CPE 4800 - Senior Design Proposal, Spring 2024

Product Requirements Document

LocIT

Rev. Number: Revision D

Date: April 15, 2024

Electrical and Computer Engineering

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Revision History

Name	Date	Reason For Changes	Version
AZAD	03-31-2024	Initial Release	Rev. - Draft
AZAD	04-15-2024	Updated minor changes to the following: revision history, I. Introduction, and II. Product specifications Major changes to the following: Table of Contents, List of Figures, List of Tables, III. System Architecture, Bill of Materials, Product Requirements, and Bibliography	Rev. - A
AZAD	10-21-2024	Bluetooth functionality has been added to the feature set. Ultraviolet sensors have been removed from the design due to excessive procurement lead times.	Rev. - B
AZAD	10-23-2024	Updated product requirements to remove any instances of ultraviolet sensors and adding Bluetooth requirements.	Rev. - C
AZAD	11-16-2024	Adjusted product requirements to account for changes that were made to the prototype given the scope of the project.	Rev. - D

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I. Introduction

1. High-level product description

This project aims to address a pressing need for families with young children and elderly members who need the accessibility and ease of locating their loved ones in real time. The proposed solution is a wearable tracker designed specifically for these demographics.

The primary goal is to provide families with peace of mind by offering a lightweight, rechargeable tracker that operates independently of cellular devices. This ensures constant access to the location of loved ones.

2. Key product feature sets

This project plans to include the following features in order to accommodate most of the target issues for the demographic.

1) Precision tracking allows the device to accurately track the user's location in real-time.
2) Solar-Powered recharging utilizes solar power ensuring sustainability and reduces dependency on traditional charging methods.
3) Cellular device independence allows the tracker to function autonomously, eliminating the need for a connected cellphone.
4) Facial recognition enhances security and assurance by identifying individuals who encounter the user.
5) Distance Monitoring will track distances covered by the user, providing insights into their movements.
6) Geofencing allows users to set boundaries within which the wearer can move, with alerts triggered if these boundaries are breached.

3. Value proposition to the customers

For families with young children and elderly members, peace of mind is invaluable. Our wearable tracker offers a solution tailored to your needs, providing constant access to the location of your loved ones without the need for a cellphone. With precision tracking and solar-powered recharging, you can rest assured knowing their whereabouts are always within reach. Our device goes beyond mere location tracking, incorporating facial recognition for added security and distance monitoring to keep you informed about their activities. Plus, with customizable geofencing, you can establish safe boundaries and receive alerts if they wander too far. Experience the reassurance of knowing your loved ones are safe and secure, no matter where they may be, with our innovative tracker.

4. Target Market Analysis

1. **Target market size: annual shipment units and total sales revenue (worldwide or US market).** There were nearly half a billion smart wearable devices sold worldwide in 2023. This includes over 305 million smartwatch units alone. The total revenue in the previous year equated to 45 billion dollars according to Statista.com[1]. The wearable smart device market is expected to continue to grow as the post COVID pandemic

[1] Statista Website: Historical Trends 2023, https://www.statista.com/topics/1556/wearable-technology/#dossier-chapter2

pushed lots of people to be more health oriented. This includes all markets, especially the Asia-Pacific one where people utilizing smart devices are expected to rise from 76% to over 94% by the end of the decade.

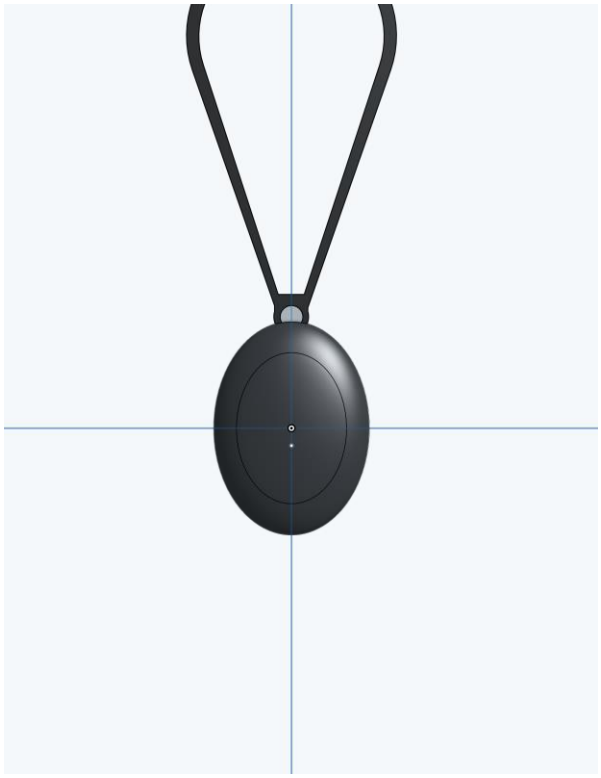
2. **Existing competition:** The smart wearable market is considered fragmented, by mordorintelligence.com[2], which is defined as a market that is highly competitive with many different competitors; however, there is no single entity taking the lion's share of the sales. The two main competitors are the Apple AirTag and the Tile tracker. The strength of Apple is its name. Everyone everywhere knows the name Apple at this point, and purchasing items from them is always safe with a guaranteed high-quality product. Their weakness though is they prefer to push items only compatible with their products. In fact, it took a major court case in Europe to get them to transition away from the Lightning cable and to the more common USB-C for their charging ports. Tile is mainly used to keep track of items like a wallet, car keys, etc., but could be repurposed to track individuals. The weakness though, much with Apple, is that they require the user to also possess a cell phone which is not the purpose of our product. We strive to provide a service that allows people to keep track of the location of their loved ones whether they are carrying a phone with them or not.

5. Visual representation of the product

Conceptually we have a variety of options to consider for the compact and design of the product. First is a necklace with a pendant with two cameras on either side, which would turn on depending on the side that receives light. The arm band is at a good height on the body to be worn and for the camera to still capture images, though it is not as compact or extremely discrete. It also has no guarantee of staying put in one direction as the user would move around so that would make implementing a set number of cameras harder. A pin or brooch would be a nice alternative if the user does not mind reattaching the device to new outfits every time. A fanny pack/sling design would be stable and not require two cameras for image capturing; however, it is not as discrete or as compact as we would like it to be.

Taking in account the factors and issues with all the options available, we have settled with a pendant design that would include a camera near the hinge. A combination of ultraviolet sensors and a gyroscope would be capable of determining orientation of the pendant and turn on the appropriate front-facing camera on either side.

[2] Mordor Intelligence, Wearable Trackers Market Share & Growth: https://www.mordorintelligence.com/industry-reports/wearable-technology-market



II. Product Specifications

Requirement ID	Description	Category	Priority

FNC-001	The wearer tracker shall give an accurate location of the wearer within 3 feet of the wearer's actual position.	Functional	Must Have
OPR-001	The wearable tracker shall update the location at a regular interval of every 30 seconds.	Operational	Must Have
OPR-002	The wearable tracker shall have a camera that is always capable of orienting towards the front and ensures image capturing in that direction.	Operational	Must Have
FAF-001	The tracker will be able to measure the total distance travelled by the wearer over a given period of a day.	Fit and Form	Must Have
FNC-002	The camera on the wearable tracker shall have facial recognition capabilities with the ability to recognize familiar faces.	Functional	Must Have
FNC-003	The tracker will be integrated with voice assistance that can speak to the trackable wearer.	Functional	Nice to Have
FNC-004	Users shall be able to set up or disable geocentric virtual boundaries for the wearer.	Functional	Must Have
FNC-005	The application must send the host phone holder a notification if the wearable tracker leaves these boundaries.	Functional	Must Have
FNC-006	The application shall send a notification to the host phone if the	Functional	Must Have

	battery level of the wearable tracker is below 20% remaining.		
ENV-001	The wearable tracker shall be chargeable using direct plug-in charging capabilities.	Enviromental	Must Have
ENV-002	The wearable tracker shall prioritize Bluetooth connectivity over Wi-Fi when available, to optimize power efficiency and extend battery life.	Enviromental	Nice to Have
INT-001	The companion app shall be able to be navigated by a user needing less than an hour of training on the app.	Interface	Must Have
INT-002	The companion app shall utilize push buttons that allow the user to toggle between the various options (ie. Location, camera, geo-boundaries, notifications, settings)	Interface	Must Have
FNC-007	The tracker shall utilize encryption techniques to securely connect between itself and the user's companion application.	Functional	Must Have
NFC-001	The tracker shall operate reliably under uncertain conditions such as change of habit, weather, or location.	Non-Functional	Must Have
PER-001	The tracker must be able to handle simultaneous connections and data processes with a greater than 97% efficiency rate.	Performance	Must Have
NFC-002	The host phone shall have the ability to add up to three wearable trackers on the companion application.	Non-Functional	Must Have

PER-002	The companion app shall be able to connect and work seamlessly with both Android and Web devices.	Performance	Must Have
FAF-003	The tracker shall be durable and resistant to water, dust, and fall protection.	Fit-and-Form	Must Have
FAF-004	The wearable tracker shall feature a rectangular design with rounded corners to enhance safety and minimize the risk of injuries or accidents.	Fit-and-Form	Must Have
FAF-005	***The tracker shall weigh less than 15 grams[3] to allow it to be worn comfortably.***	Fit-and-Form	Must Have
FNC-008	The tracker will allow for two-way communication between the companion app and wearer.	Functional	Nice to Have
INT-003	The companion app will be accessible by supporting multiple different languages, including Spanish and French.	Interface	Nice to Have
INT-004	The companion app will allow for customization, including changing the color palette.	Interface	Nice to Have
OPR-003	The wearable tracker can monitor temperature to inform the wearer of dangerous outdoor conditions.	Operational	Nice to Have
OPR-004	The wearable tracker will have the ability to monitor temperature to	Operational	Nice to Have

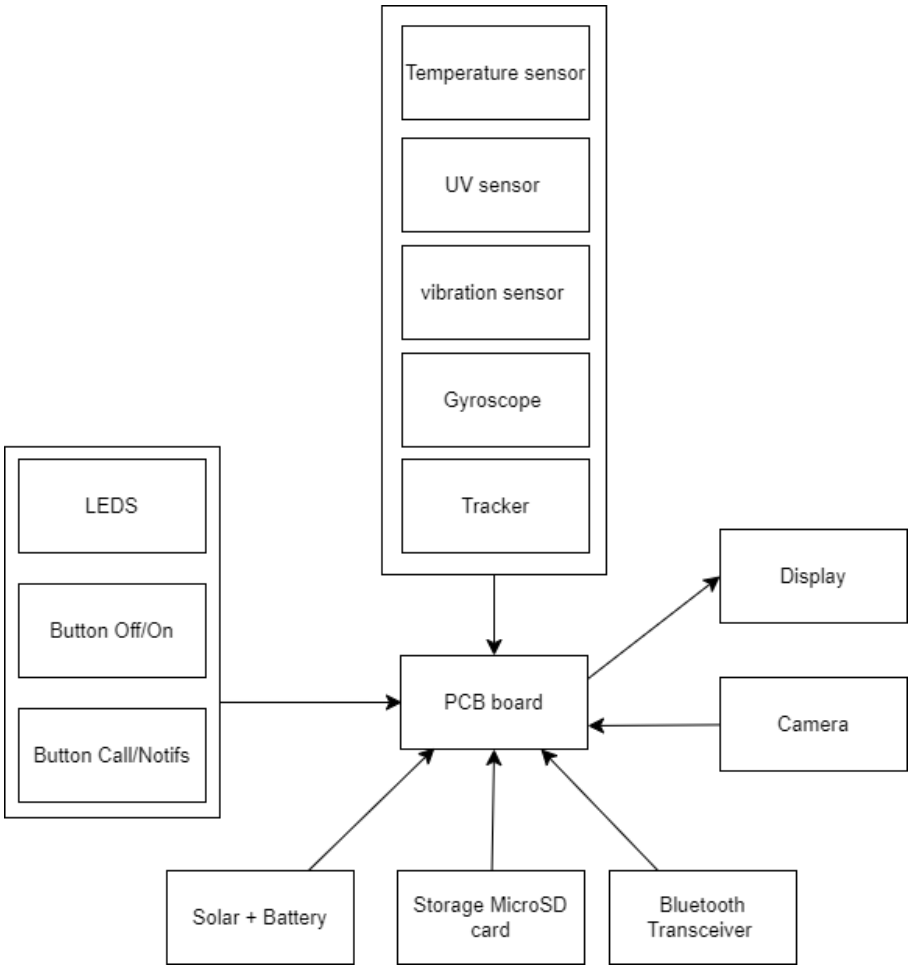
[3] Avg. Weight of Necklace: https://fetchthelove.com/blogs/necklace/how-much-does-a-necklace-weigh-in-oz

	place the system in critical mode in the event of overheating.		
FAF-006	The wearable tracker will have a vibration notification system if another individual tries to communicate with the wearer.	Fit to Form	Nice to Have
OPR-005	The wearable tracker will be able to go into low battery mode, which turns off all features except location and boundary tracking.	Operational	Nice to Have
FNC-009	***The wearable tracker will be able to store medical history information in a medical emergency.***	Functional	Nice to Have

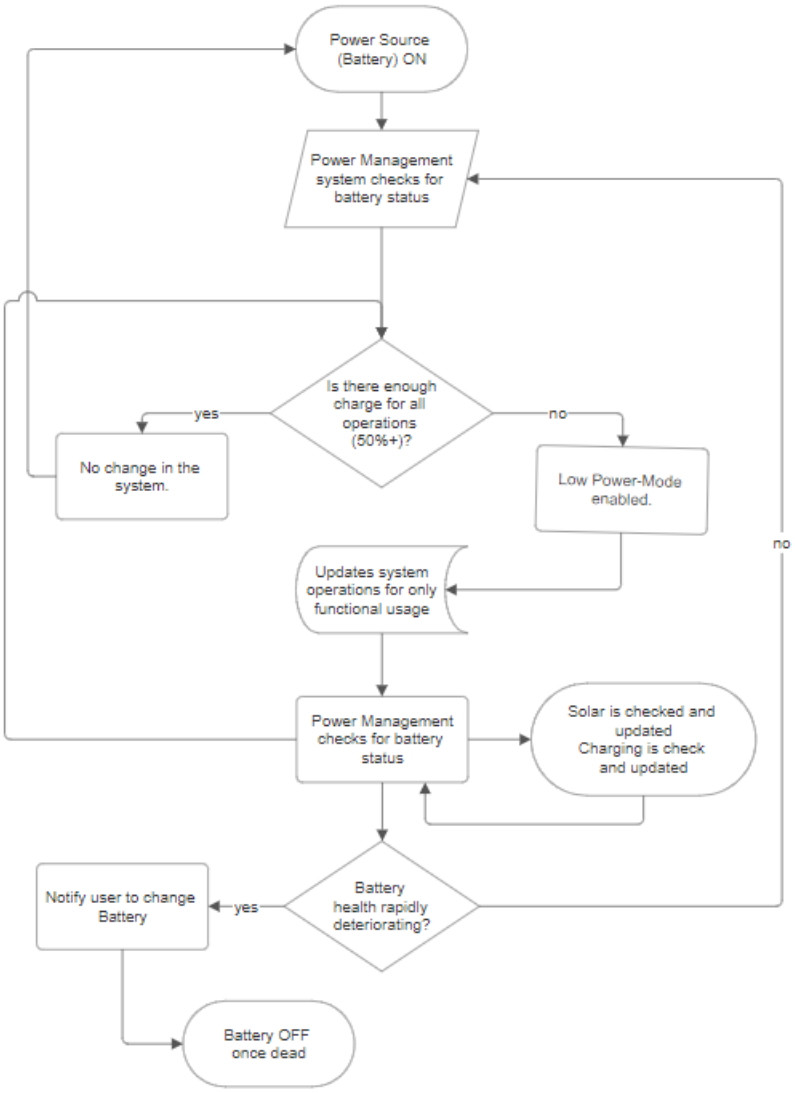
III. System Architecture

Diagrams of System's Functionality and External Interfaces:

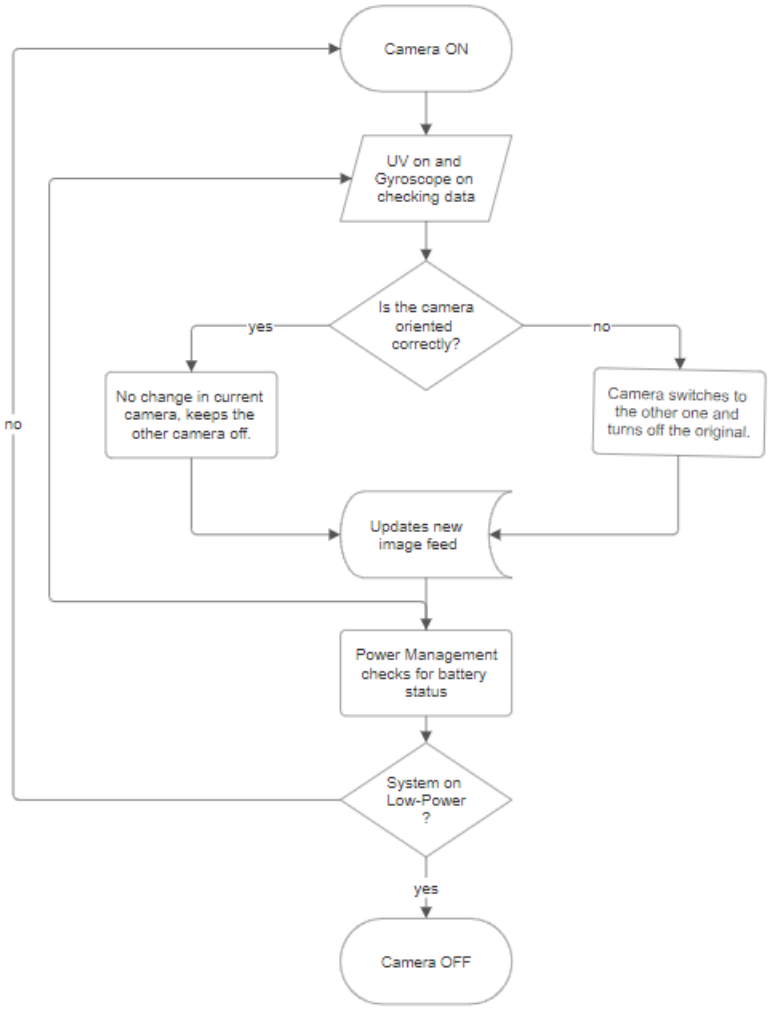
System Hardware Block Diagram:



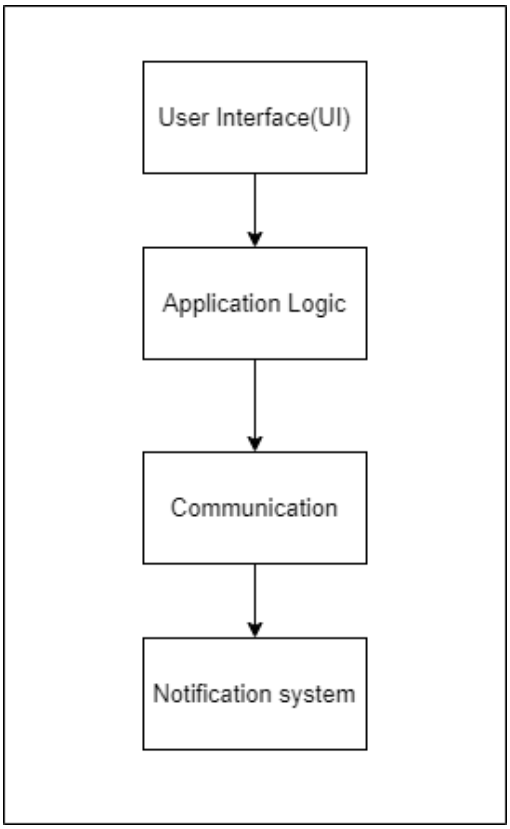
Power Management Subsystem: This subsystem includes the rechargeable battery, solar battery/panel, and software application to notify the user of the health of the battery system as well as defining the necessary function operations on low power mode.



Camera Subsystem: This subsystem would include the Cameras, UV sensor, Gyroscope, and Battery Management system. The application is also included in the process for updating images to the application.



Software Application Block Diagram:



Analysis of three use cases:

This includes narrative descriptions and Swim Lane diagrams to demonstrate interactions across different system components.

Use Case #1: Location Tracking and Safety Monitoring

Scenario: Being able to track the location of the person wearing the tracker utilizing another smart device. The wearer does not have to carry a phone themselves as the necklace should suffice.

Actor: Parent/Caregiver

Goal: Utilize the location tracking capabilities of the LocIT wearable tracker to monitor the whereabouts and ensure the safety of a loved one.

Preconditions:

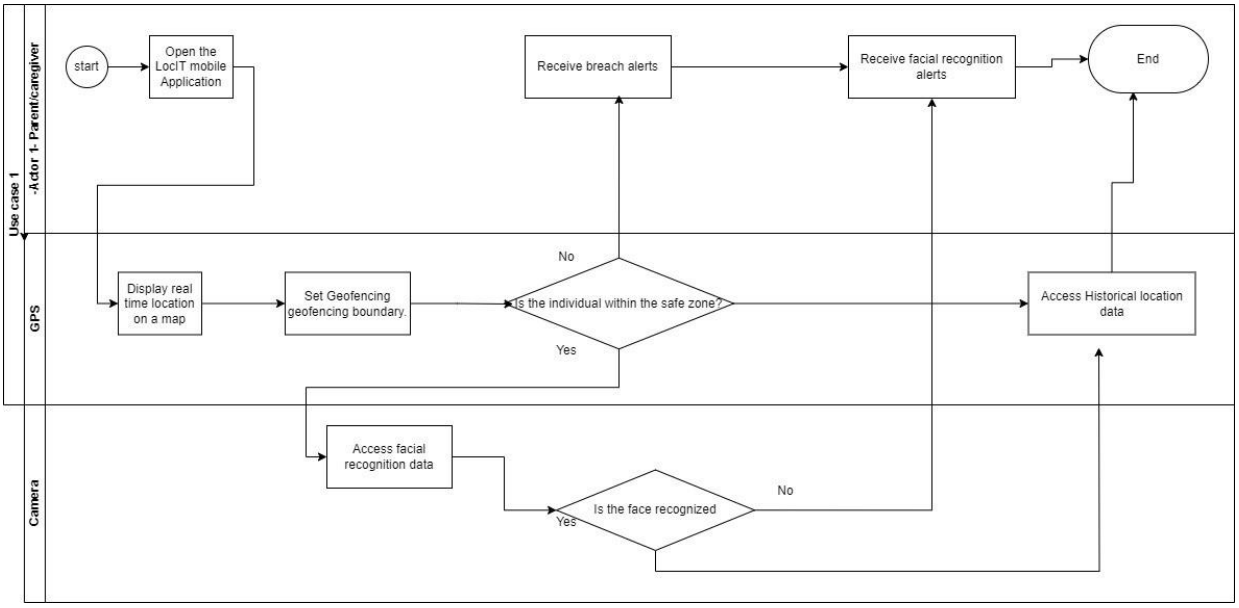
- The LocIT tracker is activated, charged, and securely worn by the individual.
- The parent/caregiver has the companion mobile application installed and configured.

Steps:

1. The parent/caregiver opens the LocIT mobile application.
2. The application displays the real-time location of the tracked individual on a map interface.
3. Geofencing boundaries are set to define safe zones or restricted areas for the individual's movement.
4. The parent/caregiver receives alerts if the individual breaches the predefined boundaries or moves beyond a specified distance.
5. Facial recognition alerts notify the parent/caregiver when unfamiliar individuals approach the tracked individual.
6. The parent/caregiver can remotely access historical location data to track the individual's movements over time.

Postconditions:

- The parent/caregiver feels reassured about the safety and well-being of the tracked individual.



Use Case #2: Facial Recognition Security
Scenario: A camera is attached to the wearable tracker. It must be attached in a way that the camera is always facing forward towards the people interaction with the wearer. This may be difficult with a necklace without a gyroscope. We are considering implementing either two cameras on either side of the pendant and having a gyroscope and/or UV detect the pendant's orientation.

Actor: User/Caregiver

Goal: Enhance security by utilizing the facial recognition camera feature of the LocIT wearable tracker.

Preconditions:

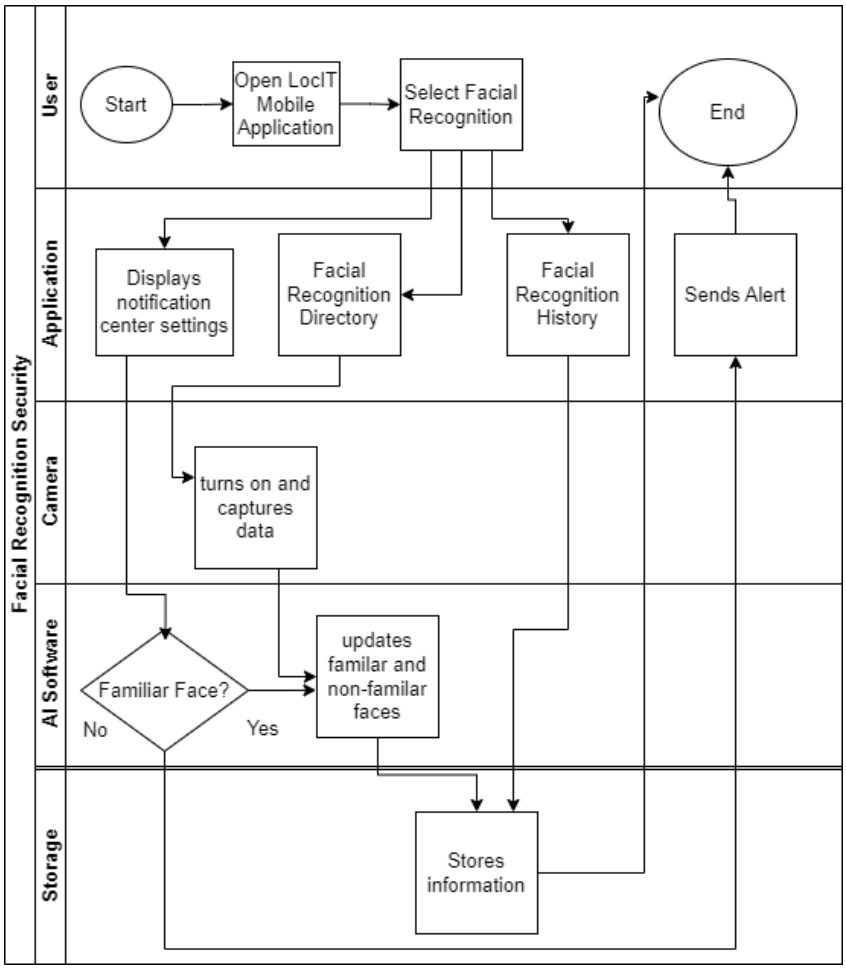
- The LocIT tracker is equipped with facial recognition capabilities and is properly configured.
- The user or caregiver has access to the companion mobile application.

Steps:

1. The user or caregiver accesses the LocIT mobile application.
2. The application provides an option to view facial recognition alerts.
3. The facial recognition camera captures the image of an individual approaching the user.
4. The captured image is analyzed by the facial recognition algorithm.
5. If the individual is recognized as authorized (e.g., a family member), no action is taken.
6. If the individual is unrecognized or flagged as unauthorized, the user or caregiver receives an immediate alert.
7. The alert includes details such as the time of the encounter and the image of the unrecognized individual.

Postconditions:

- The user or caregiver receives timely notifications of potential security threats, enabling proactive measures to ensure safety.



Use Case #3: Geofencing

Scenario: A user wants to ensure their loved one stays within a designated safe area while outside. They utilize the geofencing feature of the LocIT wearable tracker to monitor the wearer's movements and receive alerts if they stray beyond the predefined boundaries.

Actor: User/Caregiver

Goal: Utilize geofencing to monitor the child's location and receive alerts if they leave the designated safe area.

Preconditions:

- The LocIT tracker is equipped with geofencing capabilities and is properly configured.
- The parent/user has access to the companion mobile application.

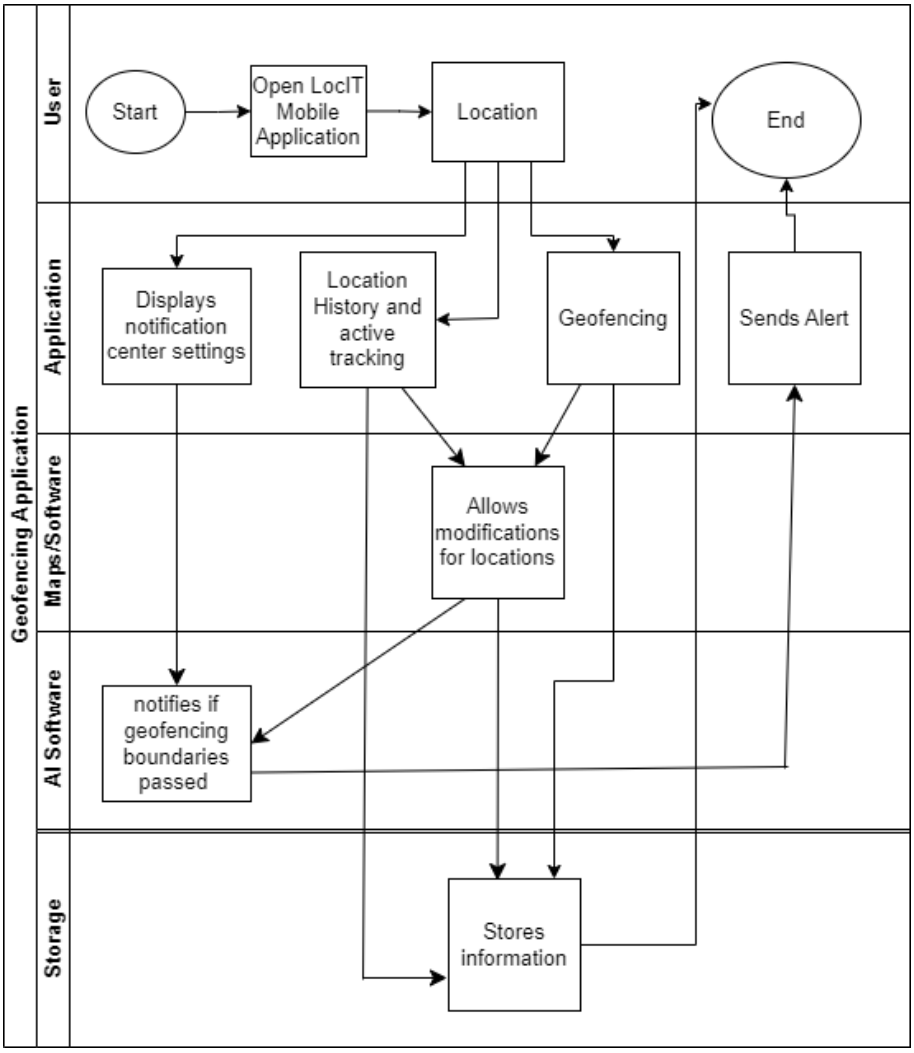
Steps:

1. The parent/user accesses the LocIT mobile application.
2. They navigate to the geofencing settings within the application.

3. The parent defines the safe area where the user can go by setting up a geofence on the map.
4. Once the geofence is set, the application confirms the boundaries have been established.
5. As the user wears the LocIT tracker and moves within the defined area, their movements are tracked by the GPS.
6. If the user moves towards the edge of the designated area, nearing the geofence boundary, the application detects this movement.
7. When the user breaches the geofence boundary, the application triggers an immediate alert to the parent/user.
8. The alert notifies the parent/user of the breach, providing details such as the time of the incident and the child's last known location within the safe area.

Postconditions:

- The parent/user receives real-time alerts when the child breaches the predefined geofence boundaries.
- The geofencing feature enables the parent/user to monitor the child's movements and take appropriate actions to ensure their safety.
- The parent/user feels reassured knowing they can remotely monitor the child's location and intervene if necessary, enhancing peace of mind.



Bill of Materials

A preliminary Bill of Materials (BOM) listing key components and estimated costs, providing an early insight into the project's scope and scale.

Component	Description	Quantity	Unit Cost (USD)	Total Cost (USD)
STM 32 Microcontroller	Central processing unit for device operations	1	15	15
GPS Module	Provides location tracking capabilities	1	65	65
Camera Module	For photographic functions and facial recognition	1	25	25

Speaker	Outputs audio for alerts and communications	1	4	4
Wireless Communication Module	Enables data transfer and remote communication	1	10.39	10.39
Vibration Motor	Provides haptic feedback	1	5	5
Environmental Sensors	Measures UV, temperature, etc.	2	6	12
Battery Management System	Manages battery charging and power distribution	1	8	8
PCB (Printed Circuit Board)	Supports and connects all electronic components	1	20	20
Rechargeable Battery	Powers the device	1	12	12
Total Estimated Cost				**176.39**

IV. Product Requirements

Subsystem #1: Physical Wearable Tracker

Description:

The physical wearable tracker subsystem comprises the tangible device worn by the user to track their location, monitor environmental conditions, and facilitate communication with the companion app. It incorporates various sensors, communication modules, user interface elements, and power management components to fulfill its functionalities. Additionally, the physical wearable tracker is designed to be durable, comfortable to wear, and resistant to environmental factors such as water and dust.

Key components:

- Location tracking module
- Camera module
- Facial recognition software
- Voice assistance integration
- Geofencing module
- Battery management system
- Two-way communication system
- Environmental sensors (UV, temperature)
- Vibration notification system
- Medical history storage module

Interfaces:

Internal Interfaces:

- Connection between GPS module and microcontroller for location data processing
- Integration of environmental sensors with data acquisition circuitry
- Communication between microphone, speaker, and wireless communication module for voice communication
- Interface between display screen/indicators and microcontroller for status feedback
- Connection between user input interfaces (buttons, touch-sensitive panels) and microcontroller for user interaction

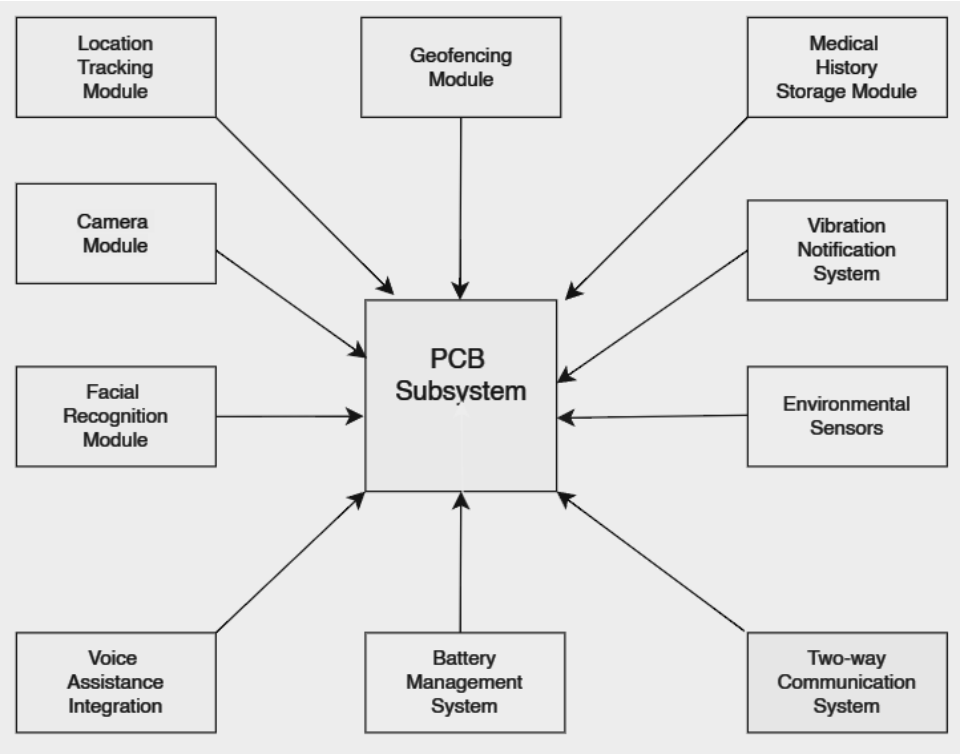
External Interfaces:

- Wireless communication with companion app for data exchange and remote control
- Charging port for power supply and battery recharging

Exceptions:

1. Exception for Requirement: The PCB board may not accommodate additional components if they exceed the physical dimensions or power constraints specified for the wearable tracker system.
2. Exception for Requirement: If specific environmental sensors are not available or feasible for integration, alternative methods for environmental data acquisition may be considered.
3. Exception for Requirement: In cases where voltage regulators cannot be implemented due to space constraints or power consumption limitations, alternative power management solutions may be explored to ensure stable operation of the system.

Subsystem Diagram:



Subsystem #2: PCB Board

Description:
The PCB, or Printed Circuit Board, subsystem serves as the hardware platform for integrating and connecting various electronic components of the wearable tracker system. It provides functionalities such as power distribution, signal processing, data storage, and communication between different modules within the system. Additionally, the PCB board ensures the efficient operation and interaction of the hardware components, enabling the wearable tracker to perform its designated functions reliably.

Key components:

- GPS module for location tracking
- Environmental sensors (e.g., temperature, UV exposure)
- Microphone and speaker for voice communication
- Display screen or indicators for status feedback
- Buttons or touch-sensitive interfaces for user input
- Wireless communication module (e.g., Bluetooth, Wi-Fi)
- Battery for power supply
- Enclosure or casing for protection and comfort
- Charging port for recharging the battery
- Circuitry for signal processing and data management

Interfaces:
Internal Interfaces:

- Connection with various electronic components (e.g., sensors, MCU, memory)
- Integration with power management circuitry for efficient power distribution
- Communication interfaces for data exchange between modules
- Interface with connectors for external peripherals

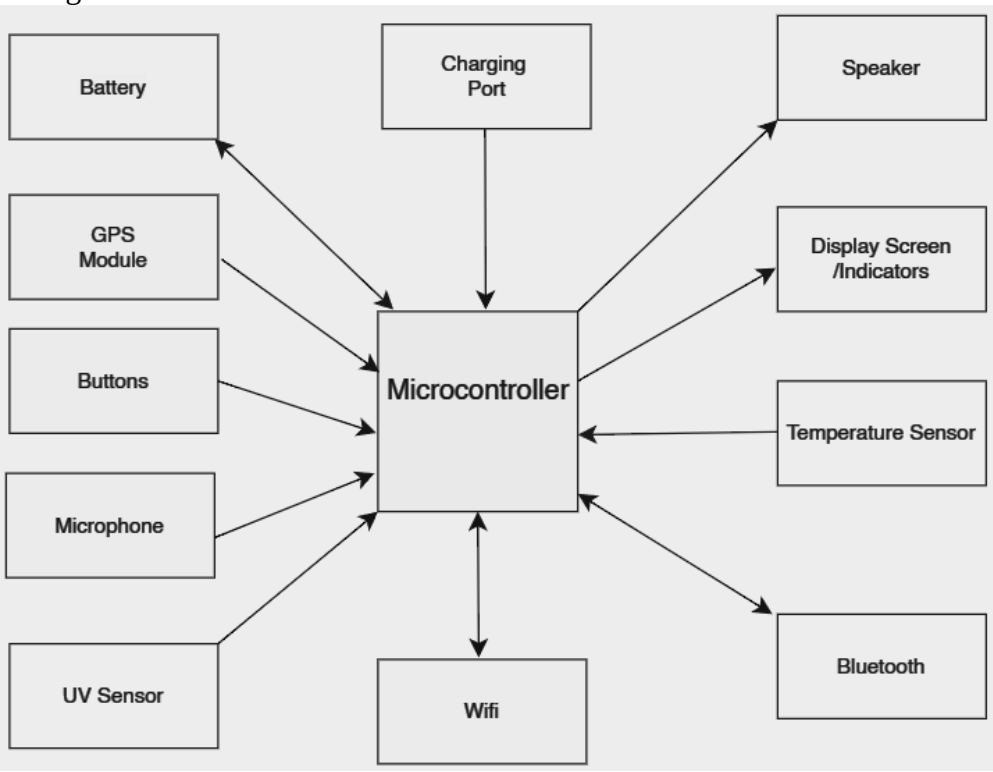
External Interfaces:

- Interaction with wearable components (e.g., sensors, LEDs)
- Connection with battery and charging port for power supply
- Interface with companion app and wearable tracker for data exchange

Exceptions:

1. Exception for Requirement: The PCB board may not accommodate additional components if they exceed the physical dimensions or power constraints specified for the wearable tracker system.
2. Exception for Requirement: If specific environmental sensors are not available or feasible for integration, alternative methods for environmental data acquisition may be considered.
3. Exception for Requirement: In cases where voltage regulators cannot be implemented due to space constraints or power consumption limitations, alternative power management solutions may be explored to ensure stable operation of the system.

Subsystem Diagram:



Subsystem #3: Mobile App/Software

Description:
The mobile, companion app subsystem serves as the user interface for interacting with the wearable tracker system. It provides functionalities such as setting up geofencing boundaries, receiving notifications, accessing location data, managing device settings, and facilitating two-way communication with the wearer. Additionally, it supports features like language customization, color palette customization, and integration with third-party devices.

Key components:

- User interface (UI)
- Geofencing setup module
- Notification system
- Location tracking display
- Settings management module
- Two-way communication interface
- Language customization feature
- Color palette customization feature
- Integration with third-party devices

Interfaces:
Internal Interfaces:

- Interaction with the wearable tracker subsystem for data exchange (e.g., location data, battery status)
- Integration with geofencing setup module for boundary configuration
- Communication with notification system for alert delivery
- Connection with two-way communication interface for wearer interaction
- Interaction with settings management module for configuration adjustments

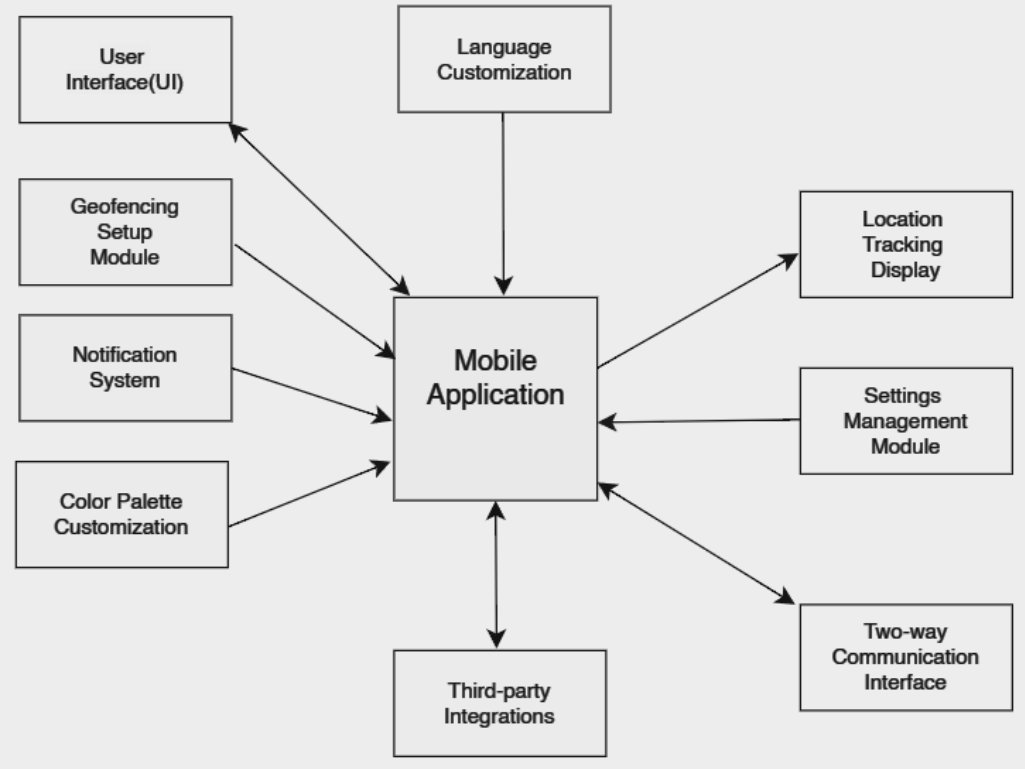
External Interfaces:

- Connectivity with wearable tracker system for data exchange
- Integration with third-party devices for interoperability

Exceptions:

- Exception for Requirement: If supporting multiple languages significantly impacts app performance or development complexity, prioritization of language support may be adjusted based on user demographics.
- Exception for Requirement: In cases where the storage of medical history information poses privacy or regulatory concerns, alternative methods for emergency data retrieval may be considered, ensuring compliance with applicable regulations.

Subsystem Diagram:



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