by Tenshi Company

ENSC 405W
Proof of Concept Presentation
April 22nd, 2021

Introduction

Background & Problem

Many infants each year succumb to sleep related deaths.

One of these causes are when babies suffocate when laying face down [1].

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"How Long Do Newborn Babies Sleep" [2]

"9 Trendy Nursery Ideas for Your Baby's Room Design" [4]

Safe sleep environments are imperative to healthy growth and reduce the chance of Sudden Infant Death Syndrome [3].

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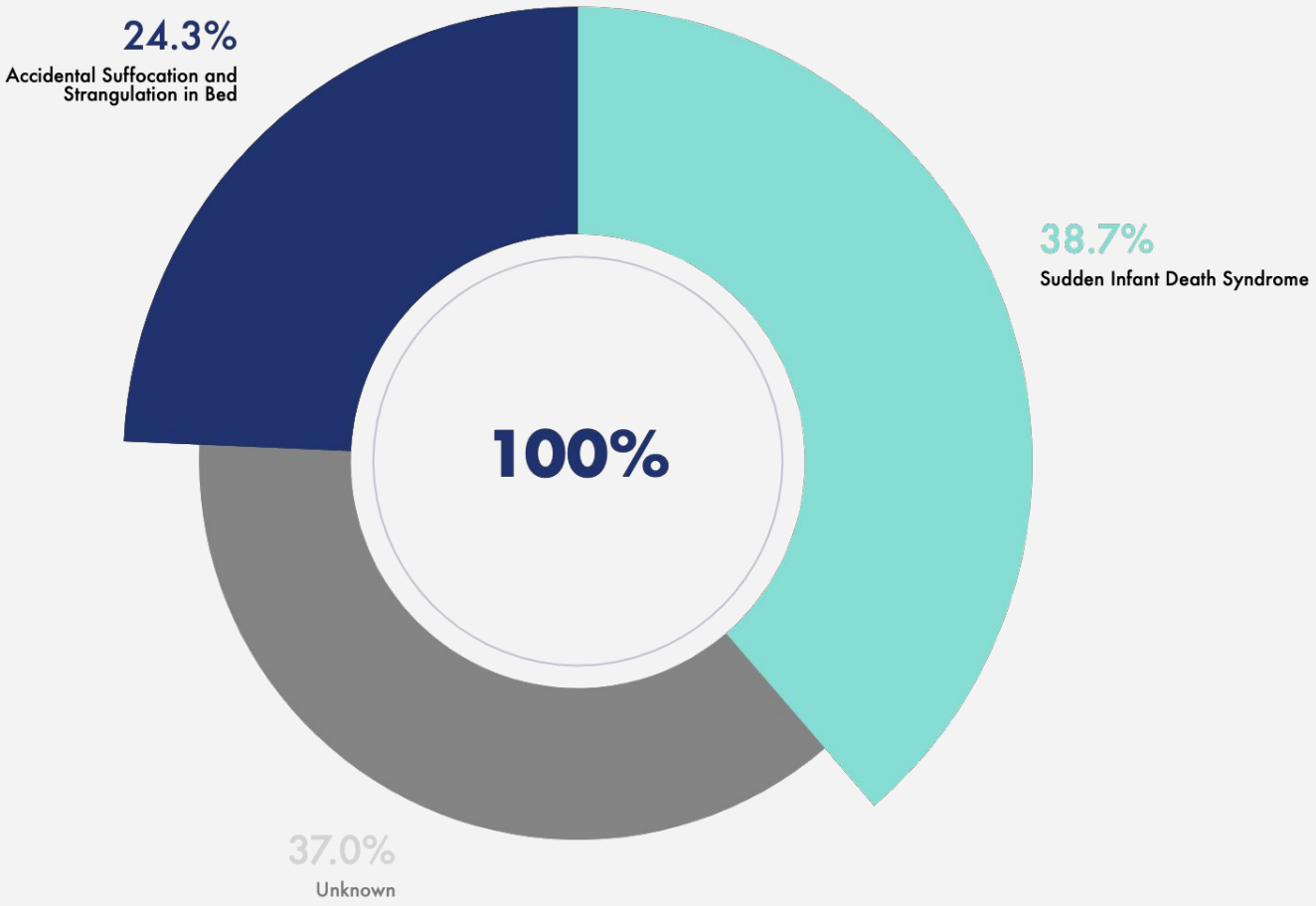

Approximately 3500 Sudden Unexpected Infant Deaths per year (USA) [5].

How do we fix this?

Baby monitors are a common solution to check on infants remotely.

The Best Video Baby Monitors Of 2021 [6]

"The Best Baby Monitors" [7]

"The Best Baby Monitors [7]

"Smart camera and baby monitor warning given by UK's cyber-defender - BBC News" [8]

User Interviews

"Tedious to bring the monitor around. I would rather have an app."

"Parent fatigue is unlike anything you've experienced before, and you just wanted to make things easier for yourself [...]"

Wearable Technology for Baby Monitoring: A Review [9]

Wearable Technology for Baby Monitoring: A Review [9]

Cameras & Wearables

Intrusive.

Susceptible to **security** flaws [8].

Impact to routine.


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Product Video

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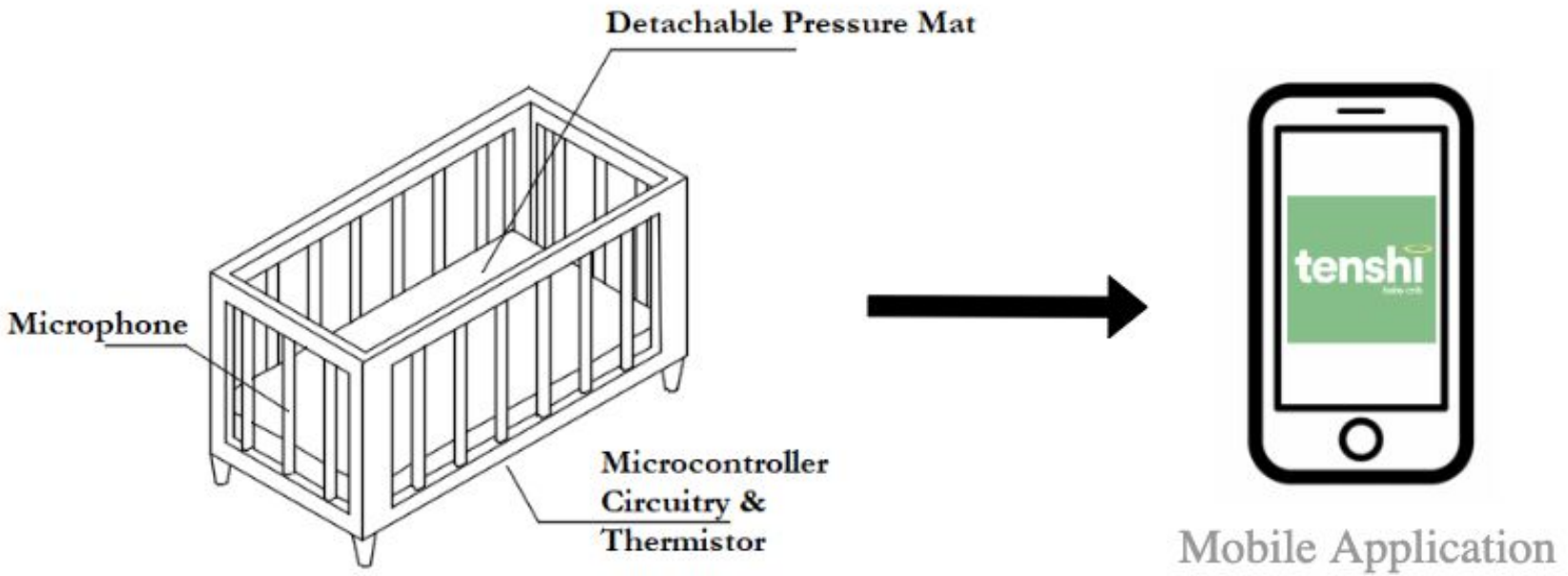
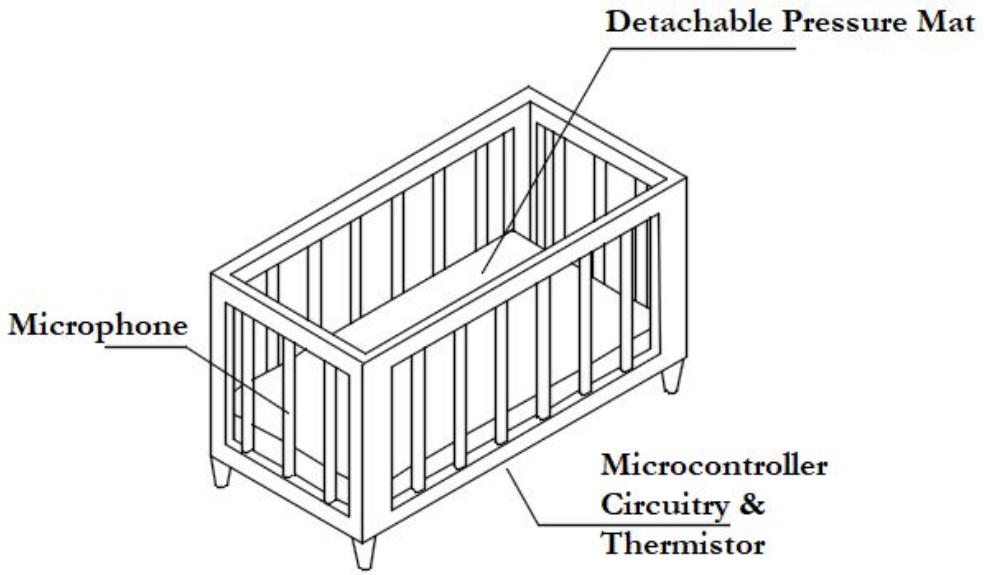
Overview

Modern Baby Monitoring Solution

System Overview



Crib System



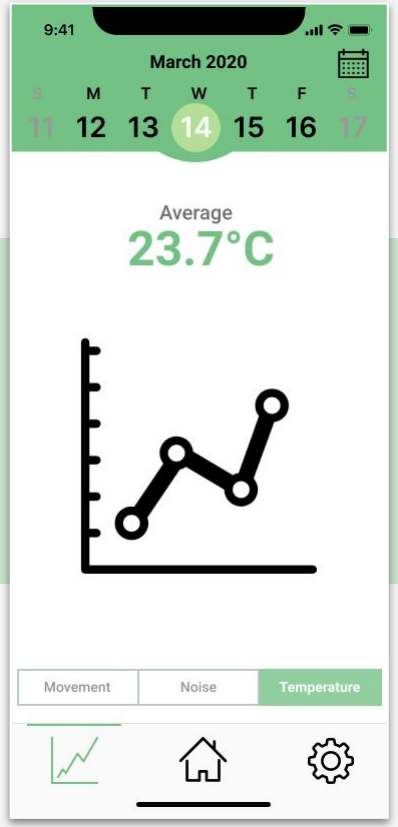
Pressure mat detects when baby lays on their front.

Microphones listens for loud noises, including the baby's cries.

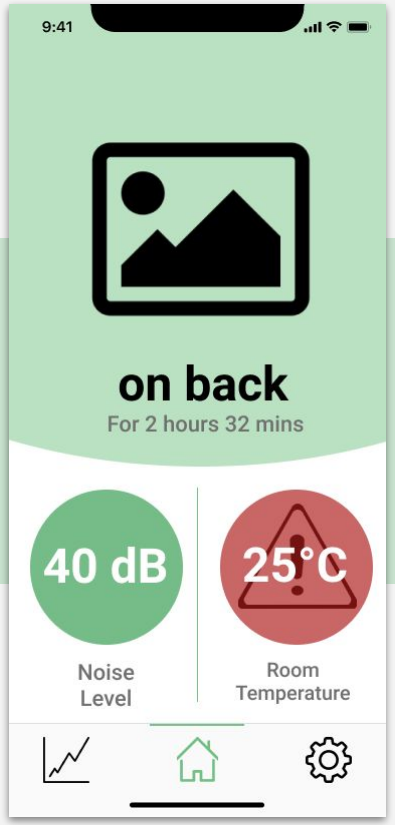
Thermistor continuously monitors the room's temperature.

Microcontroller and circuitry seamlessly integrated into the crib.

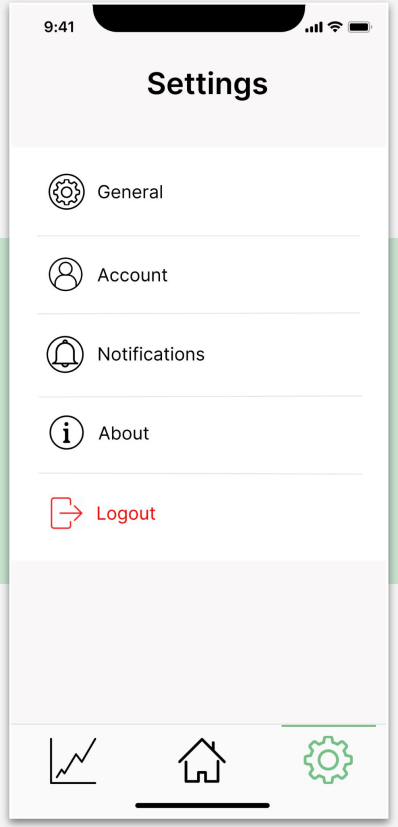
Mobile Application



Data Page



Home Page



Settings Page

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Sleeping Environment

Monitor room temperature and loud noises, including when the baby starts crying.
Reduce the chance of overheating and audibly detect what is bothering the baby.

Sleeping Position

Ensure baby lays on their backside while sleeping, as advised by health organizations [1].
Prevent suffocation in the least intrusive way.

Accessibility & Time Efficiency

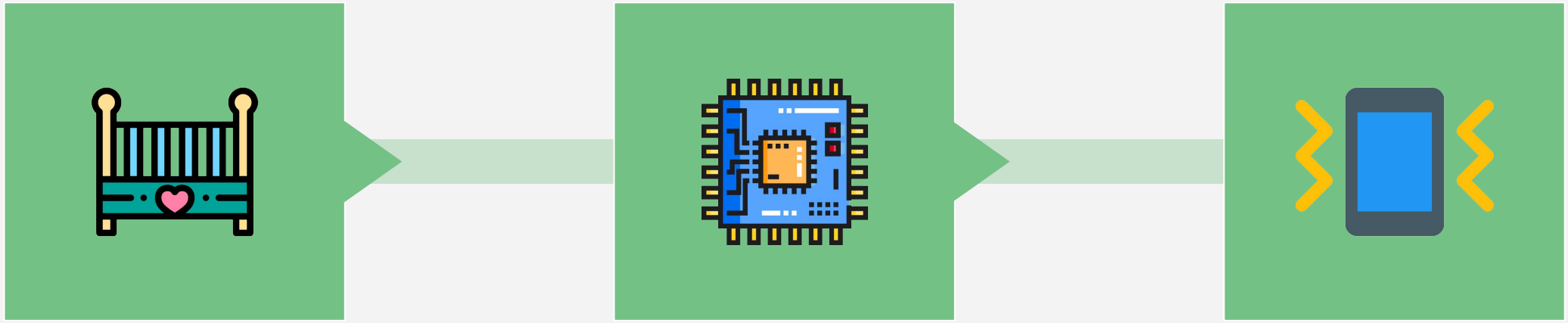
Allow parents to utilize baby monitoring solution with little impact to routine.
Provide timely alerts for parents to quickly attend to their children.

Technical Case

System Overview

Flaticon [10]

System Overview



Sensor System
Monitors room temperature, noise levels, and baby position.

Data Analysis System
Identifies vulnerable situations. Logs sensor data for visual analysis.

Notification System
Customizable and reliably notifies when baby is vulnerable.

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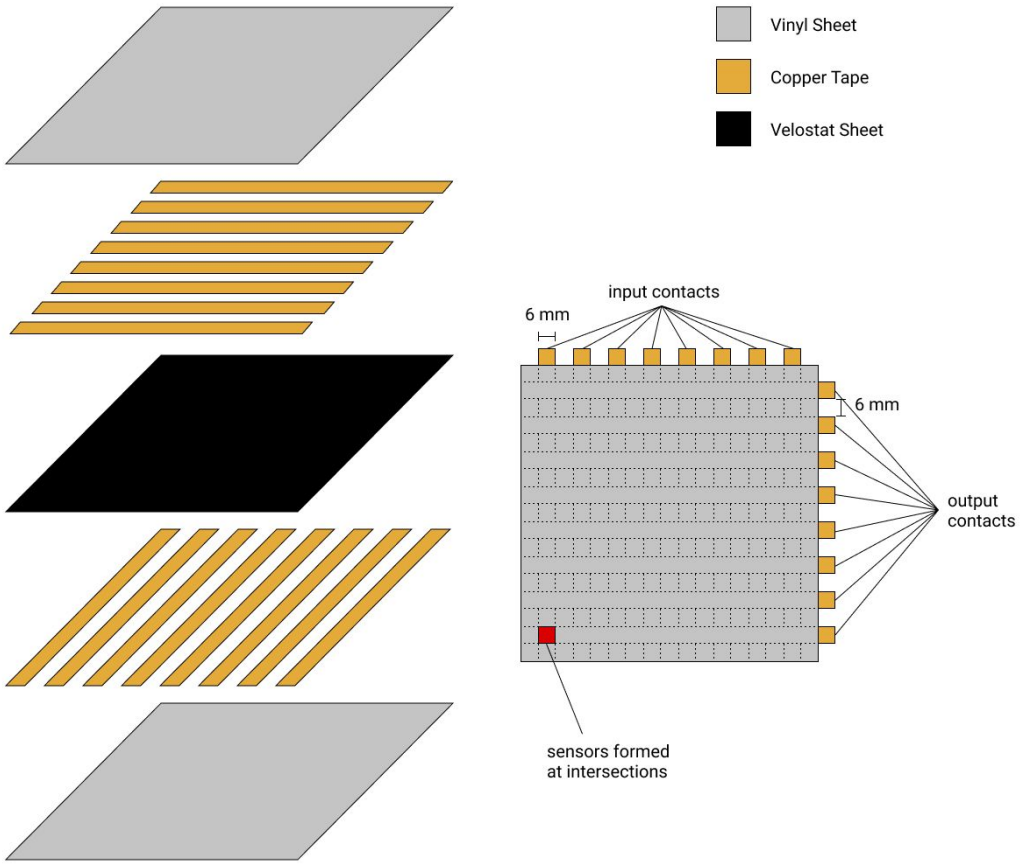
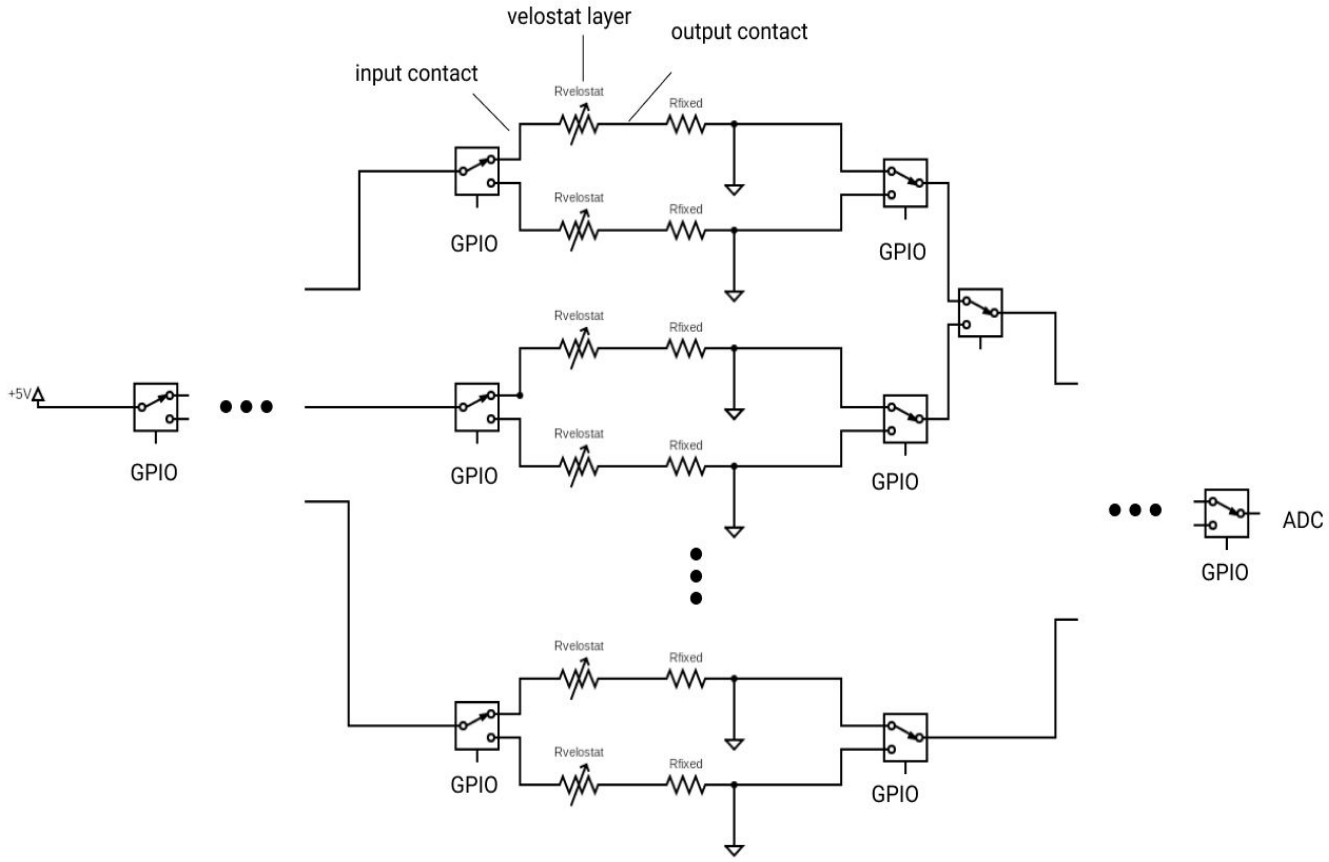
Pressure Mat

- Source of positional data
- Velostat - pressure sensitive material
- Copper tape layered on either side
- Sensors formed at intersection

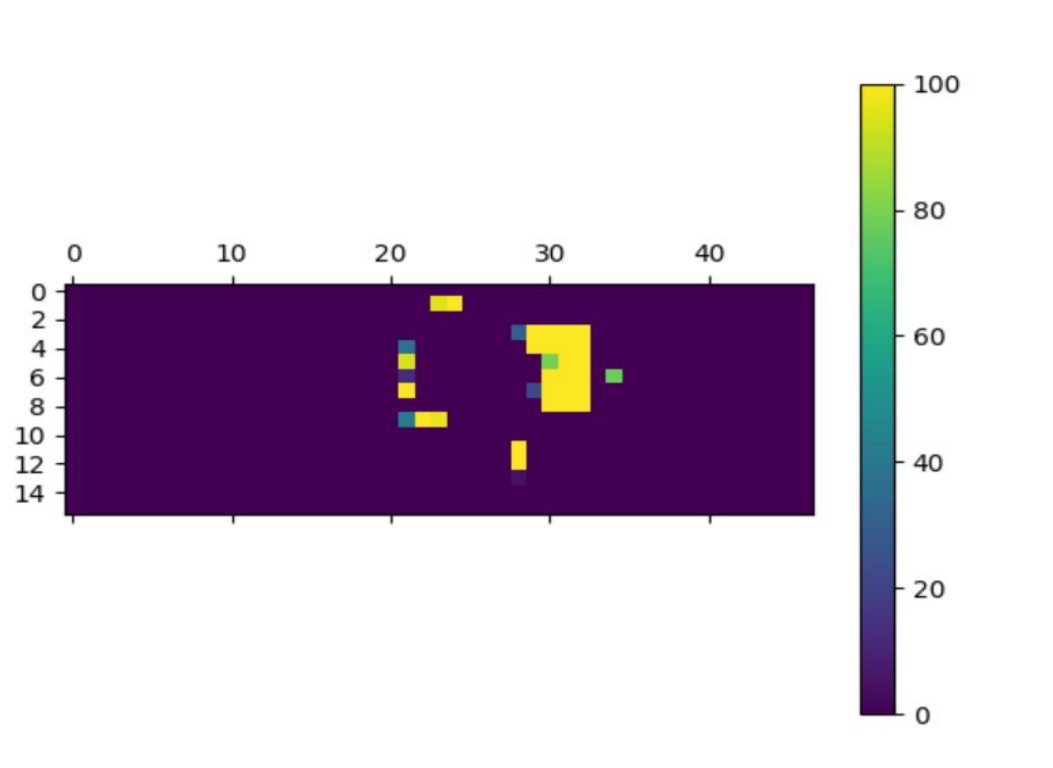


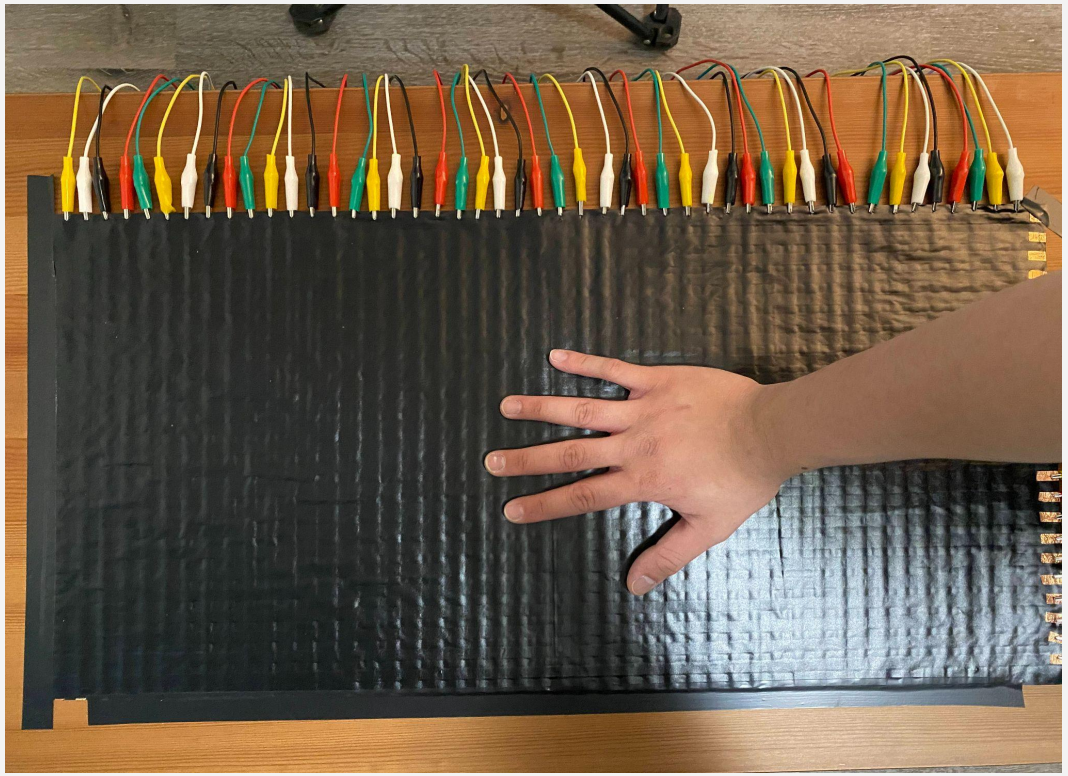
Pressure Data



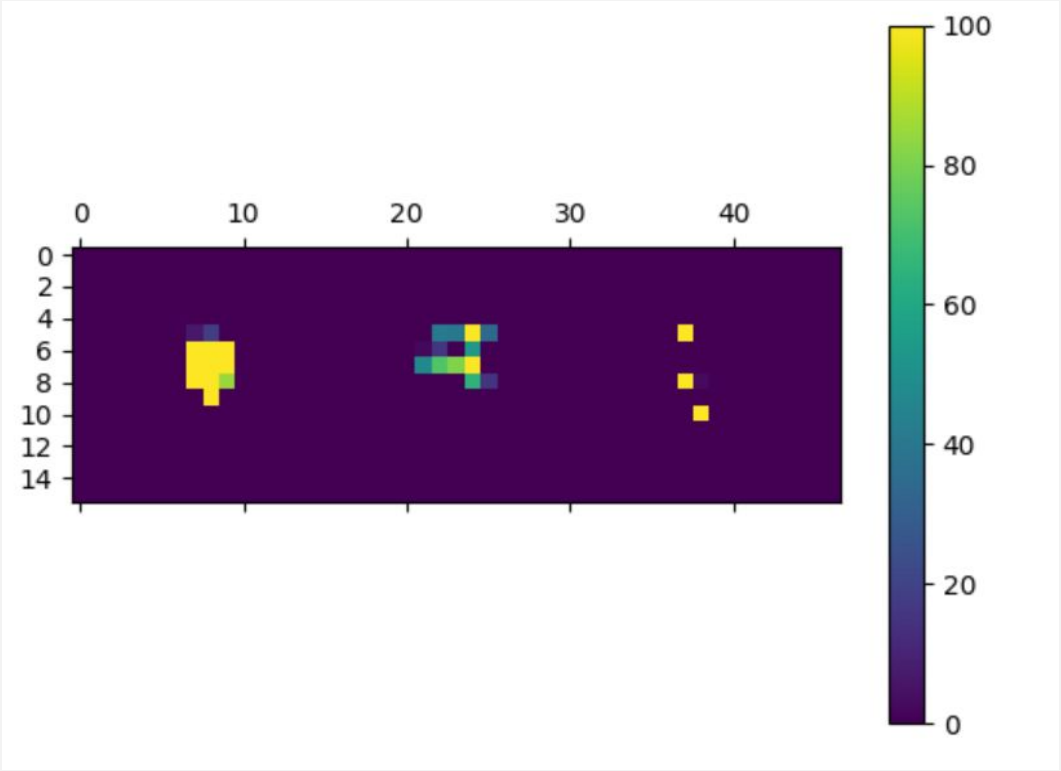
- Sampled data through input and output muxes
- Used PySerial to read data through serial port
  - Matplot to visualize pressure map
  - Generated data to train machine learning model

Hand

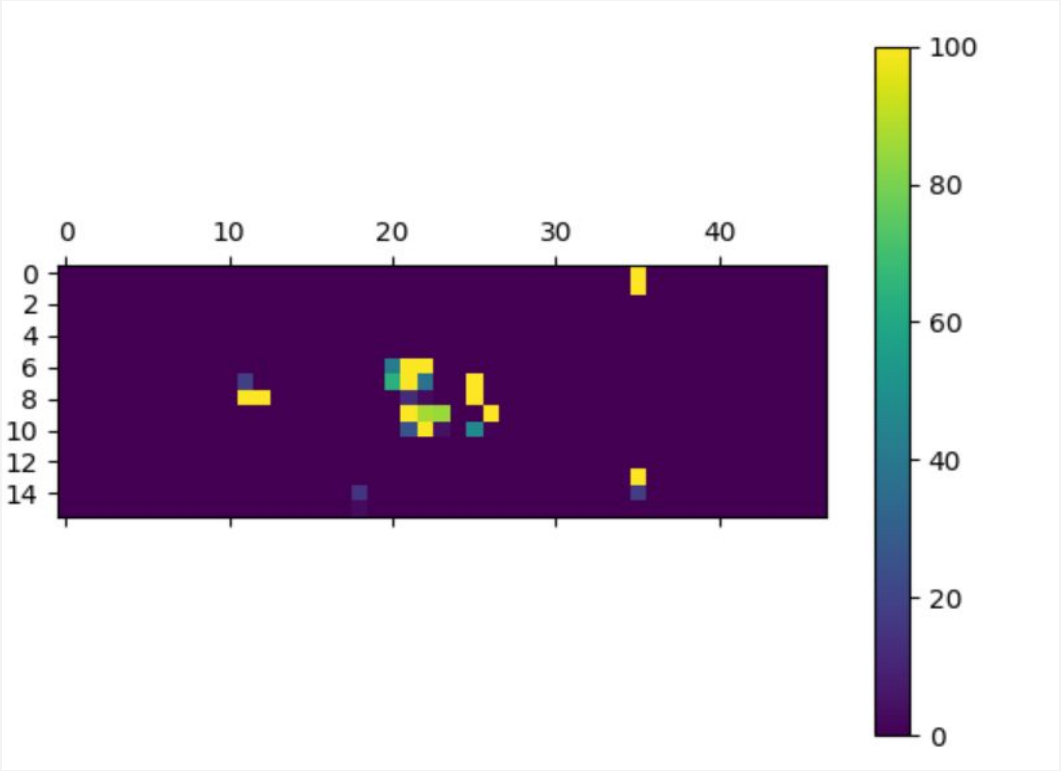


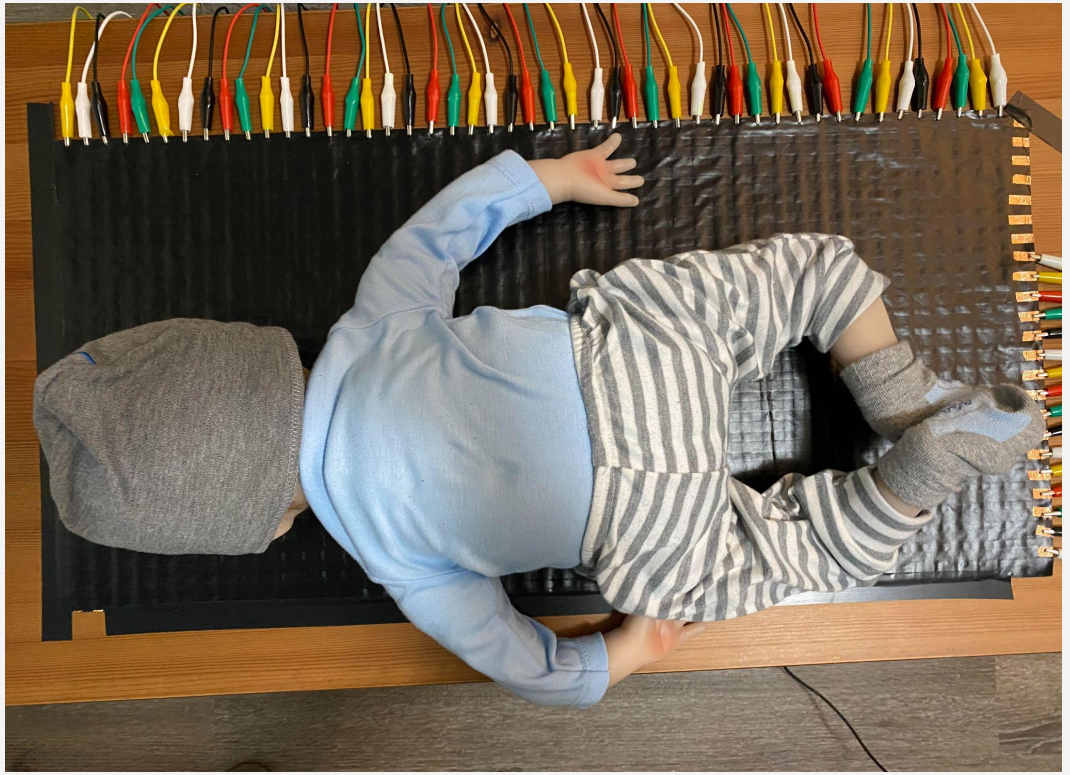


Baby on Back

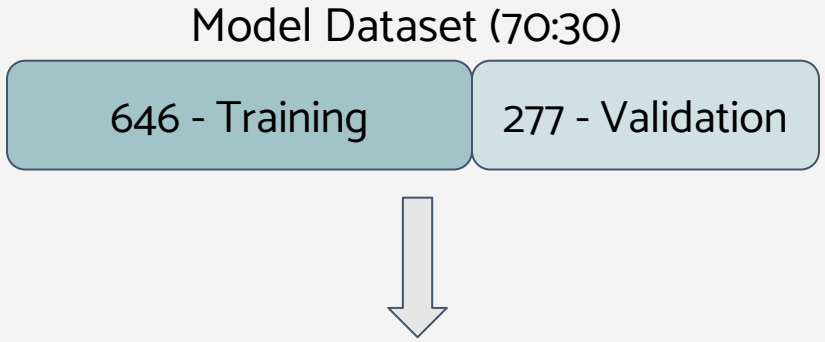


Baby on Front





Machine Learning Dataset

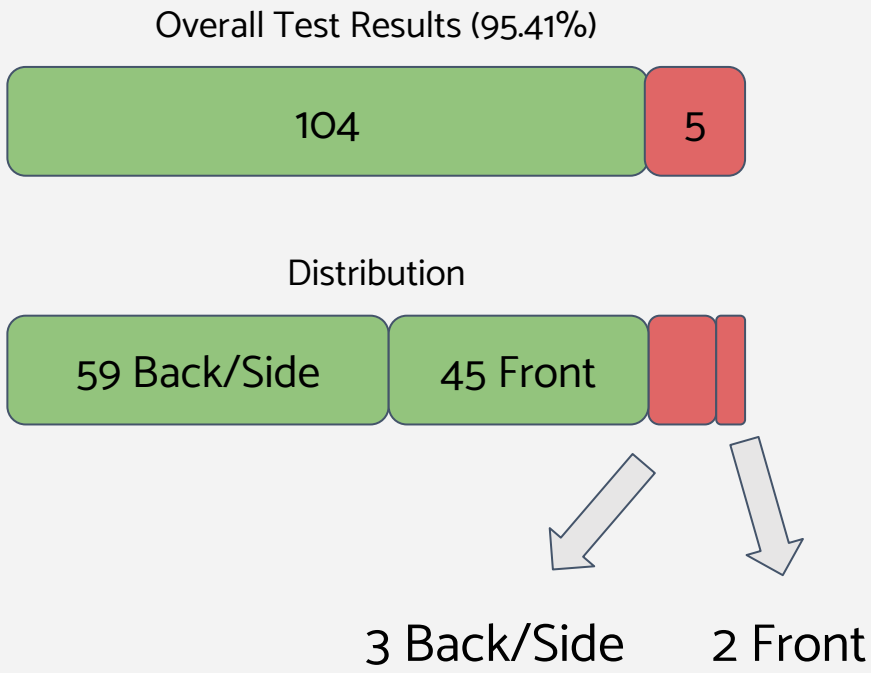


16x47 Normalized Matrix Values
Varying weight distribution in different positions.

Position Model

Convolutional Neural Network

- Able to identify low and high level features with increasing layers.
- Implemented with **Tensorflow**, an open source machine learning platform.
- **Tensorflow Lite** enables deployment to microcontrollers.
- In training our model, we found minimal overfitting.



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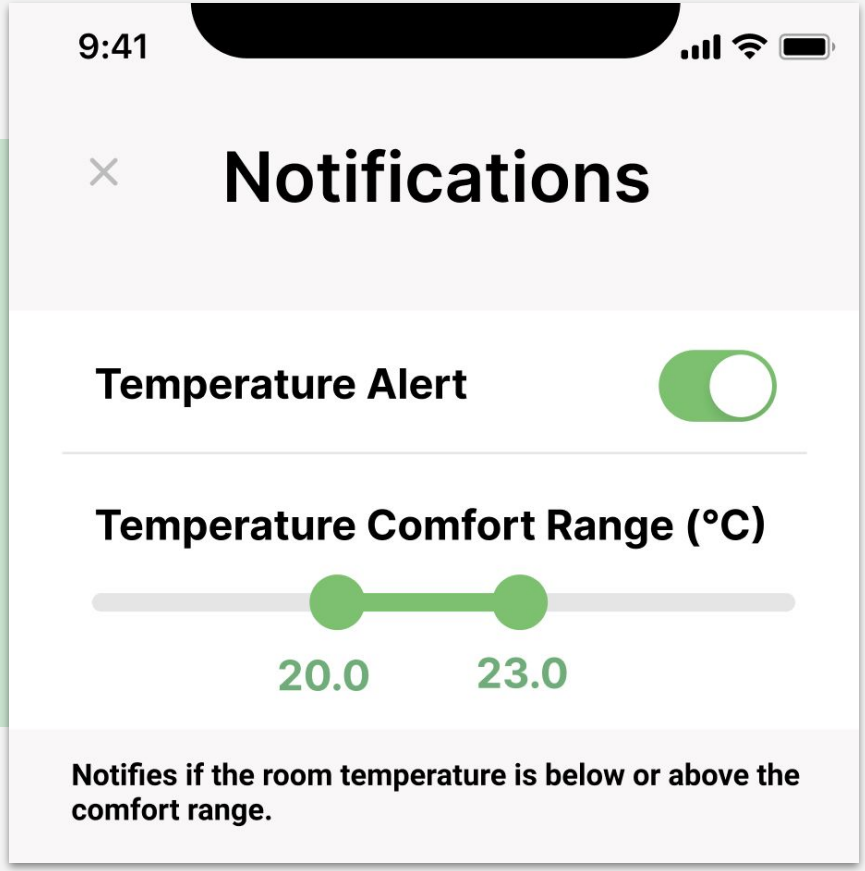
Temperature Monitoring

- Accurately measures ambient room temperature in degrees celsius (°C)
- Sends notification when temperature exceeds comfort threshold (20°C- 23°C)



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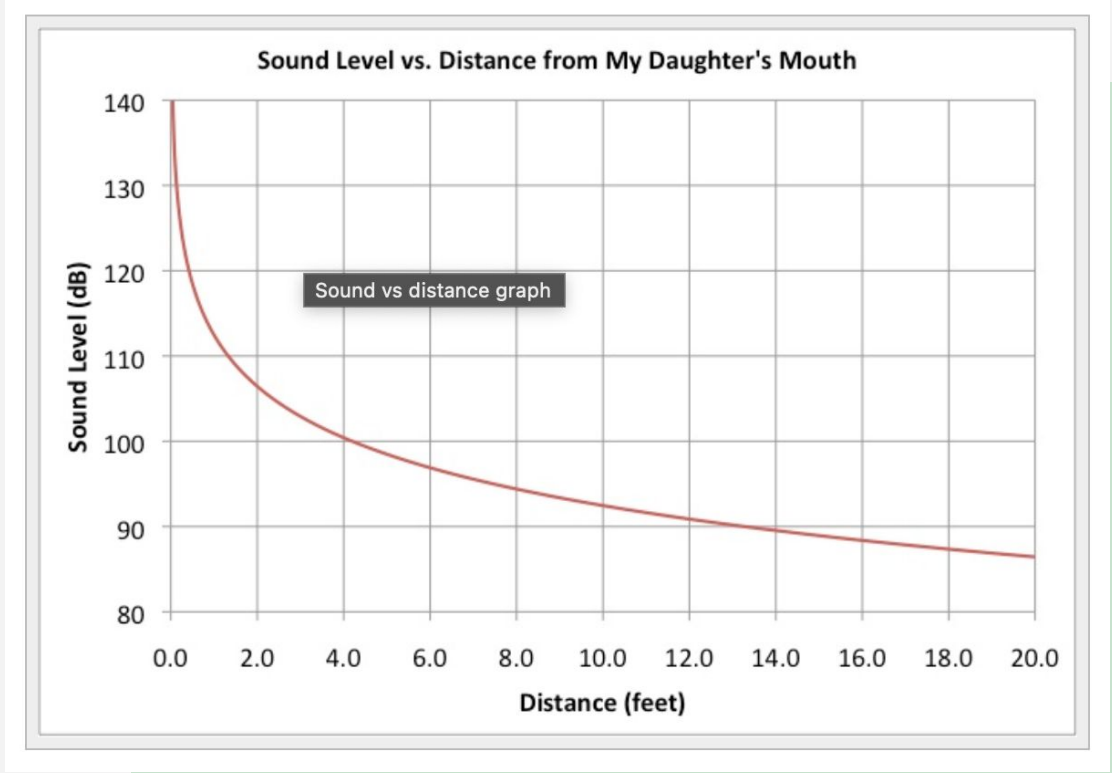
Sound Monitoring

- Uses an analog sensor
- Detects frequency of sample in hertz (Hz)
- Detects sound level pressure in room in decibels (dB)
- Sounds a notification when dB exceeds 80 dB || Hz > 300Hz



"How Loud Can Your Baby Cry?" [11]

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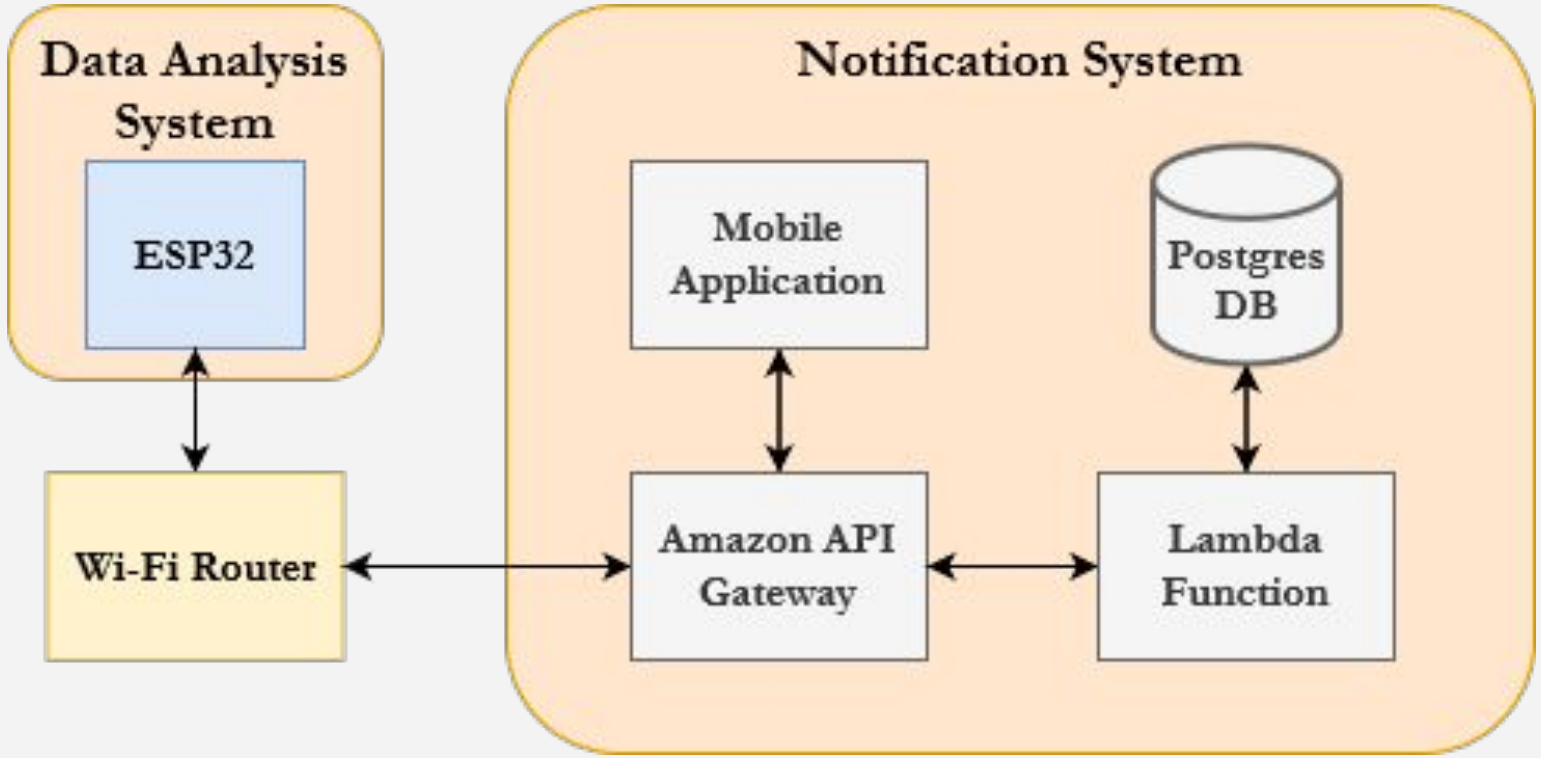
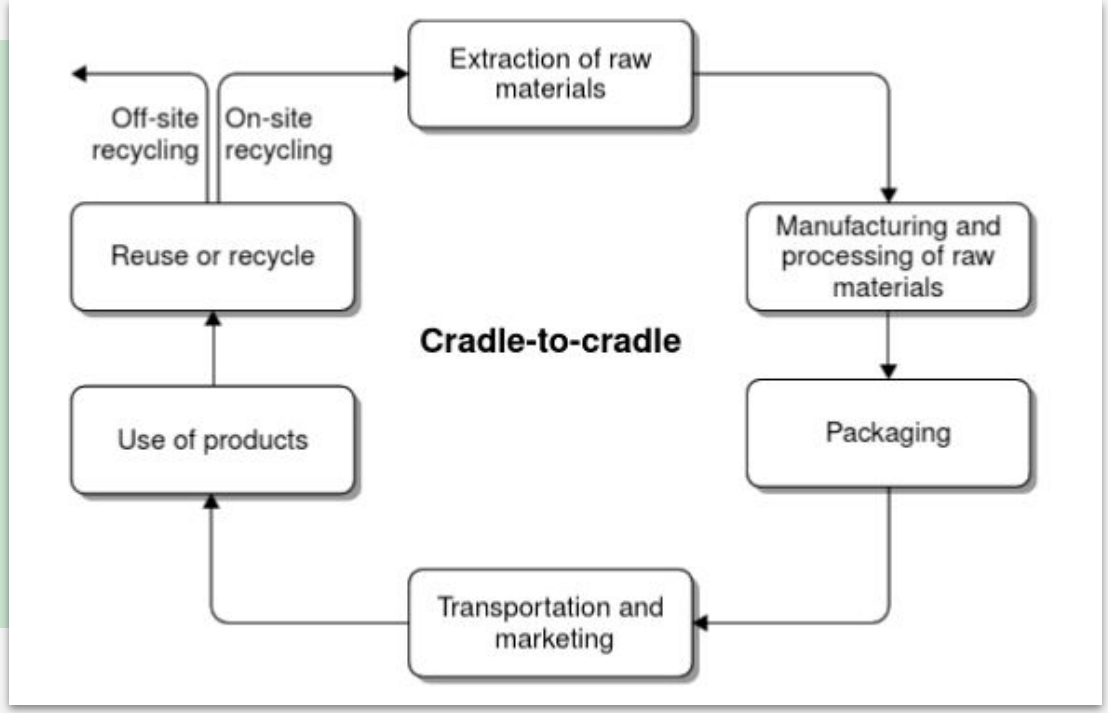
Notification System

- ESP32 connects to WiFi and communicates an API
- API communicates with Mobile app and Database



Cradle to Cradle Cycle

- Sustainable system considers environmental, economic and social interconnected components
- Design for longevity
  - Physical crib is standard-approved and can be reused.



"Sustainable Industrial Design and Waste Management: Cradle-to-Cradle for Sustainable Development" [12]

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Engineering Standards

Electronics	Software	Safety & Sustainability
IEC 61508-1:2010 Programmable Electronics	ISO/IEC 12207-2017 Software Life Cycle	SOR/2016-152 Cribs, Cradles, Bassinets
UL 2595 Battery Powered Appliances	ISO 9241-161:2016 Visual User Interfaces	
IEC 62047-33:2019 Piezoresistive Devices	Apple & Android User Interface Guidelines	CAN/CSA-ISO/TR 14062-03 Environmental Design & Development
IEEE 802.11 Wireless Communication		

[13-22]

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Proof of Concept Status

Acceptance Test	Result
Pressure mat is able to visualize pressure distribution	Baby positions and pressure distribution visualized.
Pressure mat value accuracy. Minimal outliers.	Values were normalized for 2.5kg - 4.5kg (4lb - 10lb) and used for training the model.
Baby position identification	95.4% accurate, classifying front and not front.
Temperature accuracy	Temperature circuit implemented and tested - yet to test against reliable measurement tool.
Noise accuracy	Sound circuit is currently being debugged - yet to test against accuracy measurements

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Business Case

Market & Costs

Market & Ideal Customers

- Observed trends in family working patterns
- Observed trends in technology use in parent-age individuals

→ Assumption about the market and ideal customers:

- First-time working parents who are dealing with anxiety of caring for a baby
- First-time parents whose daily activities include technology

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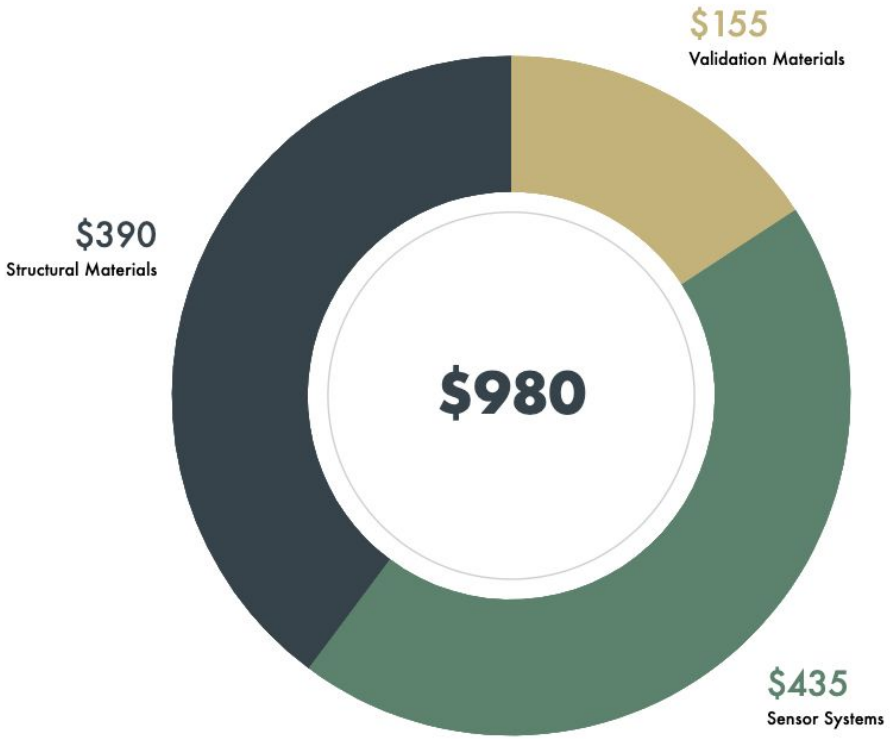
Estimated Project Costs

Sensor Systems	44%
Structural Materials	40%
Validation Materials	6%



Tenshi Crib Costs

Crib System: $600

- Crib ($200)
- Mattress ($100)
- Smart system ($300)

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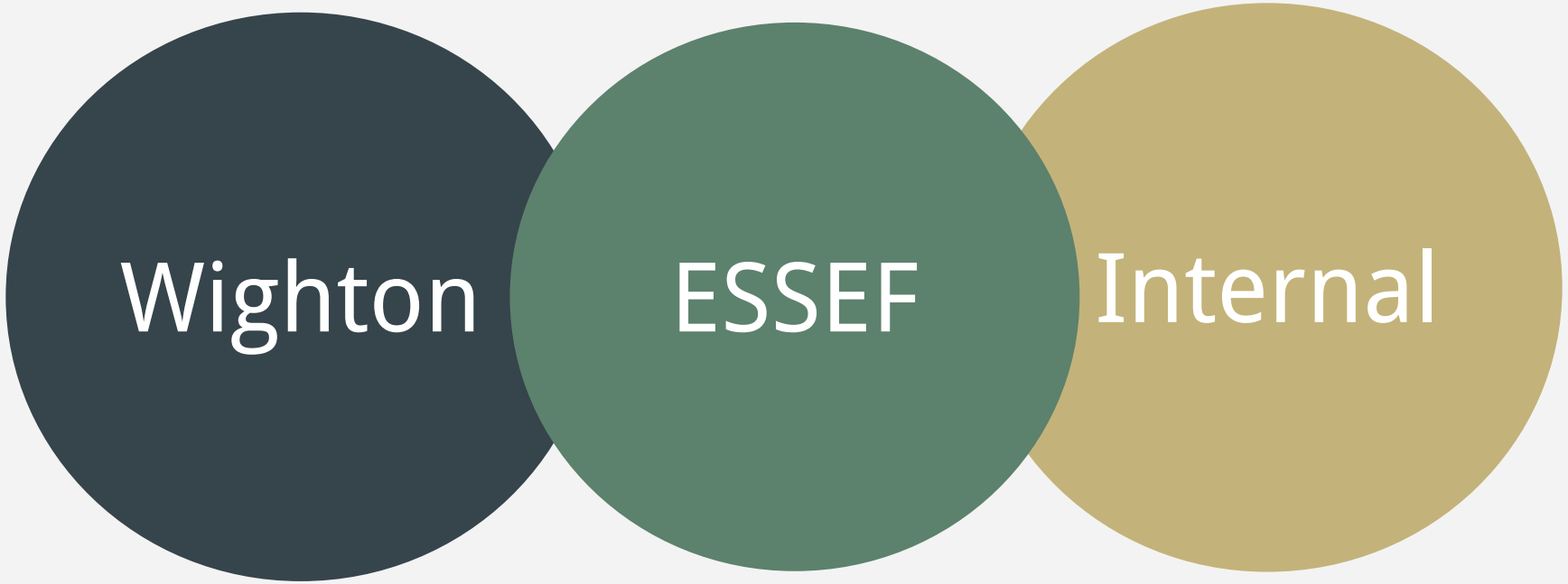
Funding



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Competitors

Main competitors are leading products that monitor similar features and/or focus on passive monitoring with a mobile application.

Leading competitors

- **Camera:** Cubo AI ($340)
- **Wearable:** Owlet Smart Sock ($400)
- **Motion Pads:** Babysense7 ($200)

Our Advantage

Non intrusive

- No wearable items
- No cameras

Seamless Integration

- No obvious technology within view
- Easy setup

All in one

- Several features, one crib, one mobile application

Risk Management

- **Physical Damages**
  - If the internal wiring of the electronics and sensors are tampered with, it may be rendered unusable

- **Crib in non-temperate climates**
  - Target market is North American regions
  - Average temperature ranges from 16°C - 23°C

- **Electronics and Crib Design**
  - Electronic Safety, Crib Safety standards.

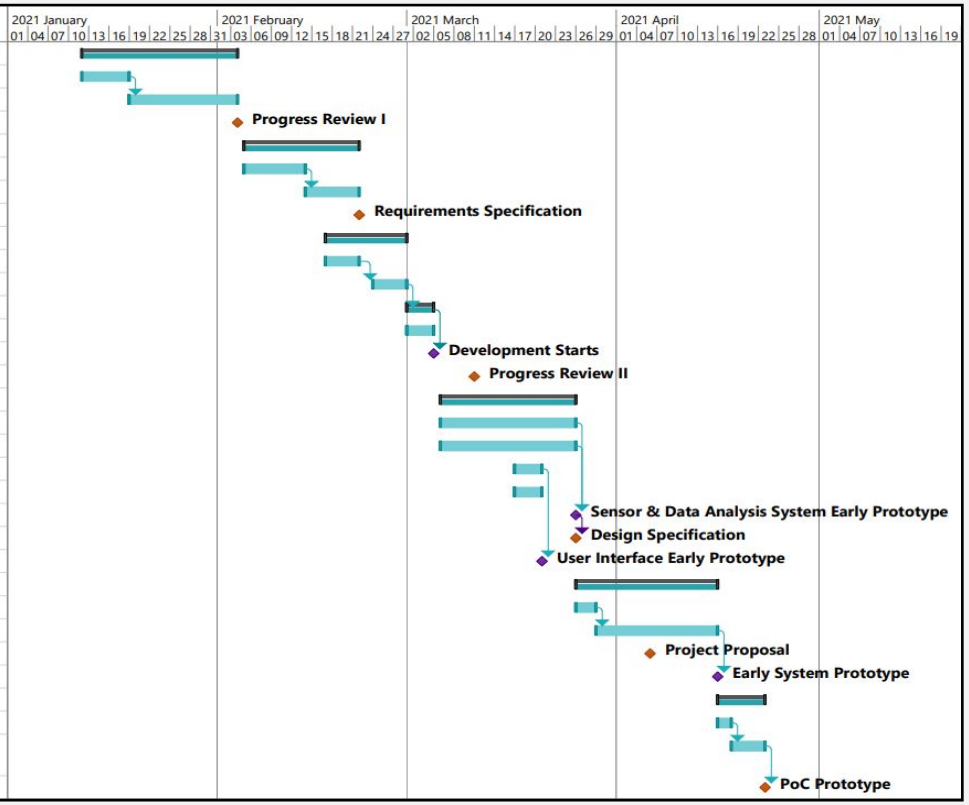
- **Wireless Notifications Risk**
  - Communication Standards & Reliable Failsafes

Schedule

Current & Future Plans

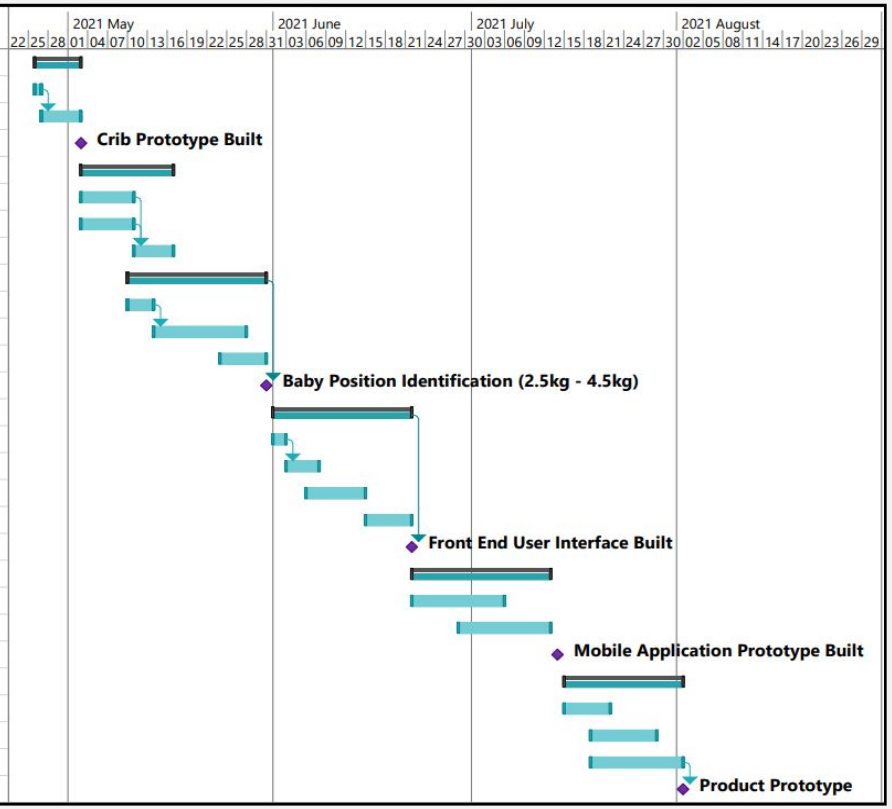
ENSC 405W Schedule

ID	Task Name	Duration	Start	Finish
1	**1. Project Ideation**	**23 days**	**January 12**	**February 03**
2	1.1 Brainstorming	7 days	January 12	January 18
3	1.2 Problem Analysis & Feedback	16 days	January 19	February 03
4	Progress Review I	0 days	February 04	February 04
5	**2. Requirements**	**17 days**	**February 05**	**February 21**
6	2.1 Requirements Elicitation	9 days	February 05	February 13
7	2.2 System Definition	8 days	February 14	February 21
8	Requirements Specification	0 days	February 21	February 21
9	**3. Sensor System Research**	**12 days**	**February 17**	**February 28**
10	3.1 Electronics Sensors Research	5 days	February 17	February 21
11	3.2 Microcontroller Research	5 days	February 24	February 28
12	**4. Data Analysis System Research**	**4 days**	**March 01**	**March 04**
13	4.1 Temperature, Sound, and Pressure Algorithms	4 days	March 01	March 04
14	Development Starts	0 days	March 05	March 05
15	Progress Review II	0 days	March 11	March 11
16	**5. Sensor & Data Analysis Design**	**20 days**	**March 06**	**March 25**
17	5.1 Circuit Design	20 days	March 06	March 25
18	5.2 Sensor Data Retrieval	20 days	March 06	March 25
19	5.3 Mobile Application Design	4 days	March 17	March 20
20	5.4 Crib Design	4 days	March 17	March 20
21	Sensor & Data Analysis System Early Prototype	0 days	March 26	March 26
22	Design Specification	0 days	March 26	March 26
23	User Interface Early Prototype	0 days	March 21	March 21
24	**7. Proof of Concept System Integration**	**21 days**	**March 26**	**April 15**
25	7.1 Sensor System & ESP32 Integration	3 days	March 26	March 28
26	7.2 Machine Learning Model Training	18 days	March 29	April 15
27	Project Proposal	0 days	April 06	April 06
28	Early System Prototype	0 days	April 16	April 16
29	**8. Proof of Concept Testing**	**7 days**	**April 16**	**April 22**
30	8.1 Acceptance Test Plan (Unit Testing)	2 days	April 16	April 17
31	8.2 Requirements Verification Test Plan (System Test Plan)	5 days	April 18	April 22
32	PoC Prototype	0 days	April 23	April 23



ENSC 440 Schedule

ID	Task Name	Duration	Start	Finish
1	**9. Crib Integration**	**7 days**	**April 26**	**May 02**
2	9.1 Sensor Placement	1 day	April 26	April 26
3	9.2 Regression Testing	6 days	April 27	May 02
4	Crib Prototype Built	0 days	May 03	May 03
5	**10. Notification System Bringup**	**14 days**	**May 03**	**May 16**
6	10.1 Amazon API Gateway	8 days	May 03	May 10
7	10.2 Mobile Application UI Skeleton	8 days	May 03	May 10
8	10.3 ESP32 Wi-Fi Notifications	6 days	May 11	May 16
9	**11. Position Identification Optimization**	**21 days**	**May 10**	**May 30**
10	11.1 Purchase Multiple Baby Dolls + Weights	4 days	May 10	May 13
11	11.2 Machine Learning Model Training	14 days	May 14	May 27
12	11.3 Edge Case Testing	7 days	May 24	May 30
13	Baby Position Identification (2.5kg - 4.5kg)	0 days	May 31	May 31
14	**12. Front End Development**	**21 days?**	**June 01**	**June 21**
15	12.1 Icon Elements	2 days	June 01	June 02
16	12.2 Text Elements	5 days	June 03	June 07
17	12.3 Placeholder Graphs & Timescale Views	9 days	June 06	June 14
18	12.4 Coloured Elements	7 days	June 15	June 21
19	Front End User Interface Built	0 days	June 22	June 22
20	**13. Back End Development**	**21 days**	**June 22**	**July 12**
21	13.1 Database Connectivity	14 days	June 22	July 05
22	13.2 Customized Notification Settings	14 days	June 29	July 12
23	Mobile Application Prototype Built	0 days	July 14	July 14
24	**14. Prototype Testing**	**18 days**	**July 15**	**August 01**
25	14.1 System Test Plan	7 days	July 15	July 21
26	14.2 Empirical Usability Testing	10 days	July 19	July 28
27	14.3 Optimization	14 days	July 19	August 01
28	Product Prototype	0 days	August 02	August 02



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ENSC 440 Planning

Crib Integration and User Interface	Embedding the electronics into the crib. Researching methods to easily connect pressure mat.
Optimizing the Position Detection Model	Capture a larger variety of body positions and weights. Consider material used.
Mobile Application and Database Architecture	Start early and delegate accordingly. The team has mobile application development experience.

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Tenshi Company

Team Roles & Reflection

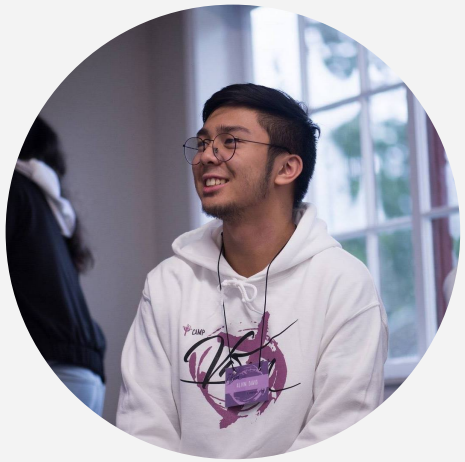
Team Members and Roles

Dexter Bigueta

Chief Design Officer

Izyl Canonicato

Chief Marketing Officer



Alvin David

Chief Exec. Officer
Chief Comm. Officer

Denyse Tran

Chief Financial Officer

Matthew Thomas

Chief Technical Officer

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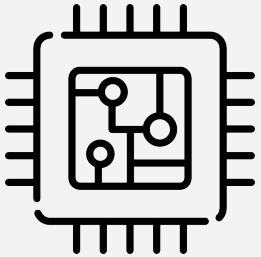
Flaticon [10]

ENSC 405W Key Takeaways



Applying ENSC Curriculum

Electric Circuits
Signal Processing
Embedded Systems
Business & Ethics

Documentation

Purpose
Audience - PANE+E
Technical Writing
Persuasive Writing

Group Work

Project Management
Risk Analysis
Expertise
Importance of Meetings

Challenges & Moving Forward

Challenges	Actions for ENSC 440
Clearly defining our product purpose and capabilities.	Continue to consider feedback from the Instructional Team.
Thinking ahead for implementing our solution.	Very early research and prototyping.
Identifying project bottlenecks.	Clearly describe progress and roadblocks for more effective meetings.
Collaborative writing.	Analyze requirements as a group and consider purpose and audience.

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Conclusion

- Our baby monitoring solution enables parents to mitigate the risk of SIDS and suffocation.
- The Tenshi Baby Crib system design adds no additional tasks to one's routine by utilizing an already essential crib, and a mobile device.
- In the market, we have an advantage with a non intrusive system.
- Development along the way has met challenges, but optimizations and a fully realized crib and application prototype are underway.

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Any Questions?

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