.
- 3. Integration testing** – During this testing, integrated each component to ensure the relationships between components works as per the expectations.
- 4. System testing** – In order to ensure the functionality and the performance of the system, conducted system testing by considering whole system as a one function.
- 5. User acceptance testing** – Once the development testing is completed, whole system was handed over to a parent to check their satisfaction level.

| Test ID | Testing scenario | Expected output | Actual output | Status |
|---------|---|--|--|--------|
| 001 | Implementing microphone module to the system and check voice collecting process. | Display the validation message by identifying the crying voice sample. | Display the validation message by identifying the crying voice sample. | Pass |
| 002 | Training the crying data set and check the cry detection process. | Display the message as “Voice is matching” | Display the message as “Voice is matching” | Pass |
| 003 | Implementing speaker to the system and check music playing process. | Play the selected music through the VLC player. | Play the selected music through the VLC player. | Pass |
| 004 | Implementing the raspotify API to the system and check the music playing process. | The Spotify mobile app will automatically open and play the selected music. | The Spotify mobile app will automatically open and play the selected music. | Pass |
| 005 | Providing a crying voice sample and check the crying detection and automated lullabied playing process. | Automatically generated the selected lullabies through the Spotify application by detecting the crying voice sample. | Automatically generated the selected lullabies through the Spotify application by detecting the crying voice sample. | Pass |

Table 7: Summary of the test cases

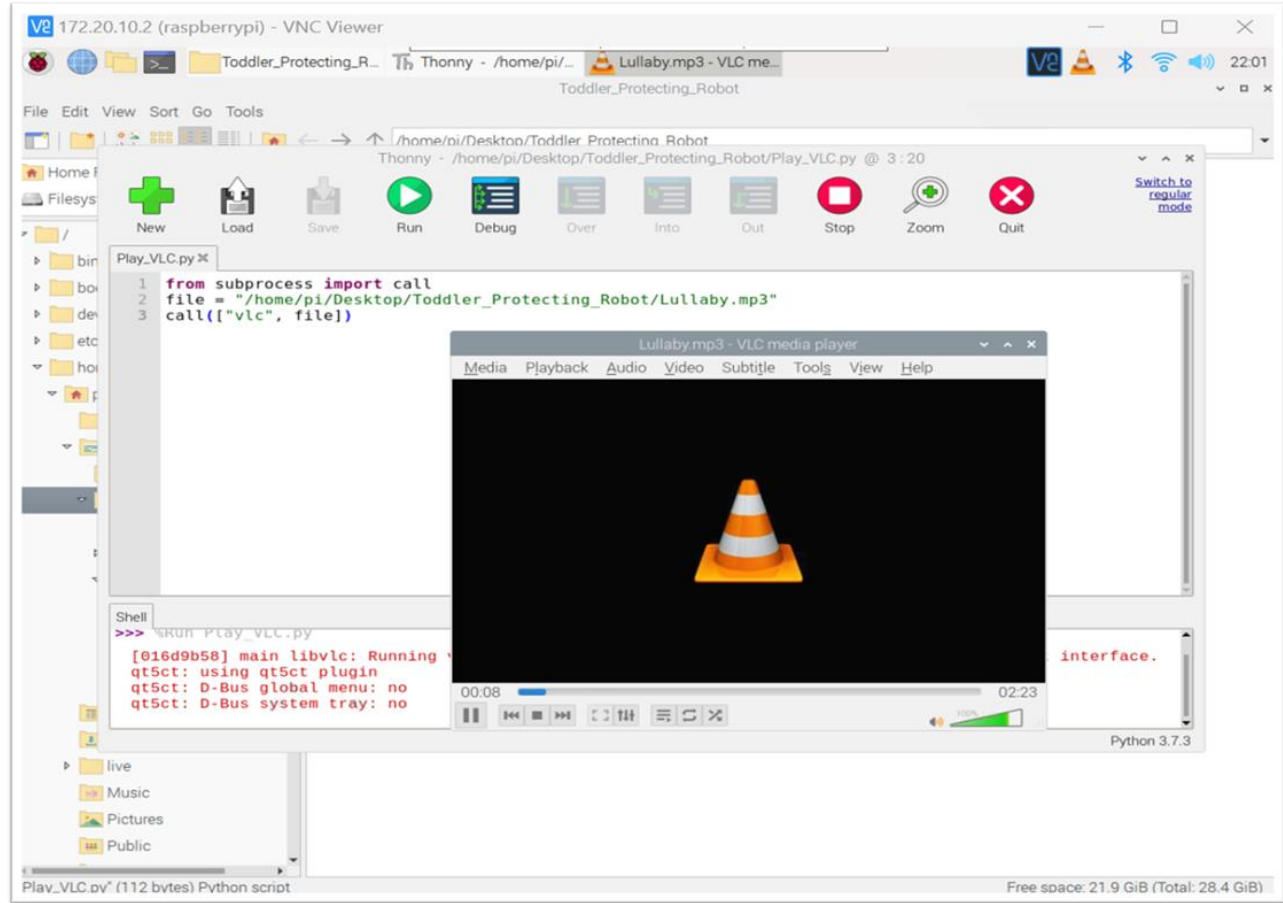


Figure 7: Sound testing through VLC player

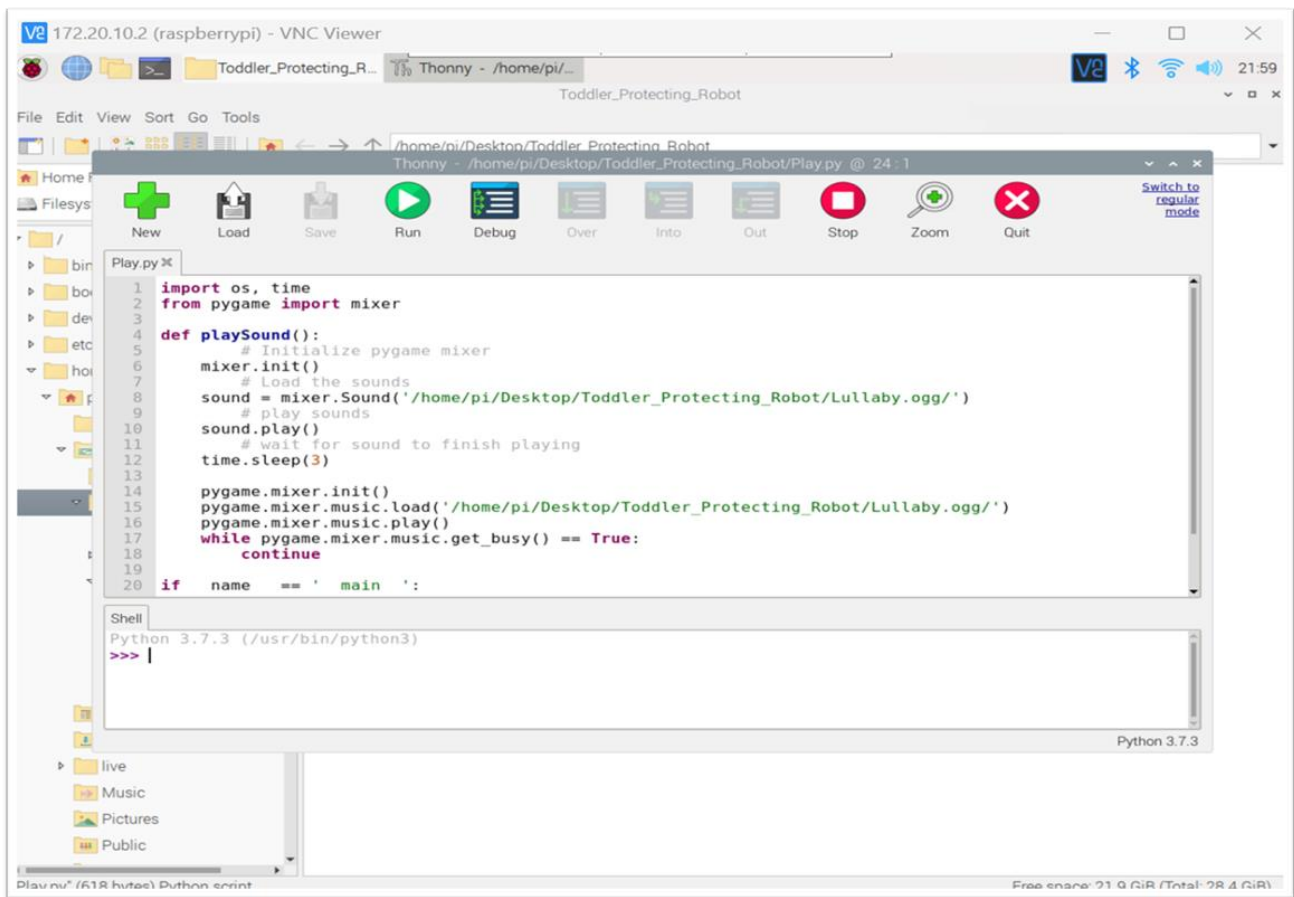


Figure 8:Lullaby playing checking

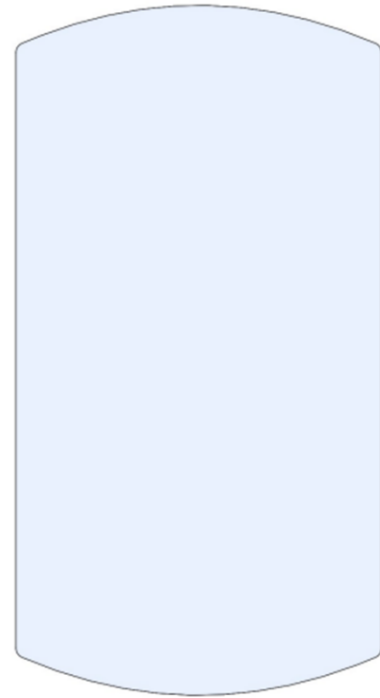
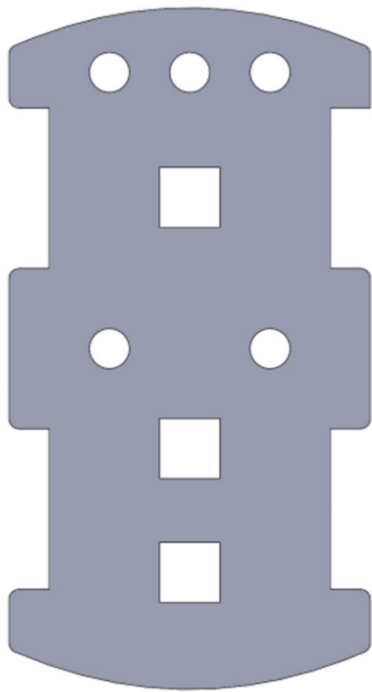


Figure 9:Solid work sketch

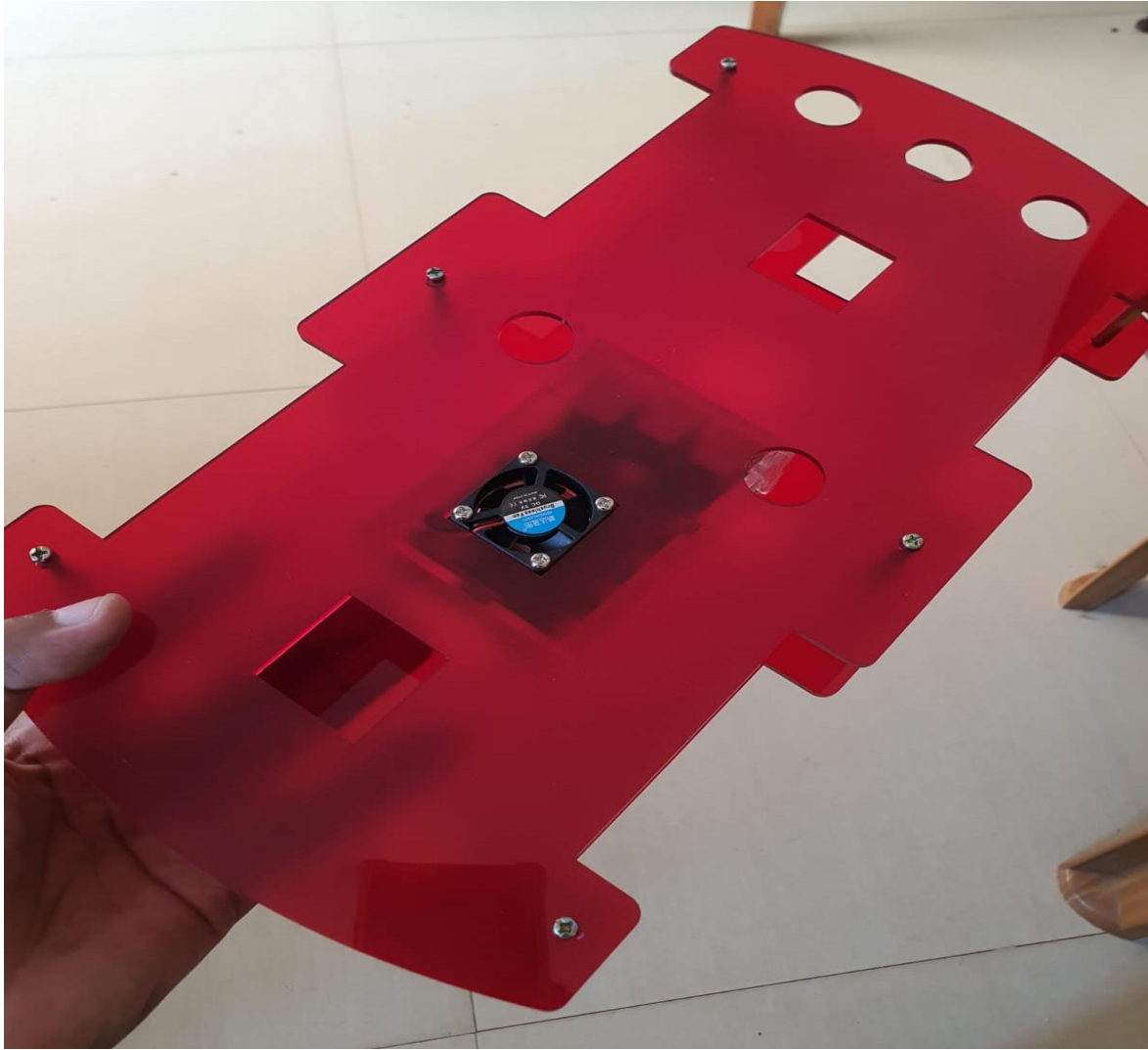


Figure 10: Base of the robot



Figure 11:Speaker Implementation

```
pi@raspberrypi: ~  
File Edit Tabs Help  
pi@raspberrypi:~ $ lsb_release -a  
No LSB modules are available.  
Distributor ID: Raspbian  
Description:    Raspbian GNU/Linux 10 (buster)  
Release:        10  
Codename:       buster  
pi@raspberrypi:~ $ sudo apt-get -y install curl && curl -sL https://dtcooper.github.io/raspotify/in  
stall.sh | sh  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
curl is already the newest version (7.64.0-4+deb10u6).  
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.  
  
Unmet minimum required package version(s):  
  
libc6 >= 2.31 is required but 2.28-10+rpt2+rpi1+deb10u1 is installed.  
coreutils >= 8.32 is required but 8.30-3 is installed.  
systemd >= 247.3 is required but 241-7~deb10u9+rpi1 is installed.  
libasound2 >= 1.2.4 is required but 1.1.8-1+rpt2 is installed.  
alsa-utils >= 1.2.4 is required but 1.1.8-2+rpt1 is installed.  
libpulse0 >= 14.2 is required but 12.2-4+deb10u1+rpt3 is installed.  
  
Please make sure you are running a compatible armhf (ARMv7), arm64, or amd64 Debian based OS.  
pi@raspberrypi:~ $
```

Raspotify

Listen Up!

Figure 12:Raspotify API Implementation

5 RESULT AND DISCUSSION

5.1 Results

The primary objective of the automated lullabies playing system component is to discern instances of a toddler's crying and play a suitable lullaby accordingly. This particular section can be further divided into two significant segments, namely the cry detection and play lullaby section. In order to construct and refine these two sections, our approach primarily relies on the utilization of machine learning algorithms. Within the cry detection section, we employ machine learning as the primary technique to identify instances of crying, employing sound sampling mechanisms as the underlying methodology. In this context, a comprehensive dataset of audio samples capturing the distinct sounds of crying infants is collected. Subsequently, a voice detection module is implemented to identify the specific vocalizations associated with a baby's crying or distress. Based on the analysis of these carefully curated datasets, the system can accurately detect crying situations by means of the voice detection module.

Within the existing framework of the lullabies playing system, a configuration has been adopted wherein two speakers serve as the output devices responsible for playing the lullabies. Leveraging the functionality provided by the raspotify API, the system enables the playback of lullabies while offering customization options for the playlist through the Spotify application. Following the successful implementation of the automated cry detection function, crying situations are identified through the voice detection module, subsequently triggering the automated generation of a suitable lullaby.

During the course of the implementation of the crying detection component, it has been empirically ascertained that the recognition accuracy experiences a decline in proportion to the distance that separates the microphone from the sound source. This fact, in turn, leads to the voice detection module encountering considerable difficulty in its task of accurately identifying crying situations. Consequently, in order to effectively surmount these aforementioned challenges, the system has been designed to incorporate highly sensitive microphones that serve to ameliorate the issues at hand.

5.2 Research Findings

The fundamental purpose of the project is to develop an automated system that plays lullabies in response to the cries of a toddler. This system has two primary components, which are the detection of cries and the playback of lullabies.

Crying Detection - The component that is responsible for cry detection uses machine learning algorithms. A collection of audio recordings comprising the cries of infants is being amassed for use in a dataset. It is necessary to develop a voice detection module so that specific vocalizations linked with a baby's crying or discomfort can be identified. Using this voice detection module, the system is able to properly identify circumstances in which someone is sobbing.

Automated lullabies playing - In order to play lullabies, the lullaby playback system makes use of two speakers in conjunction with the raspotify API. Additionally, it provides options for customizing the playlist that can be accessed through the Spotify application.

The outcomes of this research emphasize, in brief, the effective construction of a cry detection system that makes use of machine learning and voice recognition, as well as the integration of a system that plays back lullabies. Additionally, the research reveals issues that are related to microphone distance and recommends potential enhancements that could be made for future generations of the system.

5.3 Discussion

There exist various potential augmentations that may be incorporated into future versions of the system to further enhance its operational efficiency. These improvements could potentially be implemented in upcoming iterations of the system. One such enhancement involves integrating a feature that can generate lullabies in an automated manner, based on the analysis of the child's sleep patterns, including both sleep onset and wake-up times. This supplementary functionality would undoubtedly prove to be highly advantageous to both parents and toddlers, as it would render the experience of listening to lullabies more personalized and convenient for all parties concerned. Furthermore, there is a significant opportunity for heightening the overall precision of the system with regard to the cry detection mechanism, through the utilization of an exclusive model trained with the raspberry pi module. The utilization of this specific approach has the potential to enhance the system's overall accuracy and yield multiple additional benefits.

6 SUMMARY OF PERSONAL CONTRIBUTION

6.1 Toddler Following and Obstacle Avoidance Robust Navigation System

The task at hand involves the intricate design and implementation of a navigation system for our robot. This navigation system should be capable of facilitating the robot's seamless movement around a young child, striking a harmonious balance between efficiency and safety. In this endeavor, we must consider not only the nuances of navigation but also the paramount importance of ensuring the child's well-being by addressing potential mobility barriers and obstacles.

The ultimate goal is to empower the robot with the ability to navigate around the toddler with utmost efficacy and security. This entails equipping the robot with the intelligence to adapt and respond to the dynamic environment it operates in, especially in scenarios where the toddler may interact with the robot or inadvertently cause disruptions.

Establishing a positive and nurturing human-robot interaction, it is imperative that the robot possess the capability to intelligently manage and tidy the surroundings when necessary. This ensures that the child remains safe and can enjoy a positive experience with the robot. This undertaking becomes even more critical when considering that the intended user is a child under the age of three, necessitating a careful and friendly approach to human-robot engagement.

6.2 Toddler Monitoring & Animal Detection System

The endeavor involved the meticulous development of a system tailored for our robot, one that possesses the capacity to effectively perform virtual surveillance of the child's immediate environment. This multifaceted system, which was expertly designed with a high degree of attention to detail, was painstakingly constructed with an unwavering and steadfast focus on guaranteeing the absolute safety and optimal well-being of the child in question. The paramount objective was to create a comprehensive solution capable of promptly identifying any unwarranted presence or unauthorized individuals within the child's surroundings, all in real-time.

Furthermore, our system exhibits the remarkable ability to discern and flag any potential threats or hazards that may compromise the child's safety, a crucial facet of its design. Remarkably, it is also adept at detecting and managing the presence of any fauna that could potentially pose a threat to the toddler. It achieves this with great finesse, adeptly removing such creatures without causing harm to either the animal or the vulnerable child, thereby guaranteeing a harmonious coexistence while upholding the paramount goal of safeguarding the child's welfare.

6.3 Toddler behavior detection & alerting System

Creating a early warning system designed with the capability to effectively and precisely monitor a child's behavioral patterns and promptly disseminating this crucial information to the child's parents or guardians is paramount. This advanced system demonstrates the ability to adeptly

discern various actions performed by the child, including activities such as running, sleeping, or venturing into potentially perilous zones. Moreover, it showcases its proficiency in detecting instances of animal incursions into the monitored area and accurately identifying moments when the child expresses distress through crying. Subsequently, this invaluable information is seamlessly relayed to the parents via the meticulously crafted alerting system.

6.4 Toddler Crying Detection & Automate Lullabies Playing System

A robot made in the development of a novel system with the purpose of supporting parents who are trapped in the unrelenting demands of their busy life by providing them with the priceless choice of getting dependable child care for their kids during their unavoidable absences from home. This system's goal is to assist these parents by allowing them to take advantage of a valuable option. Furthermore, this innovative technology demonstrates an outstanding capability in reducing the potential disturbances originating from a toddler's inconsolable cries by effortlessly orchestrating the automatic replay of calming lullabies. This is made possible by the fact that the system smoothly orchestrates the playback of the lullabies. Beyond this, the brilliant technique that underpins this system expands the horizon of possibilities, bestowing both the child and the parents with the priceless gift of mental liberty, so enabling them to savor unrestricted moments of relaxation and freedom in their lives.

7 CONCLUSION

In conclusion, the proposed virtual interaction approach for toddlers represents a pioneering and cutting-edge solution aimed at enhancing the sleep quality and overall well-being of our youngest family members. This innovative device will leverage state-of-the-art sensors to monitor a toddler's crying situations and respond proactively to their needs, particularly in moments of distress or discomfort. By automatically playing soothing music or lullabies tailored to the child's specific crying patterns, this technology promises to be a innovative for both parents and toddlers alike.

One of the standout features of this device is its seamless integration with the Spotify music application, allowing parents to curate personalized playlists filled with their child's favorite lullabies and comforting tunes. This not only provides a customizable and comforting experience for the toddler but also fosters a sense of familiarity and security that can significantly contribute to better sleep and emotional well-being.

The potential impact of this research extends beyond just improving sleep routines; it has the power to strengthen the bond between parents and their toddlers. The soothing music and automated responses not only provide comfort to the child but also reassure parents, empowering them with tools to better care for their little ones. When parents possess the essential tools and resources, they are aptly equipped to provide exceptional care for their offspring. This, in turn, engenders a more serene and gratifying familial existence which, ultimately, heightens the overall standard of living for all parties involved.

Furthermore, it is noteworthy that this pioneering approach effectively tackles a frequently disregarded facet of contemporary child rearing: the difficulty of harmonizing occupational and familial obligations. By mitigating the distress and unease that parents encounter in regard to their young child's health and safety, this advanced methodology enables them to focus more completely on their professional obligations and achieve greater efficiency, while simultaneously maintaining a sense of inner peace and assurance regarding their child's well-being. In essence, it constitutes a profound transformation in the utilization of technological advancements to facilitate parents in fulfilling their dual roles as nurturers and providers. When we consider how this technology will soon advance and be implemented, we may imagine a future where children and their families live in greater harmony and well-being.

8 REFERENCES

- [1] Institute of Electrical and Electronics Engineers, *2017 Seventh International Conference on Affective Computing and Intelligent Interaction Workshops and Demos (ACIIW) : 23-26 Oct. 2017.*
- [2] A. K. Dey et al., *UbiComp '12 : proceedings of the 2012 ACM Conference on Ubiquitous Computing : September 5-8, 2012, Pittsburgh, USA.*
- [3] M. A. Gaikwad, M. Sweety, and J. S. Jadhav, "AUTOMATED BABY CRADLE." [Online]. Available: <http://ijics.com>
- [4] S. Choi, S. Yun, and B. Ahn, "Implementation of automated baby monitoring: CCBBeBe," *Sustainability (Switzerland)*, vol. 12, no. 6, Mar. 2020, doi: 10.3390/su12062513.
- [5] L. Tavi, T. Alumäe, and S. Werner, "Recognition of creaky voice from emergency calls," in *Proceedings of the Annual Conference of the International Speech Communication Association, INTERSPEECH*, International Speech Communication Association, 2019, pp. 1990–1994. doi: 10.21437/Interspeech.2019-1253.
- [6] Institute of Electrical and Electronics Engineers. Israel Section and Institute of Electrical and Electronics Engineers, *2016 IEEE International Conference on the Science of Electrical Engineering (ICSEE) : 16-18 Nov. 2016.*
- [7] *2010 IEEE 26th Convention of Electrical and Electronics Engineers in Israel.* IEEE, 2010.
- [8] S. Bhatnagar, B. Vidyapeeth, S. Sharma, S. Hasan, V. Jain, and M. A. Patil, "Automatic Cradle System for Infant Care Automatic Cradle System for Infant Care View project Voice-Controlled Tool for Anytime Safety of Women View project Automatic Cradle System for Infant Care," *International Journal of Research and Analytical Reviews (IJRAR)* www.ijrar.org, vol. 812, 2021, [Online]. Available: www.ijrar.org
- [9] M. Anjum and P. M. J, "Baby Motion and Cry Detection." [Online]. Available: www.ijert.org

- [10] J. TU and Q. Zhou, "DESIGN AND IMPLEMENTATION OF THE CRYING VOICE DETECTION CIRCUIT IN THE BABY'S SUPERVISION SYSTEM," *Review of Computer Engineer Studies*, vol. 1, no. 1, pp. 13–16, Sep. 2014, doi: 10.18280/rces.010103.
- [11] V. A. Mann, R. Diamond, and S. Carey, "Development of Voice Recognition: Parallels with Face Recognition," 1979.
- [12] A. Nakagawa and M. Sukigara, "The Effects of Soothing Techniques and Rough-and-Tumble Play on the Early Development of Temperament: A Longitudinal Study of Infants," *Child Dev Res*, vol. 2014, pp. 1–10, Aug. 2014, doi: 10.1155/2014/741373.
- [13] M. Severini, D. Ferretti, E. Principi, and S. Squartini, "Automatic detection of cry sounds in neonatal intensive care units by using deep learning and acoustic scene simulation," *IEEE Access*, vol. 7, pp. 51982–51993, 2019, doi: 10.1109/ACCESS.2019.2911427.
- [14] C. Ji, T. B. Mudiyanse, Y. Gao, and Y. Pan, "A review of infant cry analysis and classification," *Eurasip Journal on Audio, Speech, and Music Processing*, vol. 2021, no. 1. Springer Science and Business Media Deutschland GmbH, Dec. 01, 2021. doi: 10.1186/s13636-021-00197-5.
- [15] T. K. Perrachione, S. N. Del Tufo, and J. D. E. Gabrieli, "Human voice recognition depends on language ability," *Science*, vol. 333, no. 6042. p. 595, Jul. 29, 2011. doi: 10.1126/science.1207327.
- [16] G. Joshi, C. Dandvate, H. Tiwari, and A. Mundhare, "Prediction of probability of crying of a child and system formation for cry detection and financial viability of the system," in *Proceedings - 2017 International Conference on Vision, Image and Signal Processing, ICVISIP 2017*, Institute of Electrical and Electronics Engineers Inc., Nov. 2017, pp. 134–141. doi: 10.1109/ICVISIP.2017.33.
- [17] L. Honeycutt, "Researching the use of voice recognition writing software," *Comput Compos*, vol. 20, no. 1, pp. 77–95, 2003, doi: 10.1016/S8755-4615(02)00174-3.

- [18] R. Cohen, D. Ruinskiy, J. Zickfeld, H. IJzerman, and Y. Lavner, “Baby Cry Detection: Deep Learning and Classical Approaches,” in *Studies in Computational Intelligence*, Springer Verlag, 2020, pp. 171–196. doi: 10.1007/978-3-030-31764-5_7.
- [19] I. Silva, S. Wickramasinghe, G. V. I. S. Silva, and D. S. Wickramasinghe, “Infant Cry Detection System with Automatic Soothing and Video Monitoring Functions Non-contact 2D optical measuring algorithm View project Infant Cry Detection System with Automatic Soothing and Video Monitoring Functions,” 2017. [Online]. Available: <https://www.researchgate.net/publication/342802422>
- [20] T. O’rourke, “Temporal Trends in Music Popularity-A Quantitative analysis of Spotify API data Temporal Musical Analysis View project”, doi: 10.13140/RG.2.2.11551.71843.
- [21] S. A. Desai, P. D. Mistry, J. P. Kahar, A. S. Modak, and A. Biwalkar, “A Novel Implementation of an Interactive Smart Mirror,” in *Proceedings of the 6th International Conference on Communication and Electronics Systems, ICCES 2021*, Institute of Electrical and Electronics Engineers Inc., Jul. 2021, pp. 184–191. doi: 10.1109/ICCES51350.2021.9489060.
- [22] IEEE Staff, *2018 International Conference on Information and Computer Technologies (ICICT)*. IEEE, 2018.
- [23] C. E. Dawson Jr, S. Mann, E. Roske, G. Vasseur, C. E. Jr, and C. Dawson, “Spotify: You have a Hit!,” 2021.