International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Baby Vision Pro-Smart Baby Monitoring System in Domestic Environment

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Abstract
Modern parents, especially those who are both working, face significant challenges in balancing their professional responsibilities with childcare. Traditional daycare services and hired caregivers often involve high costs and do not completely ease parents' worries. This paper presents an IoT-based smart baby monitoring system aimed at addressing these issues by providing a reliable, cost-effective solution for infant care. The proposed system leverages the Internet of Things (IoT) to offer an array of features tailored to the needs of working parents. These include live video streaming for real-time monitoring, artificial intelligence algorithms for baby detection, and advanced sound analysis to detect and alert parents to their baby's cries. Additionally, various sensors monitor environmental conditions such as temperature, humidity, and moisture levels, as well as the baby's movement and heart rate, ensuring comprehensive oversight of the baby's well-being.

KEYWORDS: Internet of Things, Artificial Intelligence, Convolutional Neural Network, Cry & Baby Detection, You Only Look Once(YOLO),Video Lan Client, MQTT

I. Introduction

In today's fast-paced society, modern parents, especially working, face significant challenges in balancing work responsibilities and childcare. Traditional daycare facilities and the option of hiring caregivers often come with high costs and do not fully ease parents' worries. This paper introduces an IoT-based smart baby monitoring system designed to tackle these issues. By utilizing the Internet of Things (IoT), this system offers a wide range of features that help working parents monitor and care for their infants, no matter where they are.

Key components of the system include live video streaming, which allows parents to view their baby's activities in real-time, and advanced artificial intelligence algorithms that facilitate baby detection and cry detection and also trigger immediate alerts to parents, ensuring timely responses to their baby's needs. The integration of various sensors—temperature, humidity, heart rate, and moisture—provides detailed insights into the baby's environment and well-being.

The system supports the review of recorded videos from the past seven days, enabling parents to analyze their baby's behavior and developmental milestones over time. Task automation and reliable data collection minimize manual intervention, enhancing the overall user experience. The gathered data is stored in a secure database and accessible through a user-friendly web dashboard, where sensor readings are visualized, and notifications are sent to parents' phones.

This smart baby monitoring system not only addresses the practical challenges faced by working parents but also provides peace of mind by ensuring continuous and comprehensive monitoring of their infants. Furthermore, the system includes features designed to assist parents with hearing impairments. By providing visual alerts and notifications through the web dashboard and mobile applications, the system ensures that all parents, regardless of their ability to hear, can effectively monitor and respond to their baby's needs.

II. Literature survey

[1] In the proposed system, the necessary monitoring features like room temperature and humidity, cry detection, and face detection were monitored by exploiting different sensors. The sensor data is transferred to the Blynk server via controllers with an Internet connection. The system is also capable of detecting the facial emotions of the registered babies by using a machine learning model. Parents can monitor the live activities and emotions of their child through the external web camera and can swing the baby cradle remotely upon cry detection using their mobile application. They can also check the real-time room temperature and humidity level.

[2] This Paper introduce pre-processing approaches and describe a diversity of features such as MFCC, spectrogram, and fundamental frequency, etc. Both acoustic features and prosodic features extracted from different domains can discriminate frame-based signals from one another and can be used to train machine learning classifiers. Together with traditional machine learning classifiers such as KNN, SVM, and GMM, newly developed neural network architectures such as CNN and RNN are applied in infant cry research. They present some significant experimental results on pathological cry identification, cry reason classification, and cry sound detection with some typical databases.

[4] Smart Baby Monitoring System using YOLO V7 Algorithm: The paper introduces a cutting-edge smart baby monitoring system that combines IoT and the YOLO V7 deep learning algorithm. This system dynamically adjusts the camera to track the baby's movements,ensuring comprehensive monitoring. It boasts high mean Average Precision (mAP) scores and rapid real-time video processing, showcasing its capability to deliver reliable and efficient baby surveillance.

[3] In this paper, they propose two machine-learning algorithms for automatic detection of baby cry in audio recordings. The first algorithm is a low-complexity logistic regression classifier, used as a reference. To train this classifier, we extract features such as Mel-frequency cepstrum coefficients, pitch and formants from the recordings. The second algorithm uses a dedicated convolutional neural network (CNN), operating on log Mel-filter bank representation of the recordings.

III. Proposed methodology

The architecture of this project is structured into three layers: the Raspberry Pi Layer, the Server Layer, and the Client Machine Layer. Each layer plays a vital role in the overall functionality of the smart baby monitoring system, ensuring seamless data collection, storage, and accessibility for caregivers.

Starting with the Raspberry Pi Layer, this component serves as the central hub for data collection and processing. Equipped with various sensors, including the DHT11 for temperature and humidity monitoring, the SEN-11574 for heart rate tracking, the Raspberry Pi Camera for visual monitoring, and a portable condenser microphone for audio streaming, the Raspberry Pi captures vital information about the baby's environment and well-being. Through its GPIO pins, the Raspberry Pi interfaces with these sensors, continuously gathering data in real-time. All of the scripts will be activated using crontabs at boot.

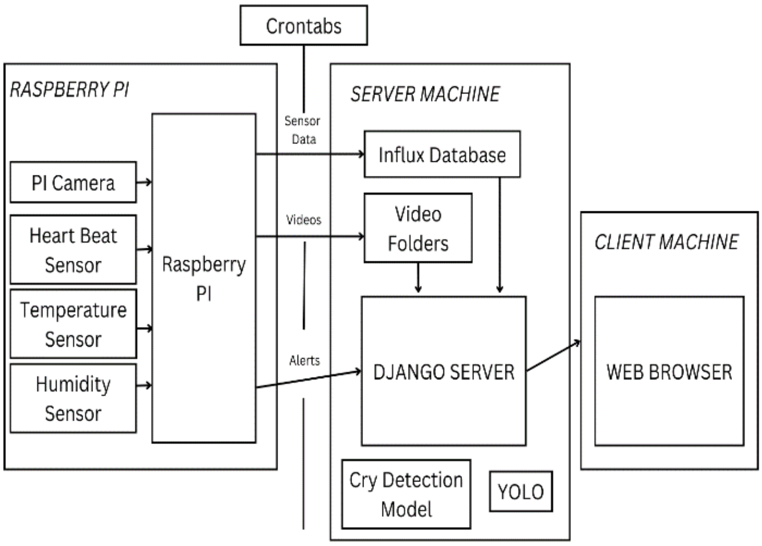

Fig 1: System Architecture

Moving on to the Server Layer, it serves as the backbone for data storage and management. Here, the InfluxDB database acts as a reliable repository for storing sensor readings collected by the Raspberry Pi. Additionally, the server is responsible for storing videos captured by the Raspberry Pi Camera. Through robust data handling mechanisms, the server ensures that valuable information is securely retained and accessible for future analysis and reference.

Simultaneously, the server facilitates the real-time streaming of videos to the Client Machine Layer. This layer, typically accessed by the baby's caregiver or parent, provides a user-friendly interface for monitoring the baby's activities. Through a standard web browser, users can access the Baby Vision Pro dashboard, which serves as a centralized platform for viewing sensor readings, live video streams, and stored videos. This dashboard empowers caregivers with timely insights into the baby's well-being, enabling them to respond promptly to any detected anomalies or emergencies

IV. Implementation

The System uses Raspberry Pi as the end device to collect heartbeat, humidity, temperature, moisture, video and audio data through the following devices.

Fig 2 : Raspberry Pi 3 Model B

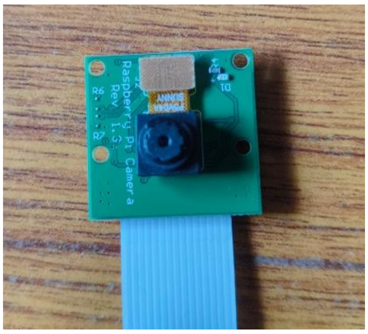

Fig 3: Raspberry Pi Camera

Fig 4 : SEN-11574 Heart Beat Sensor

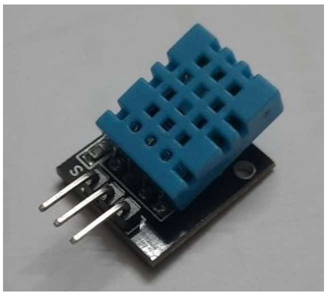

Fig 5 : DHT11 – Humidity and Temperature Sensor

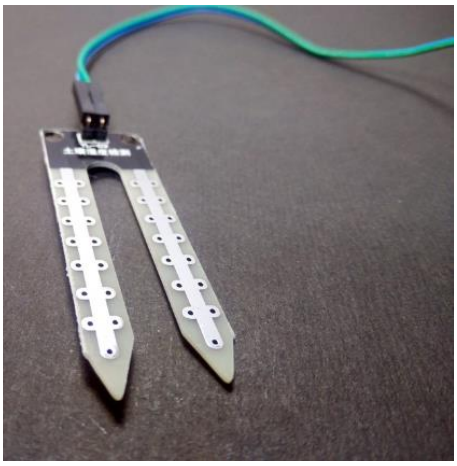

Fig 6 : Soil Moisture Sensor

Fig 7 : Condenser Microphone

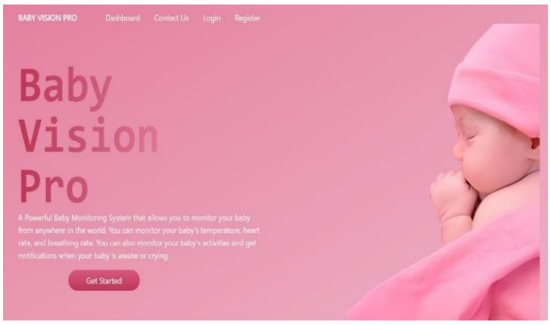

Fig 8 : Landing Page

A User friendly UI is developed for ease of use for the parent.

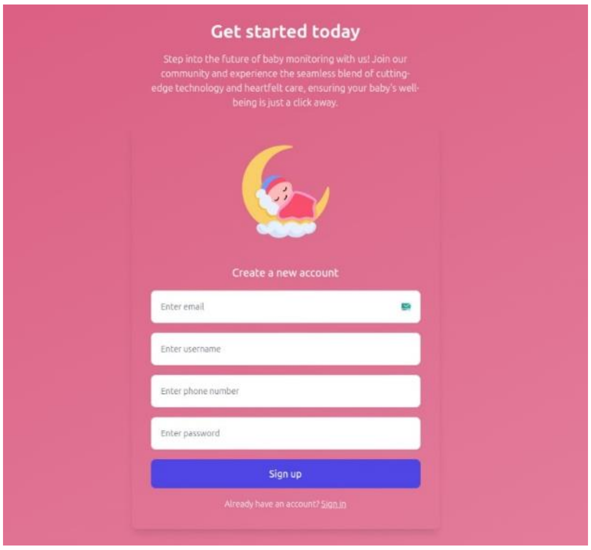

Fig 9 : Sign Up Page

The Parents view the notification panel for the history of baby crying, urinated and baby not found messages.

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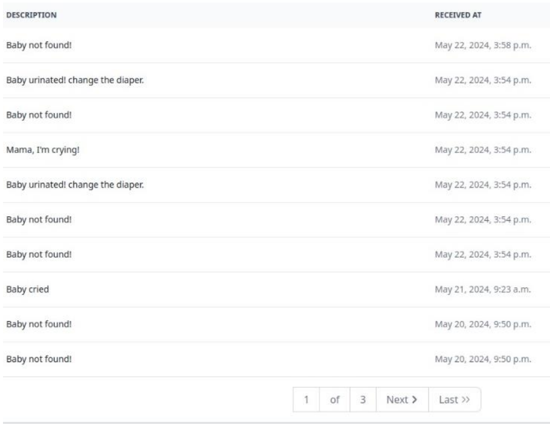


DESCRIPTION	RECEIVED AT
Baby not found!	May 22, 2024, 3:58 p.m.
Baby urinated! change the diaper.	May 22, 2024, 3:54 p.m.
Baby not found!	May 22, 2024, 3:54 p.m.
Mama, I'm crying!	May 22, 2024, 3:54 p.m.
Baby urinated! change the diaper.	May 22, 2024, 3:54 p.m.
Baby not found!	May 22, 2024, 3:54 p.m.
Baby not found!	May 22, 2024, 3:54 p.m.
Baby cried	May 21, 2024, 9:23 a.m.
Baby not found!	May 20, 2024, 9:50 p.m.
Baby not found!	May 20, 2024, 9:50 p.m.

1 of 3 Next › Last »

Fig 10 : Notifications Page

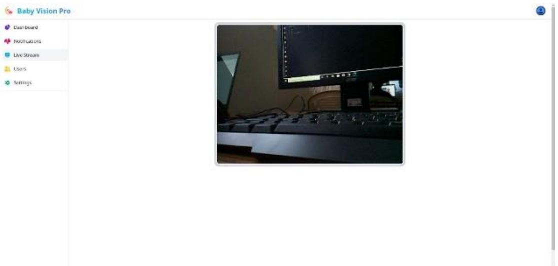
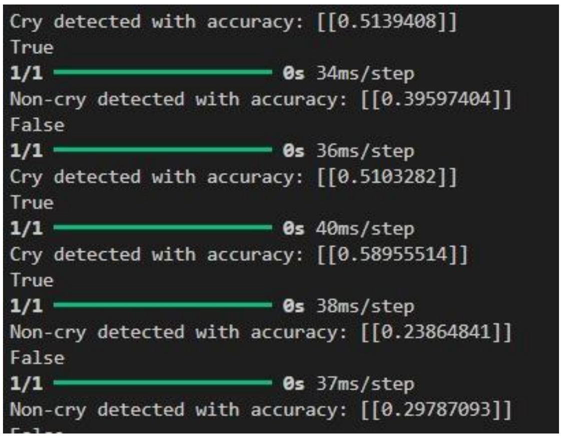


Fig 11 : Live Stream Page

Realtime feed with minimal latency is viewed in the live stream page.



```
Cry detected with accuracy: [[0.5139408]]
True
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 34ms/step
Non-cry detected with accuracy: [[0.39597404]]
False
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 36ms/step
Cry detected with accuracy: [[0.5103282]]
True
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 40ms/step
Cry detected with accuracy: [[0.58955514]]
True
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 38ms/step
Non-cry detected with accuracy: [[0.23864841]]
False
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 37ms/step
Non-cry detected with accuracy: [[0.29787093]]
```

Fig 12 : Cry Detection Model Output

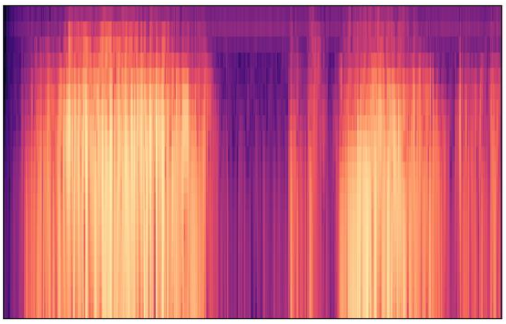


Fig 13: Cry Log Power Spectrum

V. Conclusion

In conclusion, the presented architecture for a smart baby monitoring system effectively integrates data collection, storage, and real-time monitoring across three layers. Utilizing a Raspberry Pi with various sensors, a server with InfluxDB for data management, and a user-friendly web interface, this system provides caregivers with comprehensive insights and timely alerts, enhancing the safety and care of infants.

VI. Future Work

Enhance the smart baby monitoring system by using machine learning for advanced cry analysis, differentiating between cries of hunger, discomfort, pain, or tiredness to help parents respond more effectively. Implement technology to detect the baby's emotional state through facial expressions and body language, providing insights into their well-being. Develop features to track and analyze sleep patterns, offering valuable information on sleep habits and potential issues. Integrate with wearable devices to gather additional data points like heart rate, respiration rate, and body temperature, providing a comprehensive view of the baby's health. Enable compatibility with smart home ecosystems such as Amazon Alexa, Google Home, or Apple HomeKit for seamless interoperability and expanded functionality.

VII. Reference

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