An AI + IoT Solution to prevent SIDS

Sudden Infant Death Syndrome

A PROJECT REPORT

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DEPT. OF CSE

SHIV NADAR UNIVERSITY CHENNAI

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CANDIDATE’S DECLARATION

We, Abhishek Herbert Samuel (21011102004), Aman Bhat (21011102013) & Sashank Kumar Kakaraparty (21011102043) students of B.Tech (CSE - IoT), hereby declare that the Project Dissertation titled — “An AIoT Solution to prevent SIDS” which is submitted by us to the Department of CSE, Shiv Nadar University Chennai in fulfillment of the requirement for awarding of the Bachelor of Technology degree, is not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma, Fellowship or other similar title or recognition.

Place: Chennai Date: 9th Novermber 2024	**Abhishek Herbert Samuel (21011102004)**	**Aman Bhat (21011102013)**	**Sashank Kumar Kakaraparty (21011102043)**

CERTIFICATE

I hereby certify that the Project titled ”An AIoT Solution to prevent SIDS” which is submitted by Abhishek Herbert Samuel (21011102004), Aman Bhat (21011102013) & Sashank Kumar Kakaraparty (21011102043) for fulfillment of the requirements for awarding of the degree of Bachelor of Technology (B.Tech) is a record of the project work carried out by the students under my guidance & supervision. To the best of my knowledge, this work has not been submitted in any part or fulfillment for any Degree or Diploma to this University or elsewhere.

Place : Chennai

Date : 9th Novermber 2024

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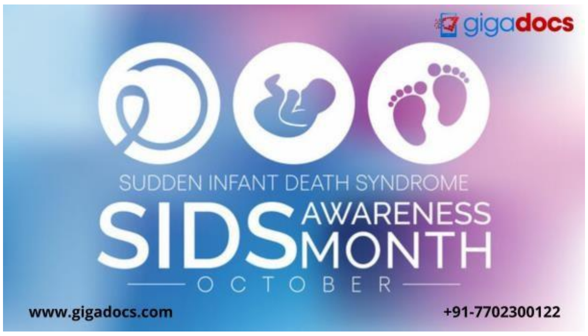

Figure 1: SIDS Awareness

ABSTRACT

Keywords - SIDS, Crib Death, Baby Monitoring System, AI, IoT

Sudden Infant Death Syndrome (SIDS), also known as crib death, is the unexplained death of an infant, typically during sleep. It is the leading cause of mortality in infants aged 1 month to 1 year and is characterized by abnormal breathing, irregular body temperature, and suffocation.

The lack of real-time monitoring of vital signs and movements can lead to delayed responses in emergencies, increasing the risk of mortality. Our proposed system aims to improve upon existing Baby Monitoring Systems, providing a low-cost solution that allows for continuous monitoring through an application that sends immediate alerts to parents upon the detection of a risk factor for SIDS, thereby enhancing infant safety.

Additionally, our approach integrates Artificial Intelligence (AI) with the Internet of Things (IoT) to analyze sensor data trends over time, identifying patterns that may indicate potential health issues. This predictive capability can empower parents and caregivers with valuable insights into the baby's health and behavior, allowing for preventive actions and ensuring a safer sleep environment for infants.

ACKNOWLEDGEMENT

The successful completion of any task is incomplete and meaningless without giving any due credit to the people who made it possible without which the project would not have been successful and would have existed in theory.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

Symbol	Description	Units
HR	Heart Rate	bpm
SpO_2	Blood Oxygen	%
T	Temperature	°C

Abbreviation	Full Form
SIDS	Sudden Infant Death Syndrome
IoT	Internet of Things
AI	Artificial Intelligence
ML	Machine Learning
PCB	Printed Circuit Board
ESP32	Microcontroller used in IoT systems

Nomenclature	Definition
Pulse Oximeter	A device used to measure blood oxygen saturation
Smart Band	Wearable device to monitor heart rate, temperature, SpO2

Chapter 1

INTRODUCTION

1.1 Overview

Sudden Infant Death Syndrome, also known as crib death, is the unexplained death of an infant, typically during sleep, and is the leading cause of mortality in infants aged 1 month to 1 year and is characterized by abnormal breathing, irregular body temperature and suffocation. SIDS remains a critical concern for parents and healthcare professionals due to its unpredictable nature. Despite advancements in healthcare, SIDS continues to affect infants worldwide, causing significant distress and loss. The motive behind our project is to blend Artificial Intelligence(AI) and Internet of Things(IoT) technologies to develop a solution that can monitor and analyze infant behaviour in real-time by providing early warnings. By providing real-time monitoring and alerts, our solution aims to reduce anxiety for parents and caregivers, allowing them to respond quickly to any potential risks, thereby creating a safer environment for infants during their sleep.

1.2 Problem Formulation

Our project addresses the critical issue of SIDS, which is a significant risk to infants aged 1 month to 1 year, often occurring during sleep without any prior warning. The lack of real-time monitoring of vital signs and movements can lead to delayed responses in emergencies, increasing the risk of mortality. The proposed system aims to provide continuous monitoring and immediate alerts to parents and healthcare providers, thereby enhancing infant safety and reducing the incidence of SIDS. The challenge lies in the inability to monitor vital signs and detect critical changes in an infant's condition during sleep, and by developing a comprehensive monitoring system that utilizes Artificial Intelligence and Internet of Things to provide real-time alerts. The proposed architecture is designed to develop a PCB based smart band.

1.3 Objectives

- We have divided our approach into two aspects which involves integrating sensors on the crib as well as design a PCB based smart band that too will consist some other sensors.
- With respect to the smart-crib we plan on integrating a camera on the crib.
- With respect to the smart band, we plan to develop one which will be placed on the baby's wrist.
- This smart band will be based on the PCB design and the SPO2 sensor, temperature sensor and the heart-beat sensor will be the main components of the band.
- The radiations will be negligible and will not affect the infant's health, hence safe for use.

1.4 Motivation

Blend Artificial Intelligence (AI) and Internet of Things (IoT) technologies to develop a solution that can monitor and analyze infant behavior in real-time by providing early warnings.

Provide peace of mind to parents and caregivers by leveraging technology to ensure infant's safety, allowing for timely interventions that could prevent potential health risks.

Chapter 2

BACKGROUND

2.1 What is SIDS

Sudden Infant Death Syndrome (SIDS) is the unexplained, sudden death of an otherwise healthy infant, usually during sleep. This tragic occurrence primarily affects infants under one year of age, with the highest risk period between two and four months. SIDS is often linked to a combination of factors, such as issues in the infant's brain that affect breathing or sleep arousal, environmental factors like sleeping position, and genetic vulnerabilities.

Research has shown that certain sleep practices can help reduce the risk of SIDS, such as placing infants on their backs to sleep, keeping the sleeping area free from soft bedding or toys, and maintaining a smoke-free environment. Even with these preventive measures, SIDS remains a complex phenomenon, highlighting the importance of further research and technology-based solutions to better understand and monitor infants' sleep and breathing patterns in real-time.

Age (months)	Heart Rate (bpm)	Breathing Rate (breaths/min)	Temperature (°C)	Sleep Position	Alert
3	130	28	36.5	Back	No
2	145	35	37.8	Stomach	Yes - High Risk
4	120	25	36.2	Side	Warning - Position
3	135	30	36.7	Back	No
1	155	40	38.1	Back	Yes - High Risk

Table 2.1: Sample Database for SIDS Monitoring

Figure 2.1: SIDS

Figure 2.2: ABC's of SIDS Prevention

Chapter 3

Results

3.1 Algorithm for Integration

Initialize Components:

- Set up a serial connection at 115200 baud rate for debugging output.
- Connect to WiFi using the provided SSID and password. Wait until a successful connection is established.
- Initialize the MLX90614 temperature sensor. If initialization fails, display an error and halt the program.

Enter Main Loop:

- **Data Collection:**
  - Read body temperature from the MLX90614 sensor.
  - Read heartbeat and SpO2 levels from the MAX30100 sensor.
- **Prepare Data:**
  - Construct a JSON-formatted string (payload) containing the sensor data:
    * `heartRate`: heart rate value.
    * `spO2`: SpO2 value.
    * `bodyTemp`: body temperature reading.
- **Send Data to Server:**

  - Check if the WiFi is still connected.
  - Create an HTTP POST request to send the JSON payload to the backend server.
  - If the POST request is successful, print the server response to the serial monitor.
  - If the POST request fails, display an error message.

- **Repeat:**
  - Repeat the process after another 5-second interval, continuously reading and transmitting sensor data.

3.2 Output Generated

Serial Monitor Output

Displays real-time readings for heart rate, SpO2, and body temperature.

Backend (Express Server)

Server Initialization

- Set up Express server with CORS and middleware.
- Establish MySQL database connection.
- Configure WebSocket for real-time updates.

WebSocket Connection Handling

- Send a welcome message on client connection.
- Log errors or closure messages.

Sensor Data Collection

- Accept POST requests for heart rate, SpO2, and body temperature.

- Validate data; store in the database if valid.
- Broadcast updates to WebSocket clients.

Dashboard Data Retrieval

On GET request, fetch the latest sensor data from the database.

User Management

- Registration: Validate and hash passwords; insert user details into the database.
- Login: Verify credentials and authenticate users.

Server Operation

Start listening on the specified port.

Frontend (React Dashboard)

State Management and WebSocket

- Initialize state for sensor data, chart data, and alerts.
- Create WebSocket connection for real-time updates.

Initial Data Fetching

Retrieve latest sensor data from the backend on load.

WebSocket Message Handling

Update sensor values, chart data (last 20 values), and alerts (last 10 alerts) upon receiving new data.

Chart Data Generation

Create datasets for heart rate, SpO2, and body temperature charts.

User Logout

Redirect to the login page upon logout.

Dashboard Rendering

Display vitals, real-time charts, and recent alerts in the UI.

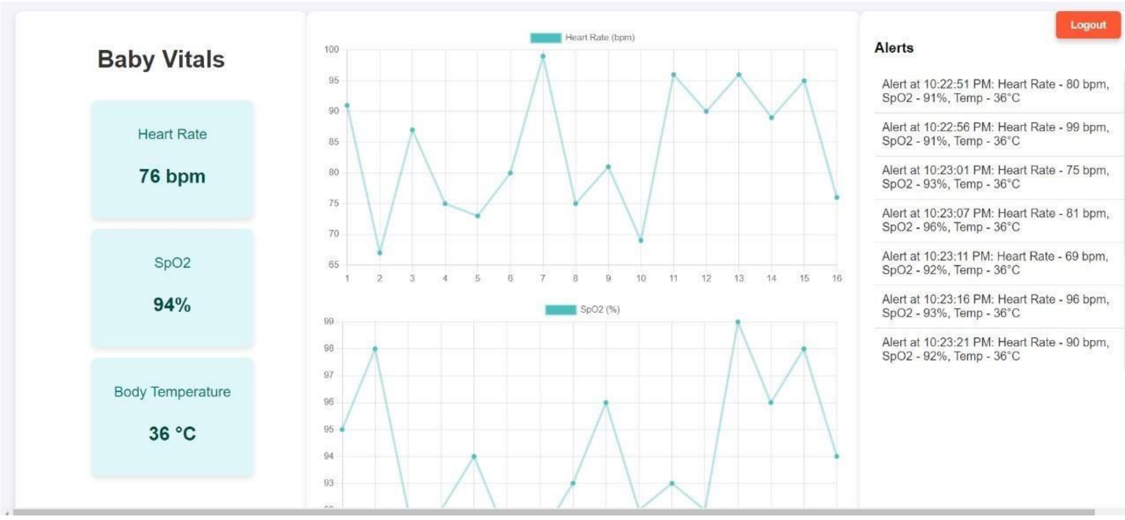

Figure 3.1: Sample output from the system

Chapter 4

CONCLUSION

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in our project represents a meaningful advancement in infant health monitoring. By developing a wearable band equipped with sensors, we aim to provide parents with a reliable solution for real-time monitoring of vital signs, such as heart rate, blood oxygen levels, and temperature. Our phased approach allows us to focus on developing both the essential monitoring capabilities and a user-friendly interface for parents, ensuring the system is both effective and easy to use. The use of compact, low-radiation hardware ensures that this solution is safe for infants while being cost-effective, portable, and practical for daily use by alerting in times of critical conditions.

Appendix

A. Technical Specifications of Hardware Components

1. Max30100 Sensor Specifications

Functionality: Integrated pulse oximetry and heart-rate monitor. Components: Includes two LEDs, a photodetector, optimized optics, and low-noise analog signal processing. Radiation: Very low and safe for continuous use. Power Consumption: Pulse oximetry module – 600 μA Heart rate module – 1.1 mA

2. MLX90614 IR Temperature Sensor Specifications

Functionality: Contactless temperature measurement. Radiation: None emitted by the sensor. Power Consumption: 1.5 mA Accuracy: ±0.2°C (in body temperature range).

3. ESP32 Microcontroller

Functionality: Provides GPIO pins, Wi-Fi, and Bluetooth connectivity. Power Consumption: Power-optimized for IoT applications.

B. PCB Design and Layout

Layers: Top Layer: ESP32 and programming circuit (CH340C, micro USB). Second Layer: Power management circuit (MT3608 buck boost). Third Layer: Charging circuit with dynamic charging method (TP4056). Bottom Layer: Temperature sensor and SPO2/heart rate sensors, connected to ESP32 via I2C.

C. Software Components

1. Frontend

Framework: React Native. Functionality: Displays real-time health parameters of the infant (heart rate, SPO2, temperature) and alerts based on predefined thresholds.

2. Backend and Database

Backend: Express framework built on Node.js -based server to process sensor data. Database: MySQL, stores real-time health data for tracking and analysis.

3. Git and Github

Version control and (CI/CD) using GitHub for code management and deployment.

4. Programming for ESP32

Programming the ESP32 to collect sensor data and manage communication.

D. Monitoring Parameters and Alert Thresholds

Parameter	**Normal Range**	**Alert Threshold**
Heart Rate (bpm)	70–90	$>$ 70 or $<$ 90
Spo2(%)	91-95	$<$ 90
Temperature (°C)	33–38	$>$ 38.0 or $<$ 33

Table 4.1: Monitoring Parameters and Alert Thresholds

E. Implementation Phases

Phase 1

Develop a web application displaying real-time health metrics for the infant, including pulse rate, SpO2, and temperature from PCB based wearable.

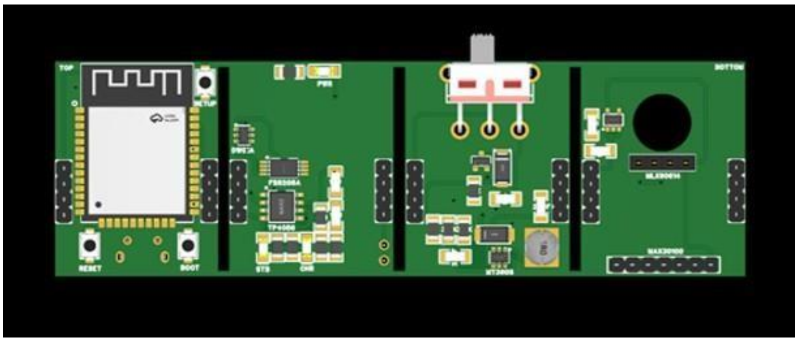

Figure 4.1: Top View - PCB band

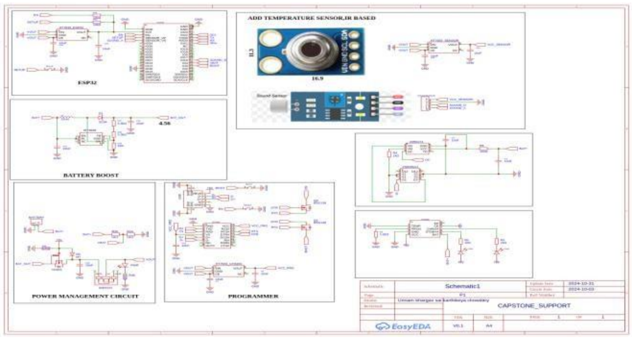

Figure 4.2: 3D Design Architecture - PCB Band

Phase 2

Integrate a crib-mounted camera to monitor sleep position and movements. Implement AI algorithms to analyze and detect abnormal positions and behaviors.

F. Advantages of Our Solution

- **High Precision Monitoring:** Real-time monitoring of multiple vital signs with accurate, sensitive detection.
- **Portability:** Lightweight, wearable wristband and crib sensor integration for continuous monitoring, even during travel.
- **Cost Efficiency:** Affordable, easy-to-replace hardware, with scalable monitoring solutions for multiple infants if needed.

4.1 Primary Research

Dr. Samidha Raje, a SIDS expert and experienced pediatrician, approved the overall design approach, affirming it as safe for use in monitoring infant health. Her feedback includes the following key points:

- **Band Material & Comfort:**
  - Recommended a chewable rubber band to ensure comfort and prevent irritation.
  - Strongly advised against Velcro, which could cause rashes.
- **Optimal Positioning:**
  - The wrist is suggested as the best position for accurate readings due to access to an artery.
  - No additional padding (e.g., cotton) is necessary between the skin and the band.
  - Leg and waist positioning were discouraged.
- **Size Specification:**
  - Advised that the wrist circumference should align with the width of two adult fingers for a secure fit.
- **Positioning Guidance:**
  - Detailed positioning instructions were provided, with a recommendation for in-person clarification to ensure proper application.
- **Cost-Effectiveness:**
  - Emphasized maintaining a low-cost design as a key differentiator, without compromising on quality or safety.
- **Future Enhancements & Image Processing:**
  - Supported plans for integrating a camera and image processing for more comprehensive monitoring in future iterations.

- **Challenges & Potential Drawbacks:**
  - Noted that vigorous baby hand movements might cause occasional false readings or alarms.

This feedback serves to guide the refinement of the design, ensuring that the wristband is both safe and effective for infant monitoring.

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