Smart Cradle System for Automated Baby Monitoring

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***Abstract*—Parents of attending to newborns often suffer from sleep deprivation. Our smart cradle attempts to reduce parents' loads by attempting to put the baby to sleep without parental intervention. The system uses a combination of a motion sensor and a camera system to detect the baby waking up, and employs an AI component to decide the appropriate lullabies to play and the intensity of the cradle's rocking motion depending on the baby's current mood. The system notifies the parents via WiFi only if it fails to put the baby to sleep within a certain time threshold, thereby allowing parents to sleep better without needing to attend to their newborn unless absolutely necessary. The AI component can be used to monitor for other signs of distress and notify the parents accordingly.**

***Index Terms*—baby-monitor, computer vision, cry detection, cradle**

I. Introduction

The reason behind our idea was the endless complaints from parents of toddlers from all over the world, be it our close relative, a mentor, a colleague and posts on social media, about one thing, "Sleep". The recommended hours of sleep for an adult would be at least 7 hours, but for parents with toddlers, it's just a dream. To make it a reality, we have proposed this idea where it will take care of both parties, the child and the parent. Our main goal is to create a device that will be very customisable according to the baby's needs. It will act as a part-time nanny to take care of a baby's immediate tantrums and the system will be built in such a way that the robot will only alert the parents if the baby's cry is a cry for help. Primary users of this system are going to be both parents as well as neonatal wards of healthcare facilities. The system will reduce the stress on caregivers and the babies.

A survey was carried out to understand the difficulties of new parents that they go through regularly, especially while the baby is asleep and wakes up suddenly for certain needs. The responses are supposed to be effective enough for us to understand how an automated cradle system would reduce the troubles of new parents so that they can maintain a better lifestyle at that point.

Out of 70 participants that were mostly around the age of 25-40, it was found that 72.7% of new parents are suffering from sleep deprivation, and it's also seen that more than half (54.5%) of the people ask for help from family and friends, which seems to be a hassle for both parties. All participants believed that it is very difficult to respond to the baby waking up in the middle of the night. The baby might wake up due to any possible reasons like hunger, defecation, etc., but the results show that 50% of the people delay in responding, which turns the situation into a risk-taking one. Also, most people (91%) believe that getting the baby back to sleep requires extremely hard work and is also time-consuming. Hence 72.7% of people voted yes to the fact that an automated cradle system would be of great help to them, and they would buy it if it were available in the market, which proves the necessity and market demand for the automated cradle.

II. Related Works

Summaries of summaries

III. Methodology

A Passive Infrared (PIR) motion sensor is used to detect the baby's motion. An Arduino micro-controller interprets motion above a set threshold to signal distress and triggers a video camera. Processing the video feed occurs on an Android smartphone using a low power ARM chip. Computer vision is used to analyse the video feed to recognise the current emotional state of the baby in the cradle.

Convolution Neural Networks (CNN) are the current state of the art for computer vision applications, with a variety of different high performance architectures available. Due to the low processing power available to mobile CPUs, MobileNetV2 is used in this project since it provides a excellent balance between detection accuracy and lightweight computational requirements. Transfer learning is used to train the pre-trained model on a dataset consisting of baby faces that range between the classes: ”asleep”, ”awake”, ”awake-crying”, ”awake-crying-heavy”.

For each of the awake states, a playlist of lullabies are maintained that are best fit to soothe the baby towards falling asleep. The system continuously monitors the baby while awake and dynamically adjusts the music to the baby’s current emotional state.

Failing to put the baby to sleep within a set threshold period, the system pushes notifications to a list of caretakers’ cellphones via WiFi.

The system is reset either by a responding caretaker, or if the baby falls asleep.

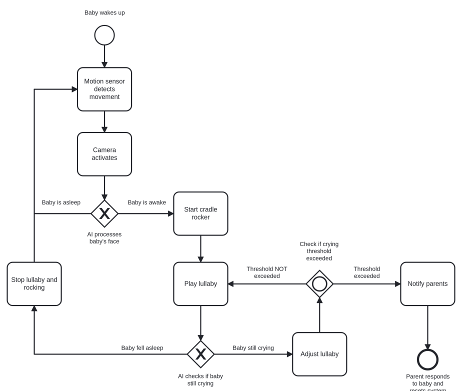

Fig. 1. Event Loop of Smart Cradle

IV. System Design

A. Hardware

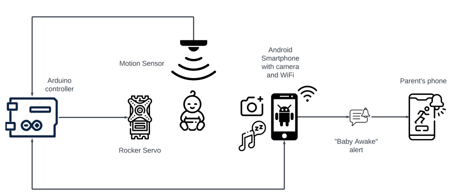

Fig. 2. Hardware Components of Smart Cradle

The scaled-down prototype consists of readily available hobbyist-grade components. An Arduino Uno micro-controller is connected to a HC-SR501 PIR motion sensor, an SG90 mini servo motor for rocking the cradle, and an Android Smartphone. The smartphone is a an extremely flexible, versatile platform that is already available at hand and performs the task of multiple standalone components - saving both prototyping cost and complexity. It performs the role of a standalone camera unit, music player, speaker, Internet-connectivity/WiFi module, and computer vision processor. The system is also powered by DC from the smartphone via USB to the micro-controller.

Fig. 3. Arduino event loop

B. Software

The system has two separate Android applications.

1) The caretaker-side application (i.e. the baby monitor app) does the following:
   - receives alerts via push-notifications
   - receives and views video feed from the cradle on demand.
2) The cradle-side applications is responsible for:
   - recording and transmitting video from cradle
   - running MobileNetV2 model on video feed
   - playing appropriate lullabies based on inference
   - pushing alert notifications to baby monitor app via WiFi

The event loops for the microcontroller and the cradle-side application are as follows:

V. Results

VI. Discussion and Conclusion

Acknowledgement

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