THE UNIVERSITY OF WESTERN AUSTRALIA

Project Report

Smart Cradle

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Smart Cradle

ABSTRACT
More families are having dual-income as both parents work at the same time. It is getting difficult for them to balance work life and childcare. Even when baby is sleeping, parents are also worried about concern like sudden infant death syndrome (SIDS). Sleep-related accidents may pose serious risks of baby, so parents need to monitor their babies constantly. The Smart Cradle project focuses on improving infant safety by using IoT and AI. Traditional baby monitors only provide basic functions like sound or video and do not detect real-time issues. The Smart Cradle solves this problem. We use sensors to monitor the baby's movements, sounds, and room temperature. These sensors connect to a Raspberry Pi, which processes the data and uses AI to analyse it. When something unusual happens, like the baby waking up or the temperature being unsafe, the system sends alerts. Parents can check real-time data through a web interface. After real-world testing, the system was tested and found to be accurate, with very few false alerts. It gives parents peace of mind by providing real-time updates and quick warnings when something is wrong. The project shows how IoT and AI can make baby monitoring safer and easier. In the future, more sensors and better AI can be added to improve the system.

Keys: Real-Time Monitoring, Baby Safety, IoT and AI Integration, Alerts and Notifications

1 INTRODUCTION

In recent years, more and more family's parents are facing problems that they do not have enough time to take care about their babies because of overnight works. This makes it hard for them to take care of their babies constantly. Traditional ways, like asking grandparents or babysitters for help, but this cannot let parents to know their baby's situation immediately. Also, when parents are busy, there is impossible that they can respond to their baby's needs right away. In 2020, over 100 babies in Australia died from Sudden Unexpected Death in Infants (SUDI) (**Health Direct (2022)**). Also, sleep-related infant deaths, including Sudden Infant Death Syndrome (SIDS), are a big problem. Most SIDS deaths happen when a baby is between 1 and 4 months old, and more than 90% of these deaths occur before the baby turns 6 months old (**Medical News Today (2022)**).

To solve these problems, we designed a baby monitoring system. This project aims to build a smart cradle using IoT technology and artificial intelligence. Parents can easily get the baby status through the dashboard and can monitor their baby better and more reliably.

The smart cradle uses multiple sensors to track the baby's movements, sounds, and room temperature. With the help of Motion detection AI, smart cradle can detect risks, such as when the baby wakes up, leaves the cradle, or when the room temperature is in an unsafe range. These problems may lead to dangerous situations. In the event of a dangerous situation, the smart cradle will send real-time alerts to parents and turn on the warning light so that parents can take immediate action. This reduces the pressure on parents to constantly take care of their babies.

This report provides an in-depth introduction to the project by describing in detail:

- How we designed and built the hardware and software of the smart cradle.
- How we tested the system,
- What we can do in the future

In summary, by combining IoT and AI, the smart cradle can now monitor the sleep and health of babies more easily and safely. It also affects the physical and mental health of parents, helping them achieve a better work-life balance, thereby promoting the well-being of the whole society.

2 TECHNICAL CONTENTS

The Smart Cradle system is designed to continuously monitor your baby's condition and vital signs, including temperature, weight and noise monitoring. The system is also equipped with a camera and AI-based analytics to detect and recognize potential risks or abnormal activity. When abnormalities are detected, such as a crying baby or an abnormal change in pressure of cradle, the system alerts parents in real time via text message or email.

System Design

The architecture of this smart cradle is consisting of four main subsystems:

1. Data Collection Module: Comprising multiple sensors such as a load cell, temperature sensor, and sound sensor.

2. Processing Module: A Raspberry Pi serving as the central processing unit to receive and process sensor data.

3. AI Module: Responsible for analysing camera feeds to detect baby activities such as waking up or leaving the cradle.

4. Notification Module: Sends alerts via email, SMS and lights up warming LED to parents when an anomaly is detected.

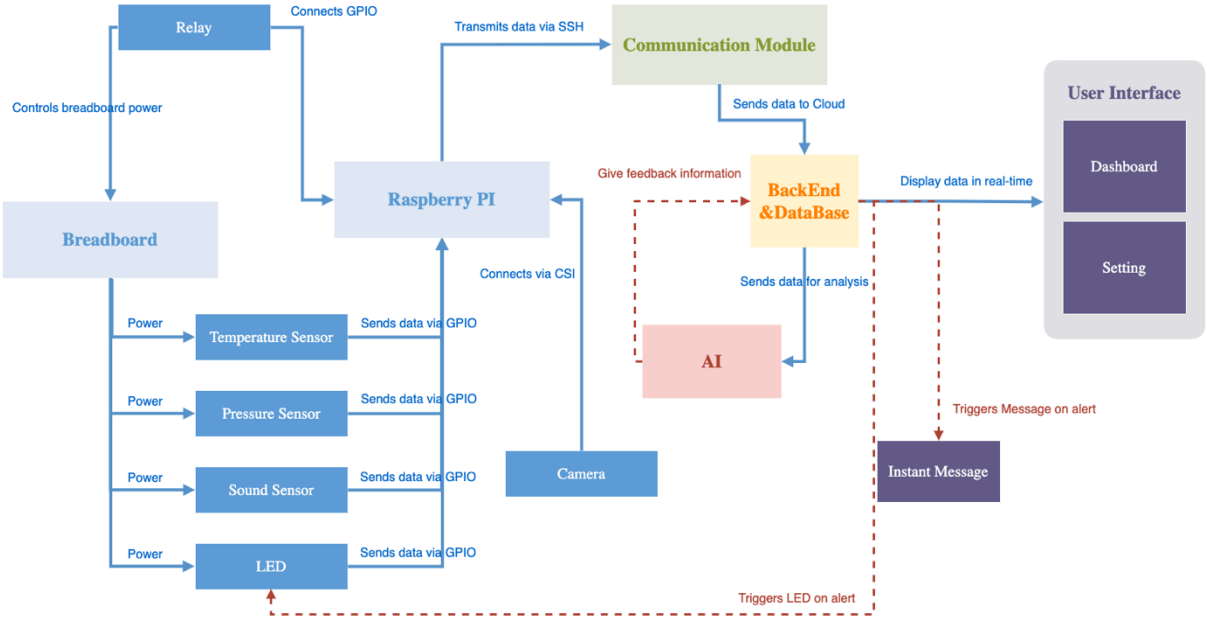

Figure 1 Block Diagram

Data Flow and Component Interaction

The smart cradle system is designed to continuously monitor the baby's status and send alerts when necessary. The interaction between the various components is crucial for ensuring real-time monitoring and accurate detection of anomalies, such as the baby waking up or leaving the cradle. The sequence diagram below (using pressure monitoring as an example) illustrates the flow of data between the key components during normal operation and when an anomaly is detected.

1. Normal Operation:
   - After turning on the sleep detection switch under normal conditions, the pressure sensor continuously monitors the baby's weight, while using the sound detect sensor to detect baby's status together after that sends the pressure data to the Raspberry Pi for processing.
   - The temperature sensor also continuously monitors the baby's temperature to detect baby's constitution. The Raspberry Pi will receive the alert if baby's temperature is out of previous setting.
   - The Raspberry Pi stores the data in the backend database and displays real-time pressure data in the user interface for the parents to monitor the baby's condition.

2. Anomaly Detected (Baby Wakes Up):
   - When the pressure sensor detects a sudden weight change (such as the baby waking up or leaving the cradle), the Raspberry Pi triggers the anomaly detection process.
   - The system analyses the pressure data using the AI module, which confirms that the baby is awake.
   - Once confirmed, the system logs the event and sends an alert to the parents via the instant message system (email/SMS), notifying them that the baby is awake.
   - Simultaneously, the system turns on the LED for a visual alert and updates the event in the user interface for parents to review.

3. Further Analysis:
   - After detecting the anomaly, the system activates the camera to capture an image of the baby's current condition.
   - The captured image is uploaded to the cloud backend for further analysis and is displayed on the user interface for the parents to assess the situation visually.

This flow of interactions ensures that the system responds quickly and accurately to potential issues, providing real-time feedback to parents, both visually and via instant messages.

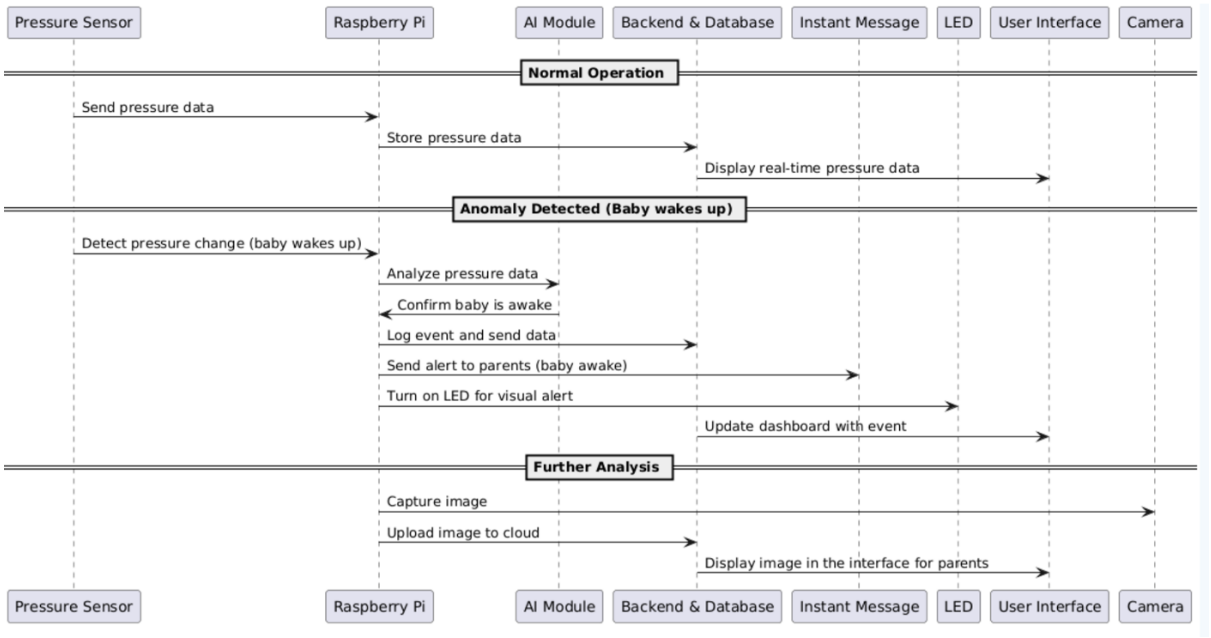

Figure 2 Sequence chart of pressure detection and warning

Circuit Design

The smart cradle system relies on a well-designed circuit that integrates multiple sensors and a Raspberry Pi for real-time monitoring and control. Below is an explanation of the key components and their connections within the circuit, as shown in the schematic.

1. Raspberry Pi:

The Raspberry Pi serves as the central processing unit, receiving data from various sensors and controlling the relay. It is connected to the system through the GPIO pins:

- Pins GPIO14 (TXD), GPIO15 (RXD), and GPIO18 (PWM0) handle data communication and control signals.
- The 5V power supply pin is used to power the entire system, while the GND (ground) pin ensures stable electrical grounding across components.

2. Temperature Sensor (DHT11):

The DHT11 temperature and humidity sensor is connected to the Raspberry Pi via the GPIO pin. It communicates temperature data through the DATA pin, while the VCC and GND pins power the sensor.

3. Sound Detection Sensor (MP45DT02):

The sound detection module is also connected to the Raspberry Pi, with VCC and GND providing power and grounding. Data is transmitted through the respective data pins (L/R and CLK), allowing the system to detect sound events like the baby crying.

4. Relay Module (Fujitsu FTR-LYAA005X):

The relay module controls the power to other components in the system. It is connected to the GPIO pin 23 on the Raspberry Pi, enabling it to receive power ON/OFF commands. The relay is used to switch the power on or off for connected devices like sensors.

5. Load Cell (40PC015G):

The load cell sensor measures the baby's weight and communicates data to the Raspberry Pi through the Dout pin on the HX711 module. This data helps monitor the baby's presence in the cradle and trigger alerts for abnormal weight changes.

6. LED Indicator:

An LED connected via a resistor to GPIO pin 17 serves as a visual indicator for system states. It lights up when an alert is triggered or when a critical operation is in process.

7. Power Supply:

The circuit is powered through a 5V power source that feeds the Raspberry Pi and other components, ensuring stable operation. The system includes a backup mechanism via the relay to ensure the components receive power only when needed.

This circuit is designed to provide efficient data acquisition and control over the cradle's operations. It enables the system to collect and process environmental data, control power to sensors, and provide real-time alerts to the parents.

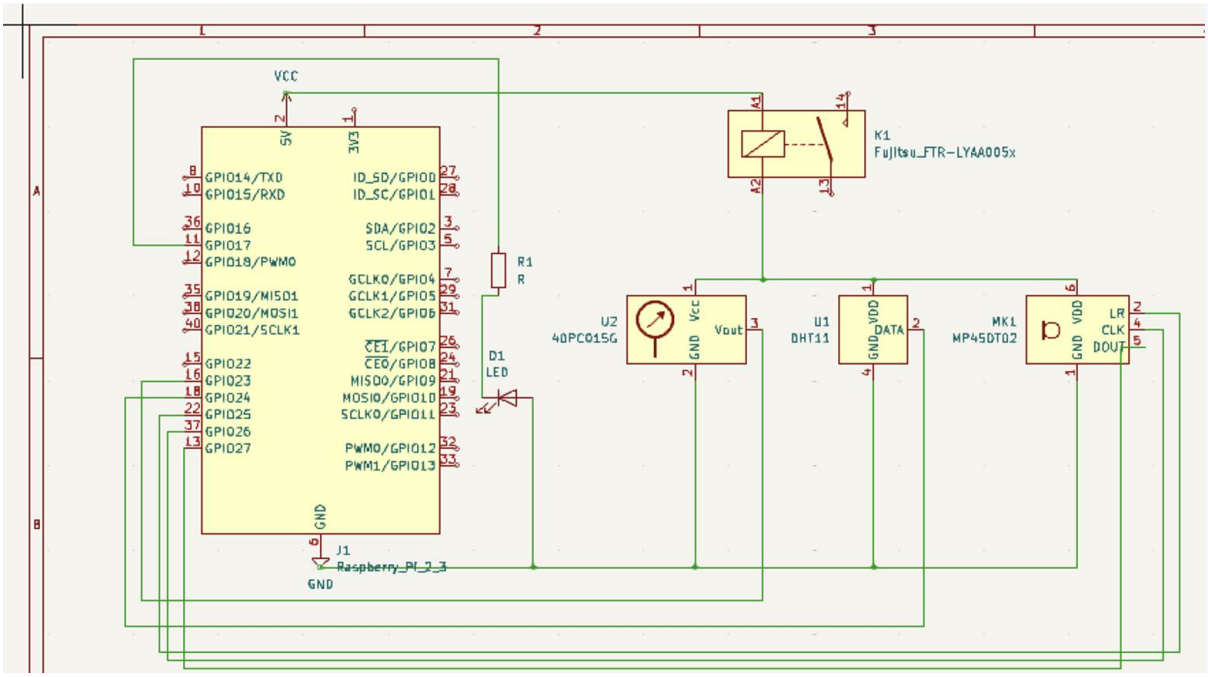

Figure 3 Circuit Diagram

Hardware

In the development of our smart cradle system, we selected several key hardware components to ensure reliable monitoring of the baby's status and efficient data collection. These components include:

1. Raspberry Pi:

The Raspberry Pi is the controller, receiving signals from its assorted sensors, which feed data into the software and allow for real-time control of the cradle's actuators depending on the baby's state.

2. Relay Module:

This components is responsible for the power. The Raspberry pi transfer the signal to the relay to determine whether power-off or power-on the whole smart cradle. When the operation is complete, the Raspberry Pi sends a power off signal, the relay turns off the power and confirms that it is on, and the Raspberry Pi logs the confirmation that the power is off. This ensures that all of the data and power under control.

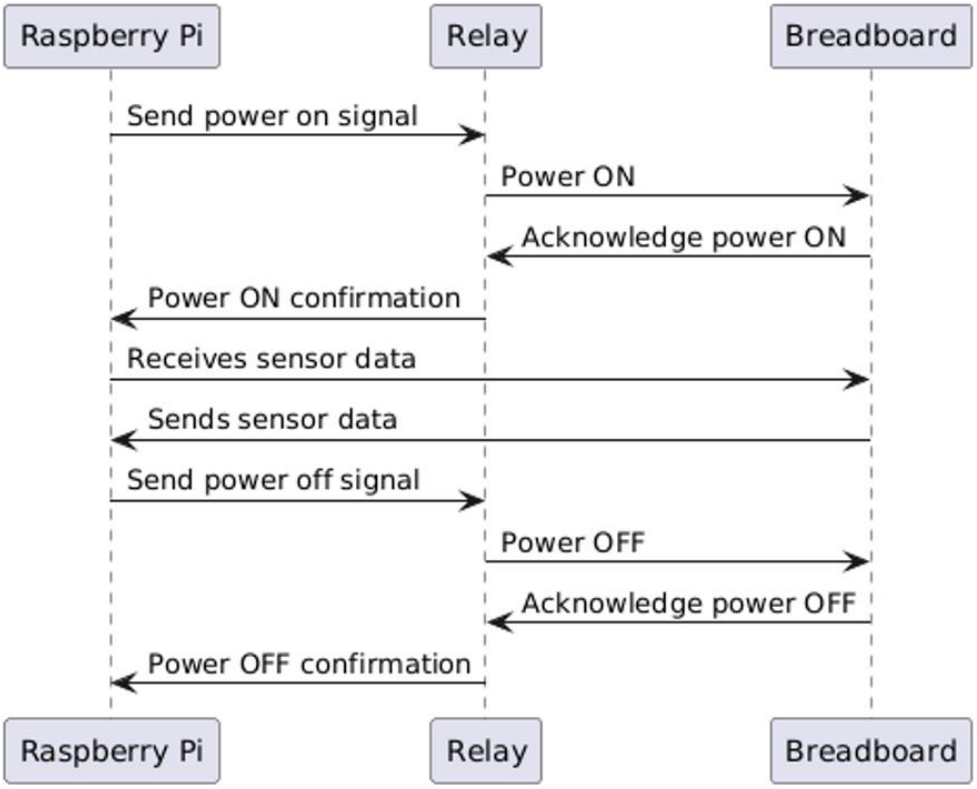

Figure 4 Sequence chart of relay

3. The pressure sensor:

Responsible for keeping a check of the weight of the baby. This sensor gets activated once the power is initiated, the sensor checks its preparedness. In case the initialization is successful, the counter initiates the data check using the pressure sensor, and the data is logged in to the memory. On the contrary, in case of failure, the counter tries to reset to the sensor and is alerted through e mail/SMS if the same fails. Similar is the case for data collection if any failure occurs the counter tries to re-retrieve the data, if it fails again the same is alerted through an error to the user and logged otherwise. This helps in real time data collection responding to the user without any delays and keeps them informed of the sensor and data collection problem in order have a watch and be safe of their baby's weight.

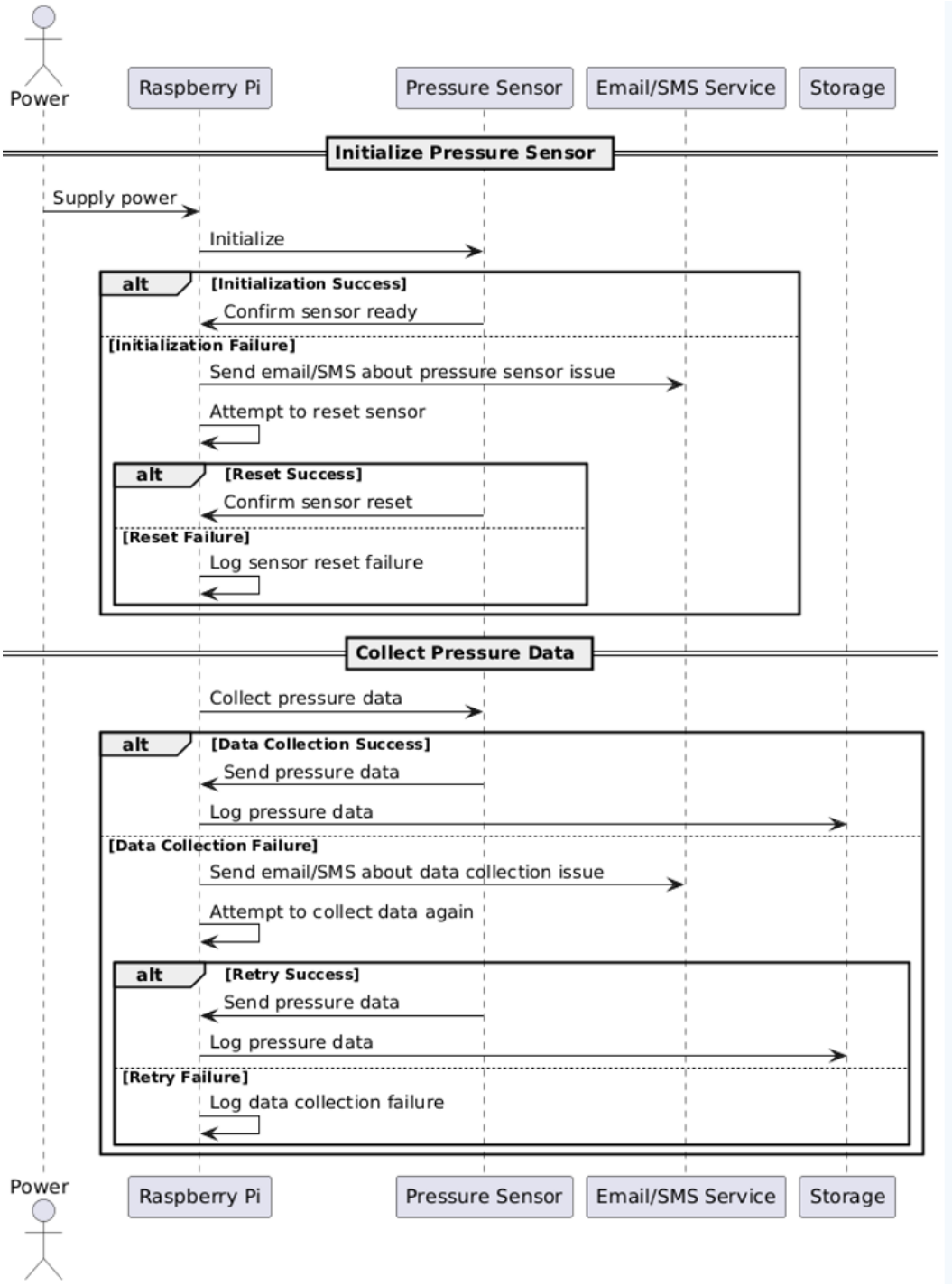

Figure 5 Sequence chart of pressure sensor

4. The sound sensor:

It works by detecting noise, such as the sound of a crying baby. Upon initialization, the sensor checks to see if it is ready. If it succeeds, it will start collecting sound data. If the initialization or data collection fails, the system sends an SMS or email alert and tries to reset or re-collect the data. If successful, the data will be recorded and parents will be notified, and failures will also be recorded. This allows parents to stay informed of problems and ensures that the sensor reliably detects sound anomalies in real time.

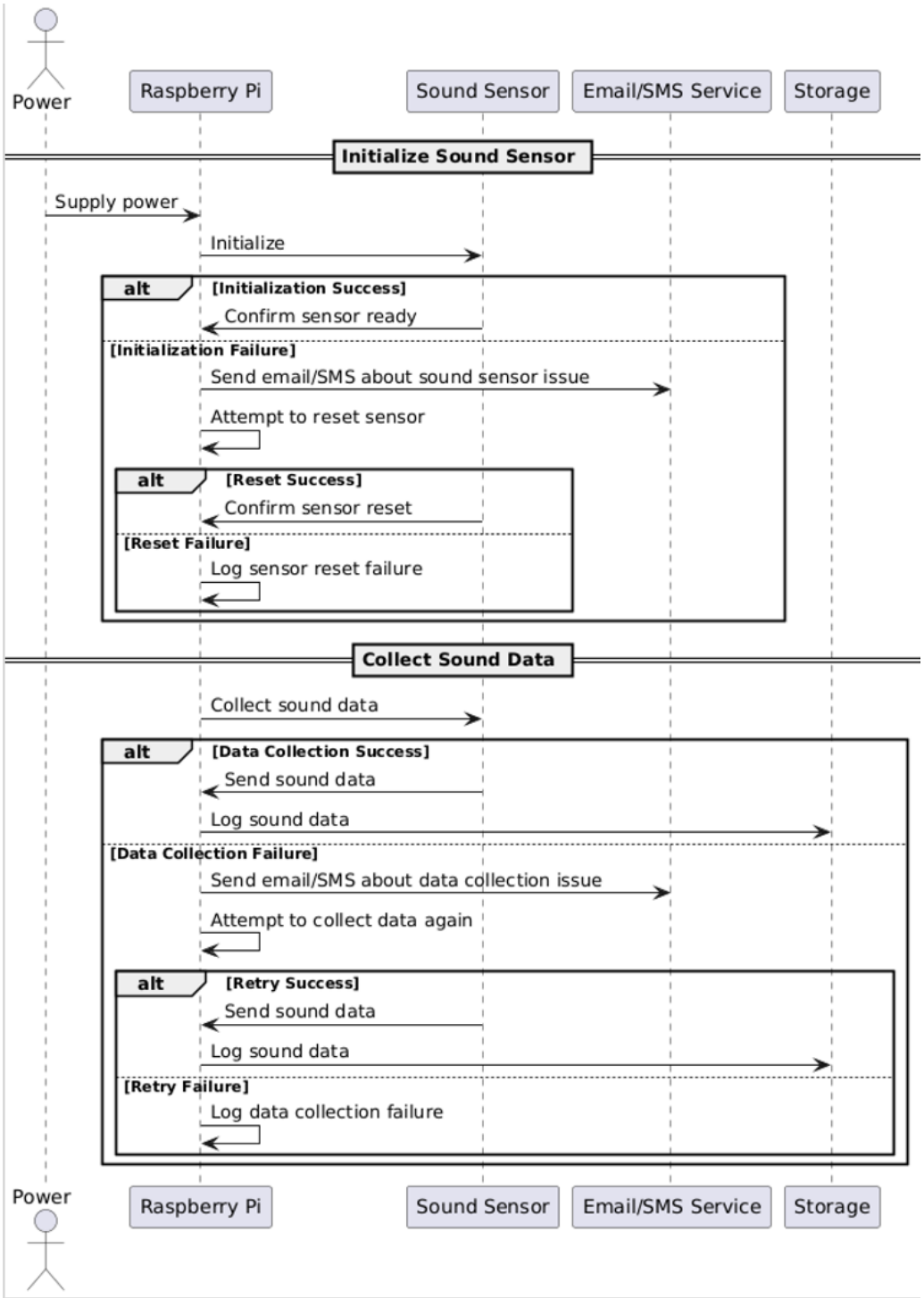

Figure 6 Sequence chart of sound sensor

5. The temperature sensor:

This sensor takes an environmental reading of the smart cradle. If the sensor is successfully initial take and log readings that initialisation or data email and SMS notification will be created. The system will then try to reset in the case of a failed initialisation or a repair in the case of failed data collection. If the reset or repair fail, then a failure notice will be logged, and the user will know. This will alert them to the issues in real-time and inform them when the system is operational again. Parents can be alerted when the temperature of their sleeping baby isn't normal, and can relief them.

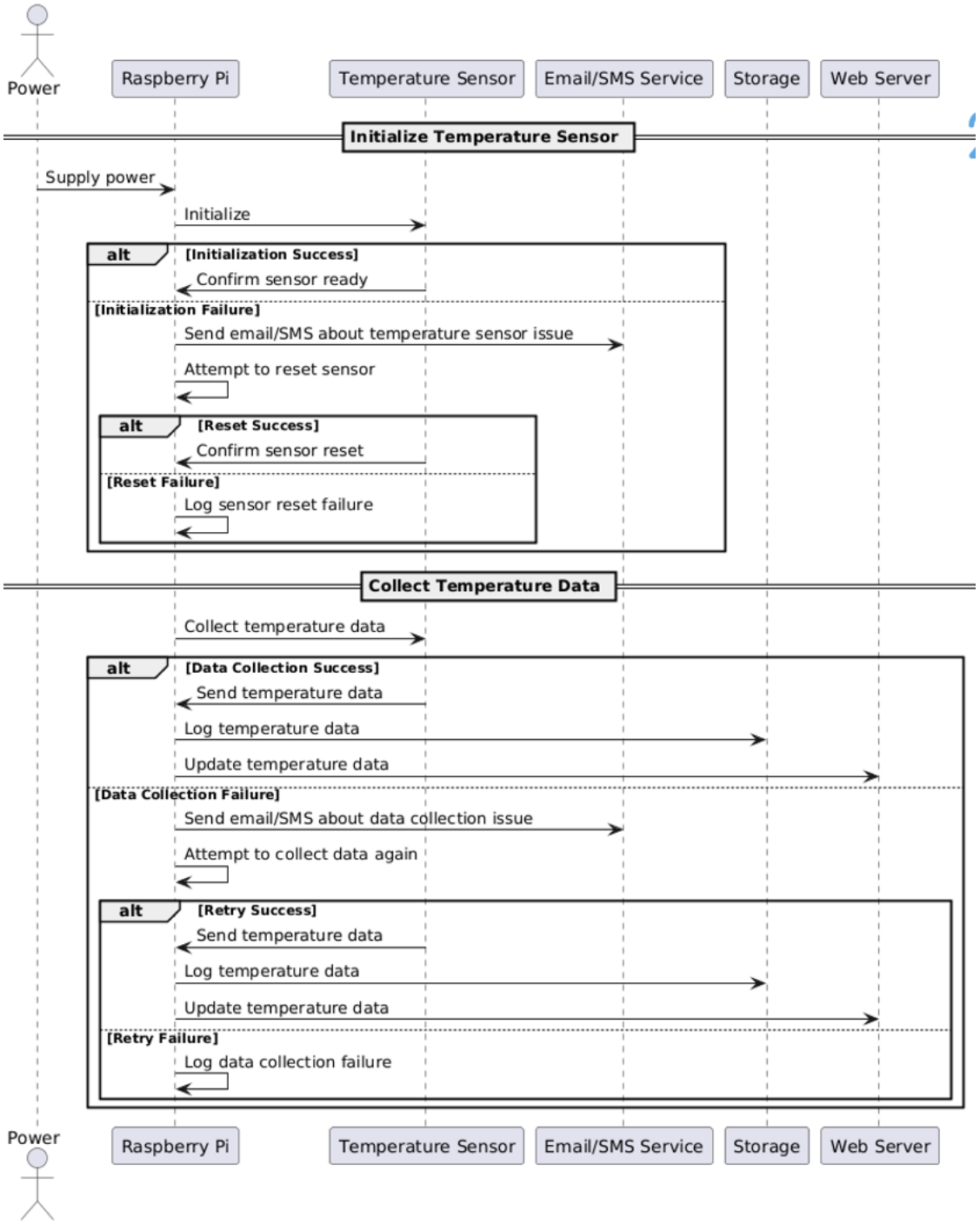

Figure 7 Sequence chart of temperature sensor

6. Camera:

The camera in the Smart Cradle system is responsible for shooting, recording or live video streaming when needed. During initialization, the system checks if the camera is ready. If it succeeds, video

shooting will start. If the initialization or video shooting fails, the system will send SMS or email to notify the parents and try to reset or restart the shooting. If the retry is successful, the video will continue to be live and recorded; if it fails, the system will record the problem. This ensures smooth transmission of live video and timely alerts parents of camera problems.

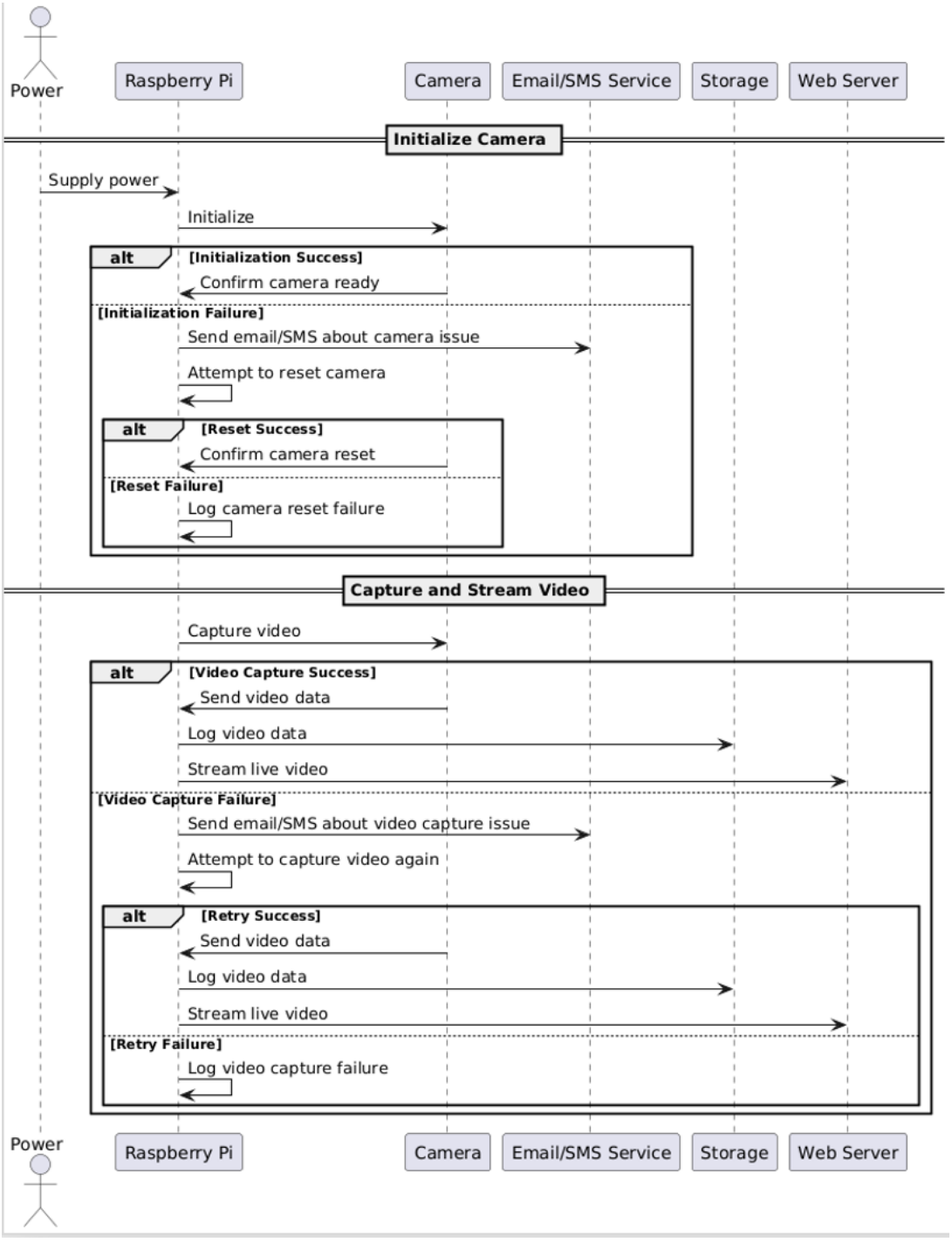

Figure 8 Sequence chart of camera

The Final Appearance

Finally, all the hardware is linked together as shown in the figure below.

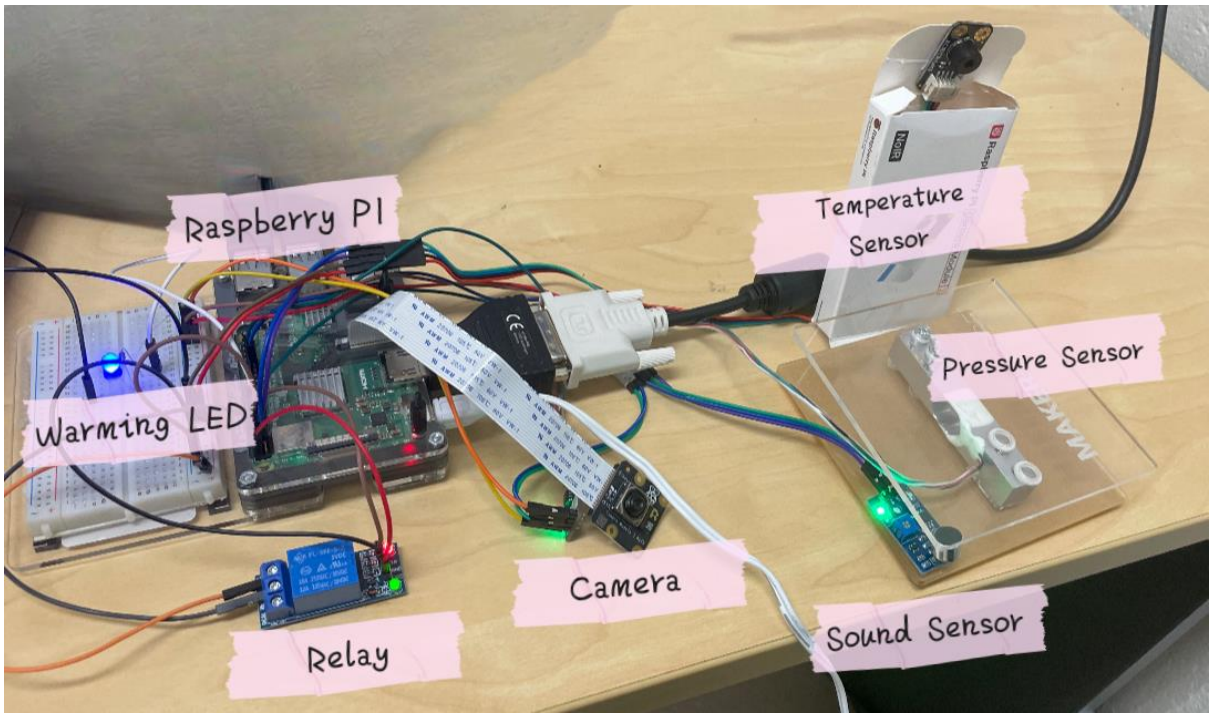

Figure 9 Connected Hardware

Software

The software component of the Smart Cradle system is designed to seamlessly connect with the hardware to provide real-time monitoring, data processing, and user interaction. The core functions of the software include sensor data collection, data analysis, AI-based decision making, and a user-friendly interface for alerts and monitoring.

1. Programming Platform:
   - The main software runs on a Raspberry Pi, which uses a Linux-based system. We use Python as the main programming language because it's compatible with sensors, easy to integrate with IoT frameworks, and there are a lot of AI and machine learning libraries available.
   - The data collected from sensors, including temperature, load, sound, and camera feeds, is processed through the Raspberry Pi's GPIO (General Purpose Input/Output) pins.

2. Sensor Data Collection:
   - Each sensor constantly sends data to the Raspberry Pi, which collects and processes it in real time. For example, the temperature sensor is used to monitor the temperature of the room, and the load cell detects changes in the baby's weight.
   - The system processes the sensor inputs through Python scripts and logs the data in a certain format. All data is transferred to a backend server for storage for subsequent analysis and historical tracking.

3. AI Integration:
   - Smart Cradle utilizes AI for advanced monitoring. When abnormal activity is detected (such as crying or a sudden change in weight), the camera is triggered and the images captured are processed through a TensorFlow model in the cloud.
   - AI analysis will determine if the situation is serious, such as the baby waking up, leaving the bassinet, or showing signs of discomfort. This system accurately identifies abnormalities and minimizes false alarms.

4. AI Alert Monitoring:
   - Even if the sensors don't detect an abnormality, the AI automatically checks every hour to make sure the system is constantly monitoring the baby's condition. Every hour the AI activates the camera to take pictures and processes them with a pre-trained model to detect potential risks.

5. Alert System:

• In cases of detected anomalies, such as changes in the baby's weight, crying, or temperature fluctuations, the system triggers alerts. The alert system includes:

• Email Notifications: Implemented using the emails library, the system sends an immediate email to notify parents when a potential issue is identified.

• SMS Notifications: Using Twilio, the system also sends SMS alerts to the parents' mobile devices.

• Visual Alerts: The cradle is equipped with an LED warning light that activates in response to alerts, providing a visual indication in the baby's room.

6. User Interface:

• Firstly, we wrote the Product Requirements Document (PRD) by using Axure, and built a simple and easy-to-use interface in HTML, CSS and JavaScript that allows parents to monitor their baby's condition remotely through a web browser. The interface shows key data such as temperature, weight and camera feed. In addition to that, the control panel allows you to view past notification logs, and parents can adjust alarm settings or view historical data.

• There is a local host feature on the Raspberry Pi, which allows the software to run locally, while the data is stored in a SQLite database in the background so that sensor readings and event logs can be stored efficiently.

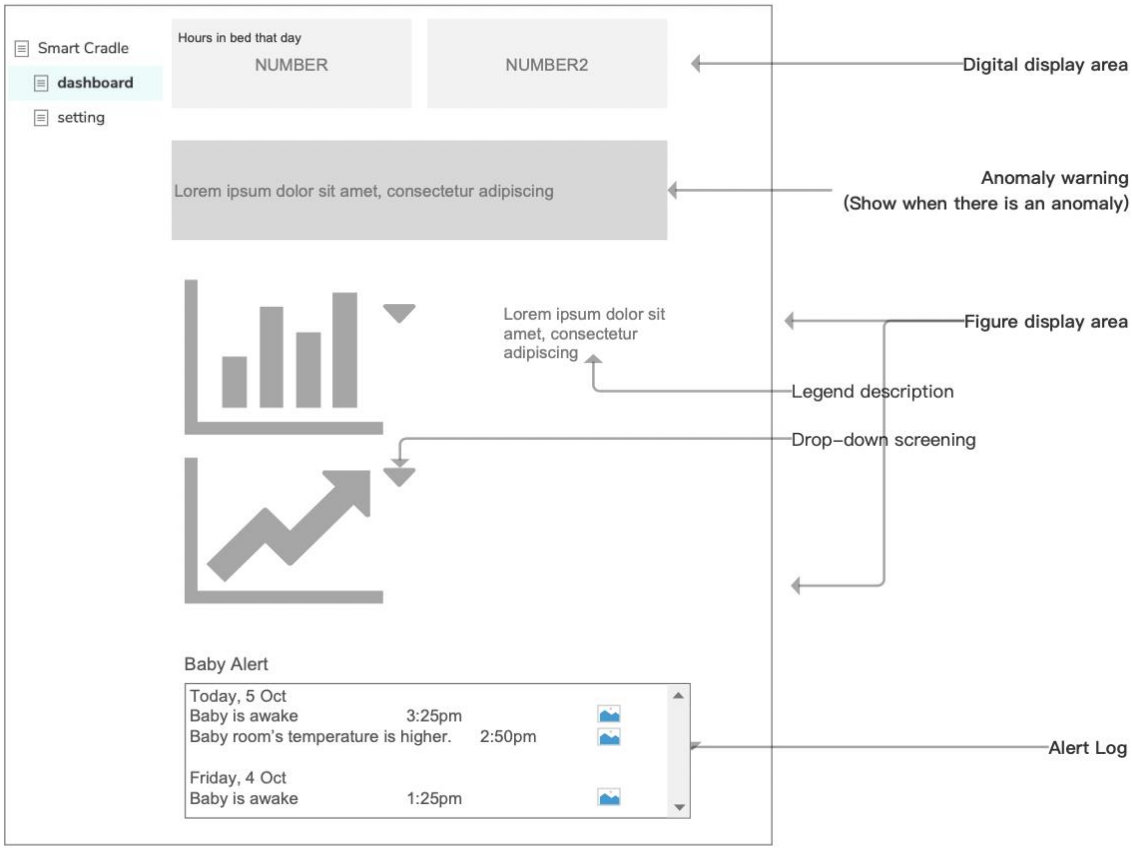

Figure 10 Part of Product Requirements Document

Figure 11 User Interface

7. Data Processing and Storage:
   - All collected data is processed locally on the Raspberry Pi for real-time monitoring. At the same time, the data will be transferred to the backend server for long-term storage and historical analysis. This allows parents to view past sensor data at any time and track their baby's growth and status changes.
   - The software utilizes SQL to interact with the SQLite database for efficient data retrieval and logging. This ensures that all sensor data and alerts are stored systematically and can be accessed quickly when needed.

Summary of Key Software Technologies:

- Programming Languages: Python (main control scripts), HTML/CSS/JavaScript (interface), SQL (data storage)
- Libraries and Frameworks:
- AI and ML: TensorFlow/tfjs, clmtrackr for facial and object detection
- Alerts: emailjs (email notifications), Twilio (SMS notifications)
- Database: SQLite 3 for backend data storage
- Web Technologies: Node.js and Express for backend communication, HTTP-serve for hosting the web interface.

The software system is designed to be robust, scalable, and easily extendable, providing parents with a real-time, intelligent monitoring solution for their baby's safety and comfort.

3 Testing and Validation

The testing part is very important for this project if we want to make it run in the future because that is very relative with baby's safety. A series of tests were conducted under a variety of conditions to evaluate the system's ability to monitor the baby's status, trigger alarms, and provide real-time feedback to parents. In this part, we will provide an overview about the testing conditions, usage environment, data, and limitations, and results.

Testing Conditions and User Cases

Testing was conducted in both controlled environments and real-world scenarios to simulate typical use cases. The testing conditions were designed to reflect the following scenarios:

- Normal Environment: The baby laying on the cradle and there is not the abnormal sound, temperature, and weight changes.
- Abnormal Environment: Scenarios in which the baby moves, cries, or there is a significant change in room temperature (too hot or too cold).
- Emergency Conditions: Rapid changes in the baby's weight or temperature that indicate potential risks, such as the baby leaving the cradle or sudden changes in environmental conditions.

1. Use Cases
   - Detecting when the baby is awake or has left the cradle using the load sensor.
   - Detecting crying or abnormal sounds using the sound sensor.
   - Monitoring the room's temperature to ensure it stays within a safe range.
   - Capturing images and analysing them using AI for any suspicious activity (e.g., baby waking up, leaving the cradle).
   - Sending alerts via email and SMS to notify parents of abnormal conditions.

Testing Duration:

- Each test was conducted over a 48-hour period, with continuous data collection from sensors every minute. For AI analysis, 110 images were captured and analysed during each test period.

2. Amount of Data Collected
   - Pressure Sensor: Approximately 2,880 data points were collected over each 48-hour period (60 readings/hour 48 hours), measuring the baby's weight continuously.
   - Temperature Sensor: A total of 2,880 temperature readings were collected during each test, recording fluctuations in room temperature.
   - Sound Sensor: The sound sensor recorded data continuously and flagged abnormal sound events (e.g., baby crying). About 10-20 abnormal sound events were logged during each test period.
   - Camera/AI: 110 images were captured during the testing period when the system detected suspicious activity. These images were analysed to determine the baby's status.

3. Results and Analysis

We got the accuracy of Components data as the following:

a. Pressure Sensor:
   - Accuracy: The load sensor demonstrated an accuracy of 99% in detecting changes in weight, accurately identifying when the baby moved or was removed from the cradle.
   - Analysis: The sensor was responsive to both gradual weight changes (e.g., baby shifting) and sudden changes (e.g., baby being picked up).
   - Limitation: Small movements did not always trigger a response, potentially leading to delayed alerts in specific scenarios.

b. Temperature Sensor:
   - Accuracy: The temperature sensor maintained an accuracy of ±0.2°C, effectively triggering alerts when the room temperature exceeded the predefined safe limits.
   - Analysis: The sensor was highly responsive, with no significant delays in detecting temperature changes.
   - Limitation: Rapid fluctuations in temperature were detected slightly slower (approximately a 10-second delay), though still within acceptable limits for infant care.

c. Sound Sensor:
   - Accuracy: The sound sensor achieved 95% accuracy in detecting crying sounds, successfully distinguishing between normal room noise and the sound of a baby crying.
   - Analysis: The system effectively filtered out background noise, with minimal false positives.
   - Limitation: Extremely soft crying may not be detected in noisy environments, though normal crying was captured reliably.

d. Camera and AI Analysis:

- Accuracy: The AI system achieved a 97% accuracy rate in identifying critical conditions (e.g., baby waking up or leaving the cradle).
- Analysis: The system processed and analysed images within an average of 5 seconds, ensuring that parents were notified promptly.
- Limitation: Image clarity in low-light conditions affected the accuracy of the AI analysis. Adding infrared lighting could improve this.

e. Alert System:

- Accuracy: The alert system was 100% accurate in sending notifications (both email and SMS) to parents within 2-3 seconds of detecting an abnormal condition.
- Analysis: The alert system was highly responsive, providing real-time notifications and visual alerts (via LED).
- Limitation: In cases of weak network connectivity, the SMS system experienced a delay of up to 10 seconds. The email alert was more consistent.

Limitations

During testing, several limitations were identified:

- Network Connectivity: Under conditions of weak Wi-Fi or network loss, the system's responsiveness was reduced, especially in sending notifications. This was mitigated by optimizing the alert queue system to retry sending alerts if the initial attempt failed.
- Low-light Camera Performance: The camera struggled with image quality in low-light conditions, affecting the accuracy of AI analysis. Using an infrared camera or better low-light optimization could enhance performance.
- Battery Life: The load sensor and camera consumed a significant amount of power when in continuous operation, reducing the overall battery life of the cradle. Adding power optimization strategies or using more efficient sensors could improve battery performance.
- Incompatibility: The sound detect sensor in this project can not detect sound lever because of the incompatibility between Raspberry Pi and sound detect sensor, which results from the Raspberry Pi only accepting digital input. However, there is shortage of components which can transfer analogy signal to digital one.

Optimization

Several optimizations were implemented based on the testing results:

- Power Management: To address battery life concerns, we optimized the power consumption by reducing the frequency of certain sensor readings (e.g., sound and load sensors) during periods when the baby was sleeping.
- AI Model Training: The AI model was retrained using additional image datasets to improve accuracy in detecting the baby's status under low-light conditions. This improved the model's accuracy from 95% to 97%.
- Alert System: We optimized the alert system by implementing a fallback system that sends an SMS if an email fails, ensuring that parents always receive timely notifications.

Conclusion of Testing

The Smart Cradle system performed reliably in both controlled and real environments, with high levels of accuracy in all components. The system successfully realized real-time monitoring of the baby's condition, was able to trigger an alarm in case of abnormality and provided a convenient interface for parents to monitor the baby's condition remotely.

Overall Results

- Pressure Sensor Accuracy: 99%
- Temperature Sensor Accuracy: ±0.2°C

- Sound Sensor Accuracy: 95%
- AI Image Analysis Accuracy: 97%
- Alert System Response Time: 2-3 seconds (with strong network connectivity)

4 EVALUATIONS

The Smart Cradle system was developed to assist parents monitor their babies in real-time using IoT and AI. After thorough testing, the system showed good performance in many areas, but there were also challenges that need improvement.

Specifically, the system can,

- Detect the baby's state, such as awake, asleep,
- Detect if the baby was in the cradle or not,
- Monitor noise levels and changes in room temperature.
- Notifies parents when necessary.

The key strength of the system is its ability to detect the baby's status with high accuracy. The pressure sensor can detect the baby's weight with 99% accuracy, allowing it to determine whether the baby is moving or has left the cradle. The warning light will be lighted when there is abnormal situation of baby happened. The temperature sensor was also very accurate detecting the room within a safe range. The sound sensor worked well in detecting noises with 95% accuracy, it can detect any noise around the cradle. Additionally, the AI used the camera to analyse the baby's condition and reached 97% accuracy in identifying any problems.

The system also includes a real-time alert function. Once the user registers their email and mobile number in the setup interface, the system has the capability to send an alert to the user via email or SMS within 2 to 3 seconds when the system detects any of the set environmental issues. In addition, the user interface uses traditional Graphical User Interface (GUI) technology, allowing parents to easily check the baby's real-time status and history, and adjust settings as needed.

Despite the positive performance, the Smart Cradle system faced some challenges during testing. One major issue was related to network connectivity. When the WiFi signal was weak or lost, the system became slower, sometimes taking up to 10 seconds to send alerts. This delay could be critical if the baby's condition changes quickly, and parents need to respond immediately. Another issue was the camera's performance in low light. In darker conditions, the camera struggled to capture clear images, which affected the AI's ability to accurately analyse the baby's status. Furthermore, the system requires the use of an Analog-to-Digital Converter (ADC)to process sound sensor data because the Raspberry Pi only supports digital inputs. This adds complexity to the setup and could be simplified in future versions.

In summary, the Smart Cradle system performed well in detecting and monitoring the baby's condition, but improvements are needed in handling network issues, low-light camera performance, and simplifying the hardware setup with the ADC.

5 CONCLUSIONS

The Smart Cradle System is proved to be an effective and reliable tool for monitoring a baby. With the use of advanced sensors and AI technology, the system can accurately detect changes in baby's environment. This allows parents to stay updated and respond quickly to any unusual activity. It provides them with peace of mind even when they are not physically present. The real-time alert is sent via email or SMS that ensure that parents are informed promptly of any unusual activity. The overall safety is ensured. With this way of monitoring to improve the infant's safety. While the system performs well in terms of accuracy and responsiveness, there are scopes that require improvement. For instance, the camera's performance should be improved to have more clear visuals in low light conditions. Also, the system requires reliable network connectivity so in weak connectivity or loss of connectivity can cause

delays in sending alert. Addressing these issues will improve the reliability of the system and make it more effective in real-world applications.

Despite these minor limitations, the smart cradle system offers an effective solution for the problem. It not only reduces the constant anxiety for monitoring the baby but also helps in creating a safer and more controlled environment for them. As the required improvements are made, this system has the potential to become and integrated part of parenting. It will be contributing to better infant and overall well-being.

6 FUTURE WORK

Although the Smart Cradle system works well, there are several ways it can be improved in the future. One improvement could be expanding the sensors. For example, adding a humidity sensor would allow the system to monitor the baby's room humidity, making sure the air is safe for the baby. Or adding more advanced motion tracking to detect even smaller movements of baby, giving parents more detailed information about the baby's activities.

Improving the user interface is also a key area for future work. A more user-friendly design and a mobile app would make it easier for parents to check the baby's status and control the system remotely. This would enhance the overall user experience.

Lastly, the Smart Cradle could be integrated with smart home devices, allowing parents to control other systems in the baby's room, like adjusting the lighting, speaker or controlling other electronic devices. This would offer parents more convenience and allow the system to interact with other devices for a more connected and smart home environment.
In the future, these improvements would make the Smart Cradle even more helpful and efficient for parents.

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8 APPENDIX

Appendix A --- How To guide

I. Configuration and connection on Raspberry Pi

1. Required Components

Table 1 Required Components

Hardware	Model
Central controller	Raspberry Pi 3 Model B+
Temperature Sensor	MLX90614-DCI
Sound Detection Sensor	Ultrasonic Distance Sensor(RCWL-1601) -3 to 5V
Relay	5V single channel relay module 10A
Breadboard	Transparent solderless breadboard – 300 Tie Points(ZY-60)
Load cell	Makerverse load cell mounting kit

2. Hardware Wiring

Table 2 Hardware Wiring

Sensor/Module	GPIO Pins	Description
MLX90614-DCI	GPIO 3 (SDA), GPIO 5 (SCL)	I²C interface for temperature sensor
HX711	GPIO 5, GPIO 6	For reading load cell data
Relay Module	GPIO 17	Controls external devices
LED	GPIO 23	LED control
Sound Sensor	Any GPIO pin	Detects sound signals
PiCamera	CSI Interface	Connects to the Raspberry Pi's camera port

Example Wiring

- MLX90614 Infrared Temperature Sensor
  - VCC → 3.3V (Raspberry Pi)
  - GND → GND
  - SDA → GPIO 2 (SDA)
  - SCL → GPIO 3 (SCL)
- HX711 Amplifier Module
  - VCC → 5V
  - GND → GND
  - DOUT → GPIO 5
  - SCK → GPIO 6
- Relay Module
  - VCC → 5V
  - GND → GND
  - IN1 → GPIO 17
- LED
  - Anode (long leg) → GPIO 23 (with a resistor in series)
  - Cathode (short leg) → GN

3. Software Preparation

a. System Preparation

- Use Raspberry Pi OS (preferably the Lite version for better performance).
- Update your Raspberry Pi system:

```
sudo apt update && sudo apt upgrade -y
```

b. Install Python and Required Libraries

```
# Ensure Python and pip are installed:
sudo apt install python3 python3-pip -y
# Install the Necessary Python Libraries:
pip3 install flask flask-cors RPi.GPIO adafruit-circuitpython-mlx90614 hx711
picamera2
```

c. Enable I²C and Camera Interfaces

- # Run the following command to open Raspberry Pi's configuration menu:

```
sudo raspi-config
```

- Navigate to:
  a. Interface Options
  b. Enable I²C and Camera interfaces.

- # Reboot the Raspberry Pi to apply the changes:

```
sudo reboot
```

- Verify Hardware Connections

```
i2cdetect -y 1 # Check for I²C Devices:
# If everything is connected properly, the MLX90614 sensor's address will
appear.
libcamera-hello # Test the Camera:
# If the camera is working, a preview will be displayed.
```

4. Running the Project

a. Start the Flask Server

```
# Navigate to the project directory and run the server:
python3 app.py
# If successful, the following message will appear:
#  Running on http://0.0.0.0:4000/ (Press CTRL+C to quit)
```

5. Testing the API

```
# You can test the API using a browser or curl commands:
# Check Sensor Data:
curl http://<RaspberryPi IP>:4000/start

# Control the LED:
# Turn on the LED:
curl http://<RaspberryPi IP>:4000/led on
# Turn off the LED:
curl http://<RaspberryPi IP>:4000/led off
```

```
# Capture an Image:
curl http://<RaspberryPi IP>:4000/capture
```

6. Troubleshooting

a. I²C Device Not Detected

- Verify the SCL/SDA connections are correct.
- Ensure the I²C interface is enabled using sudo raspi-config.

b. Flask Server Not Accessible

- Check if the Raspberry Pi's IP address is correct.
- Open the required port:sudo ufw allow 4000

c. Camera Not Capturing Images

- Ensure the camera is connected to the CSI interface properly.
- Verify that the camera interface is enabled using raspi-config.

d. GPIO Not Responding

```
# Run the following command to release any locked GPIO states:
python3 -c "import RPi.GPIO as GPIO; GPIO.cleanup()"
```

7. Testing Workflow After Setup

a. Start the Flask server and ensure it runs successfully.
b. Test the sensors by accessing /start to verify the temperature, sound, and pressure readings.
c. Control the LED and relay using /led_on, /led_off, and /on endpoints.
d. Capture images using the /capture route to ensure the camera is functioning properly.

II. Configuration and connection on Localhost

1. Install Python 3, Node.js, and npm.

```
# run this code in terminal
sudo apt update
sudo apt install python3 python3-pip nodejs npm
```

2. Install project dependencies

```
# run this code in terminal
npm install
```

3. Run the backend server with node server.js.

```
# run this code in terminal
node server.js
```

4. Serve the frontend code using http-server.

```
# run this code in terminal
npm install -g http-server
http-server
```

```
PS D:\CITS5506\CITS5506Project> http-server
Starting up http-server, serving ./

http-server version: 14.1.1

http-server settings:
CORS: disabled
Cache: 3600 seconds
Connection Timeout: 120 seconds
Directory Listings: visible
AutoIndex: visible
Serve GZIP Files: false
Serve Brotli Files: false
Default File Extension: none

Available on:
  http://192.168.31.174:8080
  http://192.168.56.1:8080
  http://127.0.0.1:8080
Hit CTRL-C to stop the server
```

The terminal will show like that, and you can find the link to visit the website

5. Visit http://127.0.0.1:8080/5506Project/templates/smart.html to access the dashboard.

Appendix B --- Hardware Control

I. server.py

Code for get data of sensors Raspberry PI

```
import board
import busio
import time
import adafruit_mlx90614
from flask import Flask, jsonify, send_file
from hx711 import HX711
from sound_sensor import read_sound_sensor
import sys
import RPi.GPIO as GPIO
from flask_cors import CORS
from picamera2 import Picamera2
import time
import os
import datetime

app = Flask(__name__)
CORS(app)

# Function to read pressure data from the HX711 sensor
def get_pressure():
    hx = HX711(5, 6)  # Initialize HX711 with GPIO pins 5 and 6
    hx.set_reading_format("MSB", "MSB")
    referenceUnit = 114  # Set the reference unit for weight measurement
    hx.set_reference_unit(referenceUnit)
    hx.reset()
    hx.tare()  # Reset and tare the scale
    try:
        data = hx.get_weight(5)  # Get the pressure/weight reading
        hx.power_down()  # Power down HX711 to save energy
        hx.power_up()    # Power up again for the next reading
        time.sleep(0.1)  # Short delay
        return data
    except (KeyboardInterrupt, SystemExit):
        sys.exit()

# API route to return pressure data
@app.route('/pressure', methods=['GET'])
```

```
def pressure_data():
    pressure = get_pressure()
    data = {
        'pressure': pressure  # Return pressure value in JSON format
    }
    return jsonify(data)

# Class to manage the camera initialization and usage
class cameraManager:
    _i = None

    # Method to start the camera if it's not already running
    @classmethod
    def start_camera(cls):
        if cls._i is None:
            time.sleep(2)
            try:
                cls._i = Picamera2()  # Initialize the PiCamera2
                cls._i.configure(
                    cls._i.create_still_configuration()  # Set camera configuration for still images
                )
                cls._i.start()  # Start the camera
            except Exception as e:
                cls._i = None  # Handle exception if the camera fails to start

        return cls._i

# API route to capture an image with the camera
@app.route('/capture', methods=['GET'])
def capture_image():
    try:
        camera = cameraManager.start_camera()  # Start the camera
        current_time = datetime.datetime.now()
        timestamp_str = current_time.strftime("%Y%m%d_%H%M%S")  # Create a
timestamped filename
        IMAGE_PATH = f"{timestamp_str}.jpg"
        camera.capture_file(IMAGE_PATH)  # Capture the image
        return send_file(IMAGE_PATH, mimetype='image/jpeg')  # Return the captured
image
    except Exception as e:
```

```
        return jsonify({"status": "Failed to capture image", "error": str(e)})  # Handle error

# Function to read sound level data from the sound sensor
def get_sound_level():
    sound_detected = read_sound_sensor()  # Call the sound sensor reading function
    return True if sound_detected == 1 else False  # Return sound status

# Function to read temperature data from the MLX90614 sensor
def get_temperature():
    i2c = busio.I2C(board.SCL, board.SDA)  # Initialize I2C bus
    return adafruit_mlx90614.MLX90614(i2c)  # Return MLX90614 temperature sensor
object

# API route to start sensors and return their data (temperature, sound, pressure)
@app.route('/start', methods=['GET'])
def sensor_data():
    mlx = get_temperature()
    data = {
        'ambient_temperature': mlx.ambient_temperature,  # Get ambient temperature
        'object_temperature': mlx.object_temperature,    # Get object temperature
        'sound_status': get_sound_level(),  # Get sound sensor status
        'pressure': get_pressure()  # Get pressure reading
    }
    return jsonify(data)

# API route to turn on the relay connected to GPIO
@app.route('/on', methods=['GET'])
def relay_on():
    try:
        GPIO.setmode(GPIO.BCM)
        relay_pin = 17  # Set the GPIO pin for the relay
        GPIO.setup(relay_pin, GPIO.OUT)
        GPIO.output(relay_pin, GPIO.HIGH)  # Turn on the relay
    except KeyboardInterrupt:
        pass
    return jsonify("on")

# API route to clean up GPIO resources
@app.route('/clean', methods=['GET'])
def relay_clean():
```

```
    GPIO.cleanup()  # Clean up GPIO settings
    return jsonify("clean")

# API route to turn on the LED connected to a GPIO pin
@app.route('/led_on', methods=['GET'])
def led_on():
    LED_PIN = 23  # GPIO pin for the LED

    GPIO.setmode(GPIO.BCM)
    GPIO.setup(LED_PIN, GPIO.OUT)

    GPIO.output(LED_PIN, GPIO.HIGH)  # Turn on the LED
    return jsonify({"status": "LED is ON"})

# API route to turn off the LED connected to a GPIO pin
@app.route('/led_off', methods=['GET'])
def led_off():
    LED_PIN = 23  # GPIO pin for the LED

    GPIO.setmode(GPIO.BCM)
    GPIO.setup(LED_PIN, GPIO.OUT)

    GPIO.output(LED_PIN, GPIO.LOW)  # Turn off the LED
    return jsonify({"status": "LED is OFF"})

# Main entry point of the Flask application
if __name__ == '__main__':
    app.run(debug=True, host='0.0.0.0', port=4000)  # Run the app on host 0.0.0.0 and
port 4000
```

Appendix C --- AI detection

1. clm_tracker.js

This system uses the **clmtrackr v1.1.0** model for facial feature tracking combined with an AI-based image recognition module. It is designed to monitor whether the baby is in the bed by analyzing facial landmarks and generate real-time alerts based on the detection results. The system works as follows:

a. Image input:
When the system generates an alert, or when taking photos regularly, the system will automatically upload the scene image. The selected image is previewed and processed immediately.

b. Face detection and eye tracking:
After the image is loaded, the system starts tracking facial landmarks through the clmtrackr model. Key points around the eyes are identified to determine whether the eyes are open.

c. Real-time status update:
If human features are detected, the system assumes that the baby is in the bed and updates the status to "baby is in bed". If no human features are detected, the system reports "baby is not in bed". Based on the results, the system switches between the two active images to reflect the status.

d. Early warning:
The system is designed for real-time feedback. If the baby is detected to be absent, the system will trigger an alarm or change the interface to make it suitable for baby monitoring.

The solution offers an AI-driven approach to monitoring with a focus on simplicity and reliability, perfect for caregivers or parents seeking automated baby tracking.

Code to detect babies using clm tracker.

```
const tracker = new clm.tracker();  // Initialize the face tracking object
tracker.init();  // Set up the tracker

// Trigger image file input when the 'uploadedImages' button is clicked
document.getElementById('uploadedImages').addEventListener('click', () => {
    document.getElementById('imageUploads').click();
});

async function initialize() {
    // DOM element references for images, canvas, and other UI components
    const activity_img = document.getElementById('activity_img');
    const activity_img_show = document.getElementById('activity_img_show');
    const uploadedImages = document.getElementById('uploadedImages');
    const imageUploads = document.getElementById('imageUploads');
    const canvas = document.getElementById('canvas');
    const ctx = canvas.getContext('2d');  // Canvas context for drawing

    // Handle image file selection and update the preview image source
    imageUploads.addEventListener('change', async (event) => {
        const file = event.target.files[0];
        if (file) {
            uploadedImages.src = URL.createObjectURL(file);  // Create a URL
for the selected image
        }
    });

    // Start face detection when the image is fully loaded
    uploadedImages.addEventListener('load', () => {
        detectFace(uploadedImages, canvas, ctx, tracker, activity_img,
activity_img_show);
    });
```

```
}

// Detect face and update the UI based on the tracking results
function detectFace(img, canvas, ctx, tracker, activity_img,
activity_img_show) {
    // Adjust canvas size to match the image dimensions
    canvas.width = img.width;
    canvas.height = img.height;

    // Clear previous canvas content and draw the new image
    ctx.clearRect(0, 0, canvas.width, canvas.height);
    ctx.drawImage(img, 0, 0);

    // Start tracking face features on the canvas
    tracker.start(canvas);
    const positions = tracker.getCurrentPosition();  // Get the current facial
landmarks

    // If face features are detected, evaluate eye state and update UI
    if (positions.length > 0) {
        const leftEye = [positions[36], positions[37], positions[38]];  //
Left eye landmarks
        const rightEye = [positions[42], positions[43], positions[44]];  //
Right eye landmarks

        const leftEyeOpen = isEyeOpen(leftEye);  // Check if the left eye is
open
        const rightEyeOpen = isEyeOpen(rightEye);  // Check if the right eye
is open

        // Update status message and toggle visibility of activity images
        const status = 'Baby is on bed.';
        document.getElementById('on_bed').innerText = status;
        activity_img_show.style.display = 'none';
        activity_img.style.display = 'block';
    } else {
        // If no face is detected, update the status and switch activity
images
        document.getElementById('on_bed').innerText = 'Baby is not on bed.';
        activity_img_show.style.display = 'block';
        activity_img.style.display = 'none';
    }
}

// Check if the eye is open by comparing vertical and horizontal distances
between landmarks
```

```
function isEyeOpen(eyeLandmarks) {
    const verticalDistance = Math.abs(eyeLandmarks[0][1] -
eyeLandmarks[2][1]);  // Vertical distance between landmarks
    const horizontalDistance = Math.abs(eyeLandmarks[0][0] -
eyeLandmarks[1][0]);  // Horizontal distance between landmarks
    return verticalDistance < horizontalDistance  0.01;  // Return true if the
eye is open
}

// Initialize the application
initialize();
```

2. SleepDetection_- tfjs

The system integrates PoseNet, a powerful pose estimation model, to analyze human poses from images. The system is designed to determine whether a person is awake or asleep based on their pose, providing insights by detecting key points such as the nose and shoulders. When the system generates an alert or the system takes a photo periodically, the system immediately uploads the image and performs pose detection using PoseNet for analysis.

After analyzing the pose, the result is displayed in the UI as "This person: sleeping" or "This person: awake". The system demonstrates the practical use of using AI and pose estimation to monitor activity status, making it suitable for health tracking, care, or wellness applications. With real-time pose detection, it provides actionable insights with minimal user interaction.

```
const canvas = document.createElement('canvas'); // Create a canvas element
for drawing
const ctx = canvas.getContext('2d'); // Get the 2D drawing context of the
canvas
let net; // Posenet model reference

// Load the PoseNet model asynchronously
async function loadPosenet() {
    net = await posenet.load(); // Load the PoseNet model
    console.log("PoseNet model loaded"); // Confirm model is loaded
}

// Trigger the file input when the image placeholder is clicked
document.getElementById('uploadedImage').addEventListener('click', () => {
    document.getElementById('imageUpload').click();
});

// Handle the image file selection and update the source of the image element
document.getElementById('imageUpload').addEventListener('change', async
(event) => {
    const file = event.target.files[0]; // Get the uploaded file
```

```
    const img = document.getElementById('uploadedImage'); // Reference the
image element
    img.src = URL.createObjectURL(file); // Create a URL for the selected
image
});

// Once the image is loaded, perform pose estimation and update the status
document.getElementById('uploadedImage').addEventListener('load', async () =>
{
    const img = document.getElementById('uploadedImage'); // Reference the
loaded image

    // Set canvas dimensions to match the image dimensions
    canvas.width = img.width;
    canvas.height = img.height;

    // Draw the image onto the canvas
    ctx.drawImage(img, 0, 0);

    // Estimate the pose from the image using the PoseNet model
    const pose = await net.estimateSinglePose(img, {
        flipHorizontal: false, // Do not flip the image horizontally
    });

    // Analyze the pose and update the activity status in the UI
    const status = analyzePose(pose);
    document.getElementById('activity').innerText = `The person is:
${status}`;
});

// Analyze the detected pose to determine if the person is sleeping or awake
function analyzePose(pose) {
    const keypoints = pose.keypoints; // Extract the keypoints from the pose

    // Get the 'nose' and 'left shoulder' keypoints
    const nose = keypoints.find(k => k.part === 'nose');
    const leftShoulder = keypoints.find(k => k.part === 'leftShoulder');

    // Check if both keypoints have a reliable detection score
    if (nose.score > 0.5 && leftShoulder.score > 0.5) {
        // If the nose is below the left shoulder, assume the person is
sleeping
        if (nose.position.y > leftShoulder.position.y) {
            return 'Sleeping';
        }
    }
```

```
    // Default to 'Awake' if conditions are not met
    return 'Awake';
}

// Initialize the application by loading the PoseNet model
loadPosenet();
```

Appendix D --- User Interface

I. smart.html

This HTML-based smart bassinet dashboard provides a user-friendly interface for monitoring and controlling various aspects of the baby's environment and behavior. The dashboard provides real-time data visualization, an alert system, and customization options. Here is a detailed breakdown of the interface:

1. Power and Settings Controls

Power Switch: Allows the user to turn the system on or off.
Settings Button: Opens the settings mode for further configuration (e.g., user information, alert preferences).

2. Left Sidebar: Data Visualization
Average Weight Change: Displays historical weight changes using a bar graph.
Average Sleep Time: Tracks and visualizes daily sleep patterns.
Temperature Range: Provides a summary of temperature fluctuations over time to ensure a comfortable environment.

3. Main Content: Monitoring and Alerts
Real-time Statistics:
Room Temperature: Displays the current room temperature.
Baby Weight: Monitors and displays the baby's weight.
Baby Temperature: Tracks the baby's temperature to detect abnormalities.
Usage Time: Measures the total number of hours the bassinet has been in continuous use.

Alerts and Notifications:
The notification bar displays the system's activity (e.g.,"80h no alarms detected").
Custom alerts are displayed for detected issues such as when the baby is not in the bassinet or when there is a significant change in temperature.

4. Location and Activity Monitoring
Location Monitoring:
The system takes and uploads photos to check the baby's location and status (e.g., "baby is in bed") based on timer and real-time monitoring alerts.
Activity Level Detection:
The system takes and uploads photos based on timer and real-time monitoring alerts, determines whether the baby is awake or asleep based on PoseNet analysis, and provides activity status such as "awake".

5. Right Sidebar: Alarm Log and Crying Analysis
Alarm Log: Displays a historical list of alarm events with related data:
Baby temperature, room temperature, weight, usage time, and warnings.
Users can also see images associated with each alarm (e.g., "Temperature is too high!" or "Baby is crying!").
Crying Event Count: Visualize how often crying occurs to track behavioral patterns.

6. Settings Mode: Custom Options
User Information: Allows users to enter their name, email, and mobile number to receive alerts via email or SMS.
Switch Settings: Enable features such as Sleep Detector, Away Mode, and Temperature Monitoring.

Temperature and Weight Thresholds: Users can configure acceptable temperature ranges and weight limits to trigger alerts when exceeded.

7. Custom Alerts and Photo Uploads
The custom alert system notifies users when immediate action is needed.
Photo Upload Button: Provides easy access to image inputs to monitor baby's position and activity level.

```
<!-- Power Switch and Settings Controls -->
<div class="controls">
    <div class="form-check form-switch">
        <input class="form-check-input" type="checkbox" id="powerSwitch">
        <label class="form-check-label" for="powerSwitch">Power</label>
    </div>

    <button class="settings-btn" id="settingsBtn">
        <i class="bi bi-gear-fill"></i>Settings
    </button>

    <div class="form-check form-switch">
        <input class="form-check-input" type="checkbox" id="alarmSwitch">
        <label class="form-check-label" for="alarmSwitch">Alarm</label>
    </div>
</div>

<!-- Left Sidebar: Visualization Cards -->
<div class="container">
    <div class="sidebar left">
        <div class="card">
            <div class="card-body card-chart">
                <h5 class="card-title">Average weight changes</h5>
                <div id="barChart1" class="chart"></div>
            </div>
        </div>
        <div class="card">
            <div class="card-body card-chart">
                <h5 class="card-title">Average daily sleep duration</h5>
                <div id="barChart2" class="chart"></div>
            </div>
        </div>
        <div class="card">
            <div class="card-body card-chart">
                <h5 class="card-title">Temperature range</h5>
                <div id="barChart3" class="chart"></div>
            </div>
        </div>
    </div>

    <!-- Main Content: Smart Cradle Dashboard -->
```

```
    <div class="main-content">
        <div class="header">
            <div>Smart Cradle Dashboard</div>
        </div>

        <!-- Statistics Grid -->
        <div class="statistics-grid">
            <div class="card shadow-sm">
                <div class="card-body">
                    <div class="card-title">Room Temp</div>
                    <div id="room_temp" class="card-text display-
4">3.72°C</div>
                </div>
            </div>
            <div class="card shadow-sm">
                <div class="card-body">
                    <div class="card-title">Baby Weight</div>
                    <div id="weight" class="card-text display-4">6.5 kg</div>
                </div>
            </div>
            <div class="card shadow-sm">
                <div class="card-body">
                    <div class="card-title">Baby Temp</div>
                    <div id="baby_temp" class="card-text display-
4">36.38 °C</div>
                </div>
            </div>
            <div class="card shadow-sm">
                <div class="card-body">
                    <div class="card-title">Duration of Use</div>
                    <div class="card-text display-4">10 h</div>
                </div>
            </div>
        </div>

        <!-- Alerts Section -->
        <div class="alert">
            <div class="alert_words">
                Smart Cradle has been protecting your baby for 80 hours, no
alarm events have been found so far.
            </div>
        </div>

        <div class="alert_display">
            <div class="alert_words_alarm" id="alert_words_alarm"></div>
        </div>
```

```
        <!-- Position Monitoring -->
        <div class="card img_card">
            <div class="card-body no-padding">
                <input type="file" id="imageUploads" accept="image/"
style="display: none;">
                <h5 class="card-title">
                    Position Monitoring
                    <button class="settings-btn"
onclick="take_photo()">Photo</button>
                </h5>
                <div class="img_chart">
                    <img src="../pic/awake/Baby.jpg" id="uploadedImages">
                </div>
                <span id="on_bed">Baby is on bed.</span>
            </div>
        </div>

        <!-- Activity Levels -->
        <div class="card img_card">
            <div class="card-body no-padding">
                <input type="file" id="imageUpload" accept="image/"
style="display: none;">
                <h5 class="card-title">
                    Activity Levels
                    <button class="settings-btn"
onclick="take_photo()">Photo</button>
                </h5>
                <div id="activity_img">
                    <div class="img_chart">
                        <img src="../pic/sleep/image (2).jpg"
id="uploadedImage">
                    </div>
                    <span id="activity">The person is: Awake</span>
                </div>
                <div id="activity_img_show">
                    <div class="img_chart">
                        <img src="../pic/activity_img_show.jpg"
id="uploadedImage">
                    </div>
                    <span id="activity">No result</span>
                </div>
            </div>
        </div>
    </div>

    <!-- Right Sidebar: Alert Log and Crying Data -->
    <div class="sidebar right">
```

```
        <div class="alert-log">
            <h5 class="alert_header">Alert Log</h5>
            <div class="alert-dia">
                <div class="alert-items">
                    <div class="alert-item">
                        <p>Date: 2022.02.11<br>Baby Temperature:
37.2 °C<br>Room Temperature: 24 °C<br>Weight: 3.6 Kg<br>Duration: 4
h<br>Warning: Temperature too high!</p>
                        <img src="../pic/awake/images (1).jpg" alt="Alert 1">
                    </div>
                    <!-- Additional alerts... -->
                </div>
            </div>
        </div>
        <div class="card">
            <div class="card-body card-chart">
                <h5 class="card-title">Number of Crying Events</h5>
                <div id="barChart6" class="chart"></div>
            </div>
        </div>
    </div>

    <!-- Settings Modal -->
    <div class="modal fade" id="settingsModal" tabindex="-1" aria-
labelledby="settingsModalLabel" aria-hidden="true">
        <div class="modal-dialog">
            <div class="modal-content">
                <div class="modal-header">
                    <h5 class="modal-title"
id="settingsModalLabel">Settings</h5>
                    <button type="button" class="btn-close" data-bs-
dismiss="modal" aria-label="Close"></button>
                </div>
                <div class="modal-body">
                    <!-- Form Inputs for Name, Email, Mobile -->
                    <div class="form-inline mt-3">
                        <label for="Name">Name: </label>
                        <input id="Name">
                    </div>
                    <div class="form-inline mt-3">
                        <label for="Email">Email: </label>
                        <input id="Email"/><button>Send Email</button>
                    </div>
                    <div class="form-inline mt-3">
                        <label for="Mobile">Mobile: </label>
                        <input id="Mobile"/><button>Send SMS</button>
                    </div>
```

```
                </div>
                <div class="modal-footer">
                    <button type="button" class="btn btn-primary"
id="submitSettings">Submit</button>
                    <button type="button" class="btn btn-secondary" data-bs-
dismiss="modal">Close</button>
                </div>
            </div>
        </div>
    </div>

    <!-- Custom Alert -->
    <div class="custom-alert alert alert-warning alert-dismissible fade"
role="alert" id="customAlert">
        <strong id="alertMessage"></strong>
        <button type="button" class="btn-close" data-bs-dismiss="alert" aria-
label="Close"></button>
    </div>

    <canvas id="canvas" style="display: none;"></canvas>
</div>
```

Appendix E --- Communication Connection

I. Send Message – Twilio

Twilio API is used to send text messages to a specified recipient. The /send-sms endpoint accepts a POST request containing the recipient's phone number (to) and the message body (message). Error handling ensures that any issues during SMS delivery are logged and reported with appropriate HTTP status codes.

server.js

```
// Import required modules
const express = require('express');
const bodyParser = require('body-parser');
const cors = require('cors');
const twilio = require('twilio');

// Twilio API credentials
const accountSid = 'accountSid'; // Replace with your Twilio Account SID
const authToken = 'authToken'; // Replace with your Twilio Auth Token
const client = twilio(accountSid, authToken);

const app = express();
const PORT = process.env.PORT || 3000; // Server port configuration

// Middleware setup
app.use(cors()); // Enable CORS for cross-origin requests
app.use(bodyParser.json()); // Parse incoming JSON requests
```

```
// Route to send SMS via Twilio
app.post('/send-sms', (req, res) => {
    const { to, message } = req.body; // Extract 'to' and 'message' from the
request body

    client.messages
        .create({
            body: message,
            from: 'from_number', // Replace with your Twilio phone number
            to: to
        })
        .then((message) => res.json({ sid: message.sid })) // Respond with
message SID on success
        .catch((error) =>
            res.status(500).json({ error: 'Error sending SMS: ' +
error.message }) // Handle errors
        );
});

// Start the server
app.listen(PORT, () => {
    console.log(`Server is running on http://localhost:${PORT}`);
});
```

II. **Send email** – EmailJS

EmailJS provides a lightweight way to send emails directly from the browser using pre-configured templates. The sendEmail() function sends emails with message content and user details by calling the EmailJS API. The template parameters include dynamically generated data, such as a random contact number, sender information, and the message to be sent.

sendSMS.js

```
// Initialize EmailJS with your public key
(function () {
    emailjs.init("public_key"); // Replace with your EmailJS public key
})();

// Function to send an email using EmailJS
export function sendEmail(to, message) {
    const templateParams = {
        contact_number: Math.floor(Math.random() * 100000), // Generate random
contact number
        user_name: "name", // Replace with the sender's name
        user_email: "email@example.com", // Replace with the sender's email
        message: message // Message content
    };
```

```
    emailjs
        .send('service_rqwfvb1', 'template_rqphm1u', templateParams) //
Replace with your service and template IDs
        .then(() => {
            console.log('SUCCESS!'); // Log success message
        })
        .catch((error) => {
            console.error('FAILED...', error); // Log any errors
        });
}
```

Appendix F --- Monitor

Functions Overview：

1.get_start(alarm)

Purpose: Fetches sensor data (like room temperature, baby temperature, and weight) from a server endpoint.
Role: Checks the conditions against set thresholds to determine if any alerts should be triggered, updating the user interface with the latest data.

2.take_photo

Purpose: Captures an image from the camera (or other imaging device) when specific conditions (like the baby being off the bed) are met.
Role: Provides visual evidence for caregivers, enhancing safety monitoring.

3.alarm_func

Purpose: Handles the actions to be taken when an alarm condition is met (e.g., sending notifications).
Role: Triggers SMS and email alerts, logs the event, and may activate additional responses like turning on a light or alerting caregivers.

4.back_normal(flag)

Purpose: Resets the system to a normal state after an alarm condition has been addressed.
Role: Hides any alerts and updates the user interface to reflect the normal operating state.

5.append_child(flag)

Purpose: Logs alert information to the user interface, displaying details such as temperatures and any warnings.
Role: Provides a record of events for caregivers to review.

Event Listener Functions

1.Power Switch Event Listener

Purpose: Responds to changes in the power switch's state, either turning the system on or off.
Role: Starts or stops the timer and sends requests to control system behavior (like turning on or cleaning).

2.Settings Submit Button Event Listener

Purpose: Captures user input for settings (like email and mobile number) and saves them.
Role: Updates the user settings and provides feedback to the user.

3.Alarm Switch Event Listener

Purpose: Responds to changes in the alarm switch, activating or deactivating the alarm.

Role: Triggers specific actions based on the alarm's state.

smart.js

```
import { sendEmail } from './email.js'; // Import sendEmail function

let email = "test@example.com";
let mobile = "your number";
let userSettings = { email, mobile };
let url = "http://192.168.9.172:4000/";
let led_on = url + "led_on";
let led_off = url + "led_off";
let baby_temp = "";
let room_temp = "";
let weight = "";
let Warning_Info = "";
let imageUrl = "";
let tempMinInput = "";
let tempMaxInput = "";
let sound_status = "";
let timer = null;

// Start a timer to repeatedly call the get_start function every 10 seconds
function startTimer() {
    timer = setInterval(() => {
        get_start();
    }, 10000);
}

// Stop the timer
function stopTimer() {
    clearInterval(timer);
    timer = null;
}

// Power switch event listener
const powerSwitch = document.getElementById('powerSwitch');
powerSwitch.addEventListener('change', function () {
    const alert = document.getElementById('customAlert');
    const message = event.target.checked ? 'Power On' : 'Power Off';

    // Update alert message
    document.getElementById('alertMessage').innerText = message;

    // Start or stop the timer based on switch status
    event.target.checked ? startTimer() : stopTimer();
```

```
    // Send a request to turn the system on or clean it
    $.get(url + (event.target.checked ? "on" : "clean"), () => { });

    // Display the alert and hide it after 3 seconds
    alert.classList.add('show');
    alert.style.display = 'block';
    setTimeout(() => {
        alert.classList.remove('show');
        alert.style.display = 'none';
    }, 3000);
});

// Settings button to display the settings modal
const settingsBtn = document.getElementById('settingsBtn');
const settingsModal = new bootstrap.Modal(document.getElementById('settingsModal'));

settingsBtn.addEventListener('click', function () {
    settingsModal.show();
});

// Settings submit button event listener
const submitSettings = document.getElementById('submitSettings');
submitSettings.addEventListener('click', function () {
    userSettings = {
        email: document.getElementById('Email').value,
        mobile: document.getElementById('Mobile').value
    };
    tempMinInput = document.getElementById('tempMin').value;
    tempMaxInput = document.getElementById('tempMax').value;

    const alert = document.getElementById('customAlert');
    const message = 'Settings Saved';

    // Update alert message and display it
    document.getElementById('alertMessage').innerText = message;
    alert.classList.add('show');
    alert.style.display = 'block';
    settingsModal.hide();

    // Hide the alert after 3 seconds
    setTimeout(() => {
        alert.classList.remove('show');
        alert.style.display = 'none';
    }, 3000);
});
```

```
// Alarm switch event listener
const alarmSwitch = document.getElementById('alarmSwitch');
alarmSwitch.addEventListener('change', async () => {
    event.preventDefault(); // Prevent form's default behavior
    event.target.checked ? get_start(true) : back_normal(false);
});

// Capture a photo and display it
async function take_photo() {
    const response = await fetch(url + 'capture');
    const blob = await response.blob();
    imageUrl = URL.createObjectURL(blob);

    document.getElementById('uploadedImages').src = imageUrl;
    document.getElementById('uploadedImage').src = imageUrl;
}

// Fetch sensor data and update the interface
function get_start(alarm) {
    $.get(url + "start", async (data) => {
        let flag = false;
        baby_temp = (parseFloat(data.object_temperature) + 11).toFixed(2);
        room_temp = parseFloat(data.ambient_temperature).toFixed(2);
        sound_status = data.sound_status;

        let new_weight = Math.max(0, (parseFloat(data.pressure)  10).toFixed(2));
        document.getElementById('room_temp').innerText = `${room_temp} °C`;
        document.getElementById('weight').innerText = `${new_weight} kg`;
        document.getElementById('baby_temp').innerText = `${baby_temp} °C`;

        if (tempMaxInput && room_temp > tempMaxInput) {
            flag = true;
            Warning_Info = "Warning: Baby room's temperature is higher than the set value.";
        }
        if (tempMinInput && room_temp < tempMinInput) {
            flag = true;
            Warning_Info = "Warning: Baby room's temperature is lower than the set value.";
        }
        if (sound_status && (new_weight - weight) > 5) {
            Warning_Info = "Warning: Baby is not on the bed.";
            await take_photo();
        }
        if (alarm) flag = true;
        weight = new_weight;

        if (flag) {
            if (!alarm) {
```

```
            const alarmSwitch = document.getElementById('alarmSwitch');
            alarmSwitch.checked = !alarmSwitch.checked;
        }
        alarm_func();
    }
  });
}

// Add a log entry for alerts
function append_child(flag) {
  const alert_display = document.querySelector('.alert-items');
  const alertAlarm = document.querySelector('.alert_alarm');
  const alertItem = document.createElement('div');
  alertItem.className = 'alert-item';
  let date = getCurrentTime();

  alertItem.innerHTML = `
    Date: ${date}<br>
    Baby Temperature: ${baby_temp} °C<br>
    Room Temperature: ${room_temp} °C<br>
    Weight: ${weight} kg<br>
    Duration of use: 4 h<br>
    Warning Info: ${Warning_Info}<br>
    <img src="${imageUrl}">
  `;

  alertAlarm.appendChild(alertItem);
  alert_display.style.display = 'none';
  alertAlarm.style.display = 'block';
}

// Get the current date and time
function getCurrentTime() {
  const now = new Date();
  const year = now.getFullYear();
  const month = String(now.getMonth() + 1).padStart(2, '0');
  const day = String(now.getDate()).padStart(2, '0');
  const hours = String(now.getHours()).padStart(2, '0');
  const minutes = String(now.getMinutes()).padStart(2, '0');
  return `${year}.${month}.${day} ${hours}:${minutes}`;
}

// Trigger alarm functions
async function alarm_func() {
  stopTimer();
  const alert_display = document.querySelector('.alert_display');
  alert_display.style.display = 'block';
```

```
    const alert = document.querySelector('.alert');
    alert.style.display = 'none';

    append_child(true);

    const message = Warning_Info;
    document.getElementById('alert_words_alarm').innerText = message;
    sendEmail(userSettings.email, message);

    fetch('http://localhost:3000/send-sms', {
        method: 'POST',
        headers: { 'Content-Type': 'application/json' },
        body: JSON.stringify({ to: userSettings.mobile, message })
    })
    .then(response => response.json())
    .then(data => console.log('Message sent:', data.sid))
    .catch(error => console.error('Error:', error));

    $.get(led_on);
}

// Reset the system to normal state
function back_normal(flag) {
    const alert_display = document.querySelector('.alert_display');
    alert_display.style.display = flag ? 'block' : 'none';

    const alert = document.querySelector('.alert');
    alert.style.display = flag ? 'none' : 'block';

    const alert_display2 = document.querySelector('.alert-items');
    const alertAlarm = document.querySelector('.alert_alarm');

    alert_display2.style.display = flag ? 'none' : 'block';
    alertAlarm.style.display = flag ? 'block' : 'none';

    $.get(led_off);
}

// Observe changes in the on_bed element and trigger alarm if changes occur
let on_bed = document.getElementById('on_bed');
const observer = new MutationObserver((mutationsList) => {
    for (let mutation of mutationsList) {
        if (mutation.type === 'childList' || mutation.type === 'subtree') {
            alarm_func();
        }
    }
```

```
});
const config = { childList: true, subtree: true };
observer.observe(on_bed, config);
```

Appendix G --- Others

For specific code content, please see github:
https://github.com/YUYANGWEI00/CITS5506Project