Senior Design Project: Cognitive Assistance with LiDAR Localization (C-ALL)

Project Preliminary Design

Ahmad Shah, Neeti Mistry, Sara Gaber & Sohan Chatterjee

Team Members and Roles

Neeti

Documentation Manager + User Advocate + Risk Management

Sara

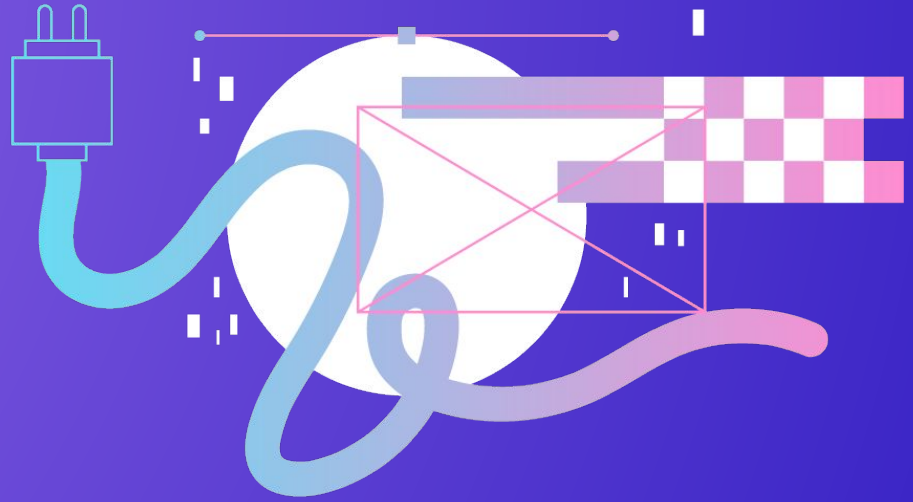
Use Cases + Front-End Lead

Ahmad

Development + Hardware Lead

Sohan

Test Lead + Buildmeister

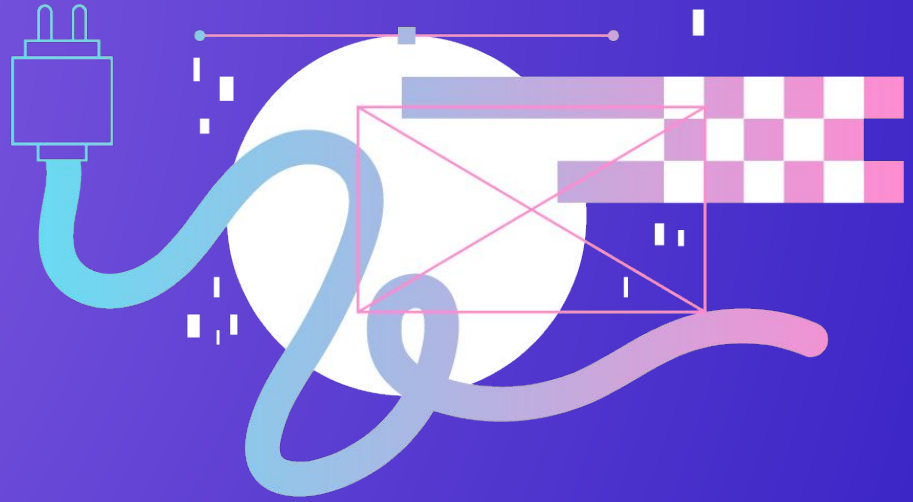


Introduction

Project Description and Development Plan Overview

Introduction

- Designed to **empower** visually impaired individuals with enhanced mobility and **independence**
- Utilizing **LiDAR** technology integrated into **iPhones**
- App feedback assists users in **avoiding obstacles, recognizing pathways, and navigating complex environments** with **minimal reliance** on human assistance
- Offering an affordable, user-friendly device
    - C-ALL **aims** to address accessibility and cost challenges
- **Scope** of preliminary design includes core functional aspects of user interface and the essential interaction flows required for basic navigation
- Covers **key use cases**, such as starting and stopping navigation, receiving real-time **obstacle alerts**, and managing **user settings**
- Initial **UI** elements include the h**ome, navigation, obstacle detection, settings, and support screens**, each tailored to provide clear and accessible feedback that aligns with user needs



User Persona

Fictional representation of an ideal or typical user based on research, intended to understand the needs, goals, behaviors, and challenges of target audience

Persona 1: Emily – Independent Commuter

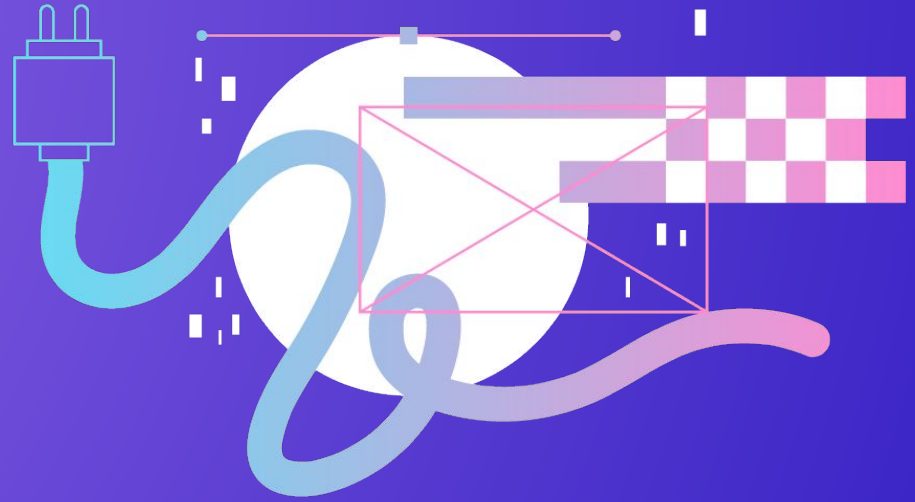
- **Age:** 33
- **Background:** Full-time employee, legally blind, moderate experience with assistive tech
- **Motivation:** Navigate urban spaces independently, especially for commuting to work
- **Challenges:** Difficulty interpreting crowded, unfamiliar environments
    - Limited access to affordable, real-time navigation tools
- **Goals:** Navigate independently in complex areas (e.g., transit stations, busy streets)
    - Get accurate, real-time feedback for obstacle avoidance
    - Receive clear, easy-to-follow directional cues
- **Tasks:**
    - Input destination in C-ALL app before commute
    - Use haptic feedback for guidance in crowded areas
    - Respond to alerts for obstacles or sudden changes
- **Scenario:** At a crowded bus station, Emily uses the C-ALL app to select her work location, receiving real-time feedback to navigate safely and avoid obstacles. The app continues to provide updates, helping her prepare to disembark at her stop.

Persona 2: Samir – Beginner with Assistive Tech

- **Age:** 55
- **Background:** Recently lost vision, new to assistive tech
- **Motivation:** Gain independence in his local neighborhood with a simple, affordable device
- **Challenges:** Complex tech interfaces
  - Cost of high-end assistive devices
- **Goals:** Safely navigate familiar areas with a simple setup
  - Avoid nearby obstacles with easy-to-understand guidance
  - Build confidence in independent mobility
- **Tasks:**
  - Launch C-ALL app and select a neighborhood route
  - Follow prompts from the glove, adjusting feedback settings for comfort
  - Gradually explore more routes as confidence grows
- **Scenario:** Samir uses C-ALL to walk to a nearby park, guided by the glove's motions to stay on course and avoid obstacles. Each walk builds his confidence, allowing him to be more independent.

Persona 3: Ava – Student

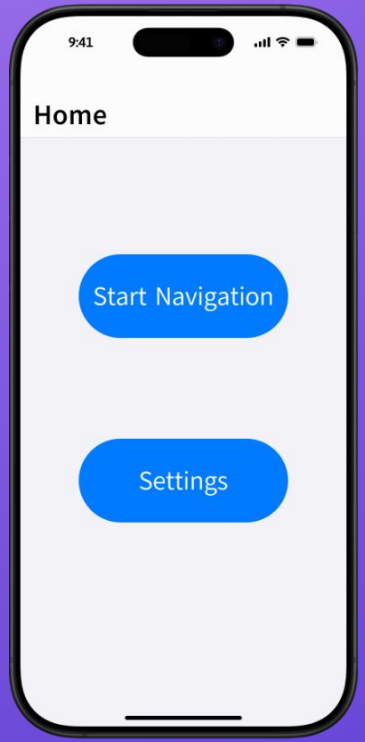
- **Age:** 20
- **Background:** College student with partial vision loss; frequent user of digital devices
- **Motivation:** Wants a navigation tool compatible with her smartphone for independent movement on campus
- **Challenges:** Needs a tech-integrated device that fits her digital lifestyle
- **Goals:**
  - Navigate campus with smartphone and glove-based haptic feedback
  - Receive accurate navigation cues while multitasking with other apps
- **Tasks:**
  - Activate C-ALL app with haptic glove for navigation
  - Follow glove's vibrations/taps for any turns and hazards
  - Adjust glove settings for different environments
- **Scenario:** Ava uses the C-ALL app and haptic glove to navigate to the library, guided by glove patterns for turns and obstacles. This allows her to navigate safely without checking her phone, moving confidently and independently across campus.

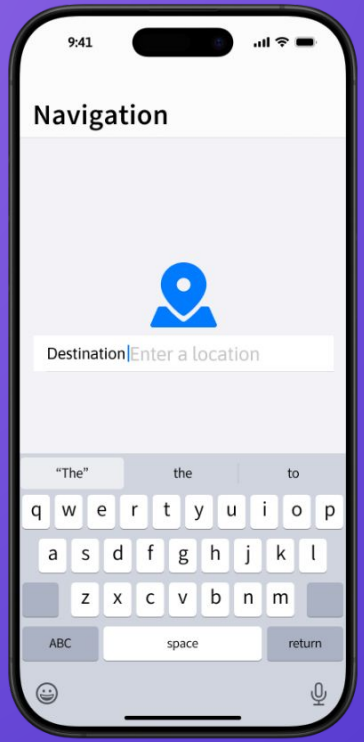


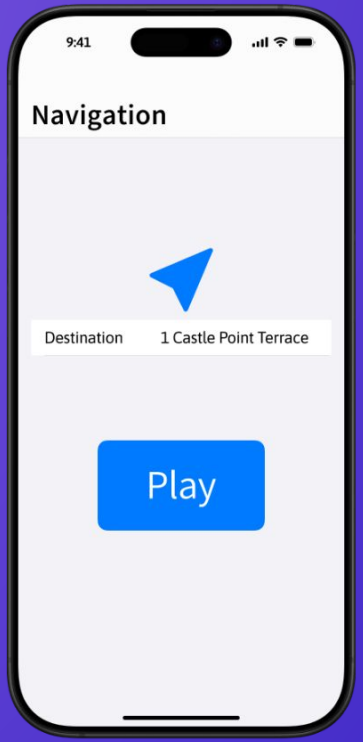
UI Prototyping

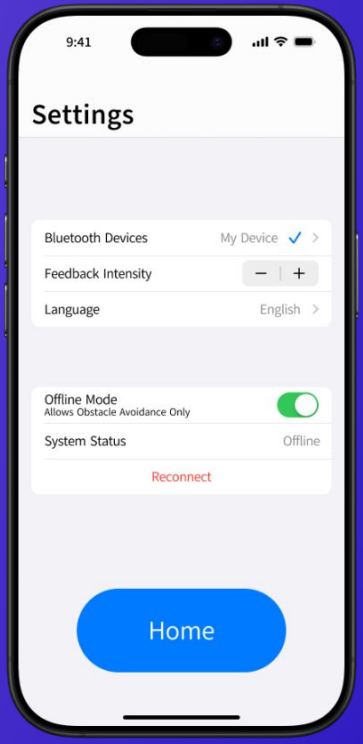
Preliminary mock-up of a user interface (UI) to visualize design, layout, and interactions of our application

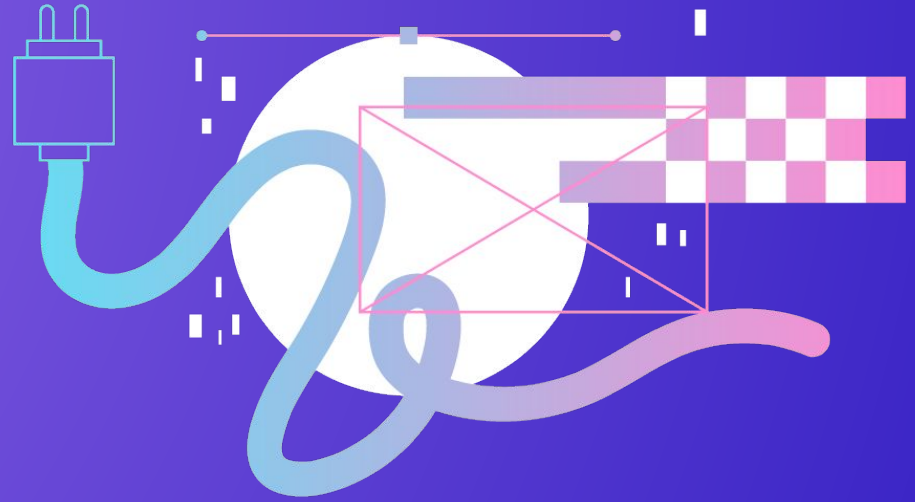
UI Prototyping











System Architecture
4 + 1 View

Architecture Design and Modeling

User Stories

User Story 1: Independent Navigation

- As a visually impaired user,
  I want to receive real-time direction cues,
  So that I can navigate to my destination independently and confidently.
- **Context:** Users rely on timely and precise directions to navigate safely, so accuracy and minimal latency are critical.
- **Acceptance Criteria:**
  - Directions are delivered through haptic feedback on the glove, based on user preferences.
  - Directions update in real time as the user progresses along the route.
  - The system recalculates and corrects the route if the user deviates or encounters obstacles.
  - Upon reaching the destination, the system confirms arrival with a distinct sound or vibration pattern.

User Stories

User Story 2: Obstacle Avoidance

- As a user navigating unfamiliar areas,
  I want the system to alert me of any obstacles in my path,
  So that I can avoid them without needing additional assistance.
- **Context:** Visually impaired users need reliable and early obstacle detection to make safe adjustments to their path.
- **Acceptance Criteria:**
  - The system detects obstacles within a predetermined range and alerts the user with sufficient time to respond.
  - Alerts are distinct and consistent, either through specific notifications on the mobile app or movements on the glove that distinguish them from other cues.
  - Users are provided with guidance on how to avoid the obstacle (e.g., motions on left glove indicates to move left).
  - If the obstacle is temporary (e.g., a moving person), the system recalculates the route as needed.

User Stories

User Story 3: System Reliability and Fail-Safe

- As a user dependent on navigation assistance,
  I want to be informed immediately if the system encounters an error or failure,
  So that I can take the appropriate actions to ensure my safety.
- **Context:** Trust in the device's reliability is critical for users, especially in unexpected situations where system failures could pose risks.
- **Acceptance Criteria:**
  - The system performs self-checks periodically to detect any hardware or software failures.
  - If a failure occurs, the user is notified through a distinct alert.
  - In case of a connectivity loss, the system provides stored information or directs the user to a safe location.
  - The system logs errors for later diagnostics to help identify and fix recurring issues.

User Stories

User Story 4: Easy Setup and Personalization

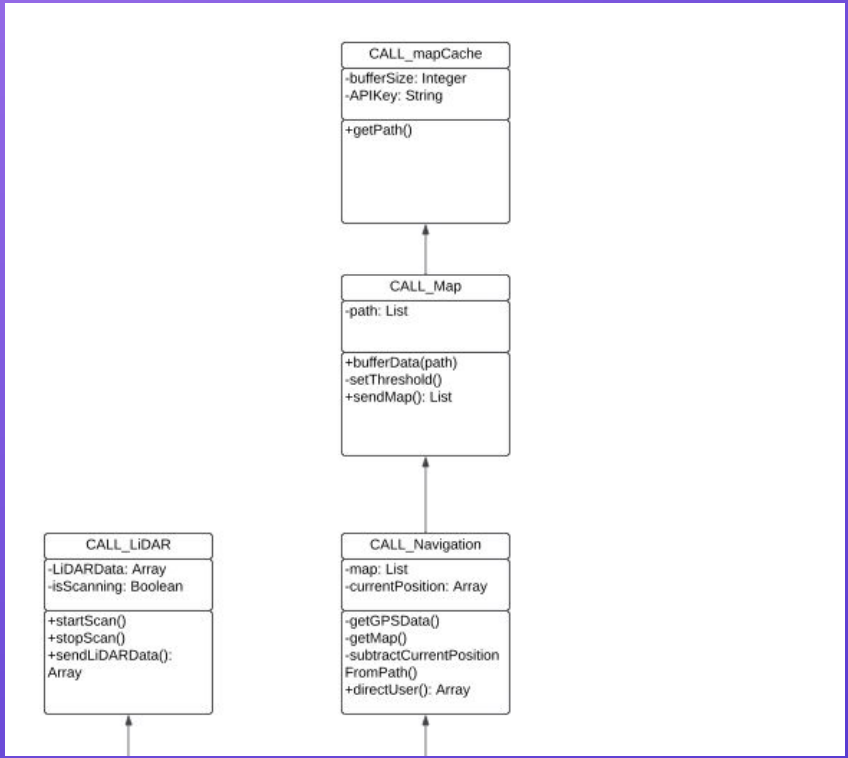
- As a first-time user,
  I want a straightforward setup and calibration process,
  So that I can quickly configure the system to meet my preferences and begin using it effectively.
- **Context:** First-time users need a simple, guided setup that minimizes frustration and ensures proper calibration for effective use.
- **Acceptance Criteria:**
  - The setup process includes an initial walk-through tutorial.
  - The app offers a personalization menu for adjusting alert frequency, notification types, and navigation preferences.
  - Settings are saved across sessions so users don't need to re-configure each time.

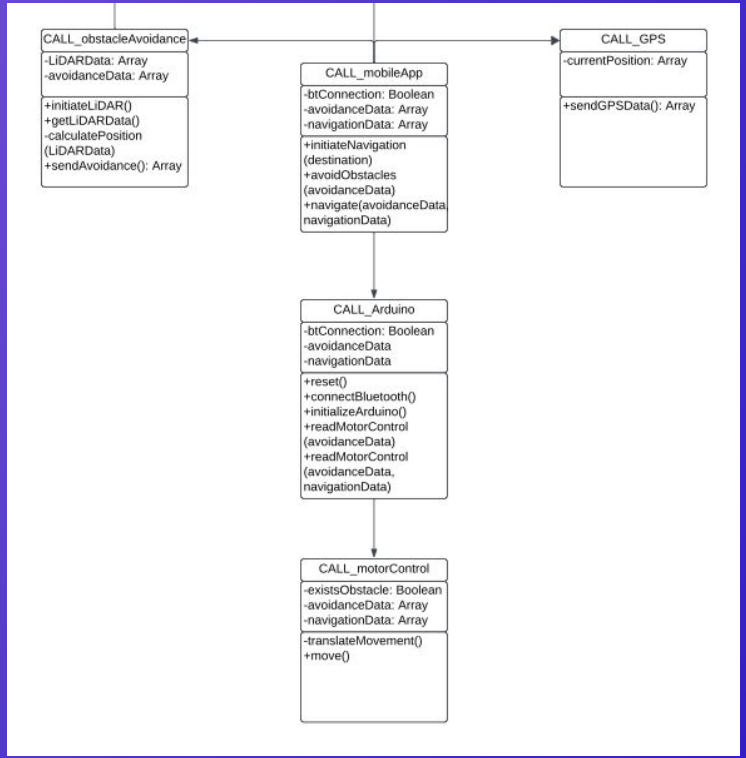
User Stories

User Story 5: Continuous Feedback on Route Progress

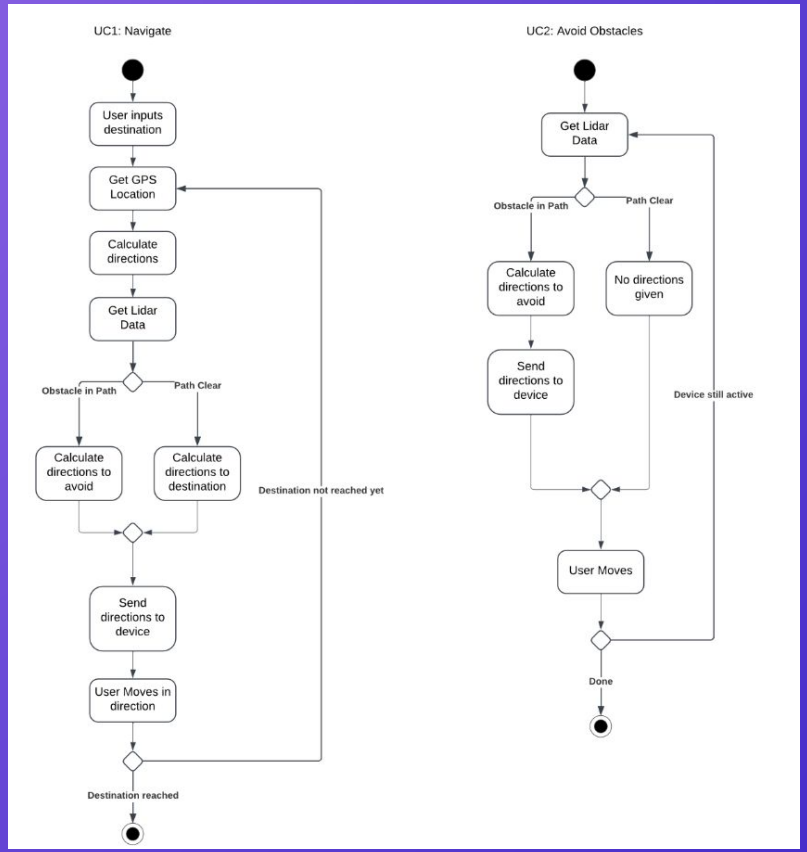
- As a user moving towards a set destination,
  I want periodic feedback on my progress and any deviations from the route,
  So that I feel reassured that I am on the correct path.
- **Context:** For visually impaired users, regular feedback is essential to stay informed of their progress and prevent unnecessary detours.
- **Acceptance Criteria:**
  - If the user deviates from the route, the system promptly provides correctional feedback.
  - Feedback is continuous but unobtrusive, providing enough information without overwhelming the user.

Logical View: Class Diagram





Process View: Activity Diagrams



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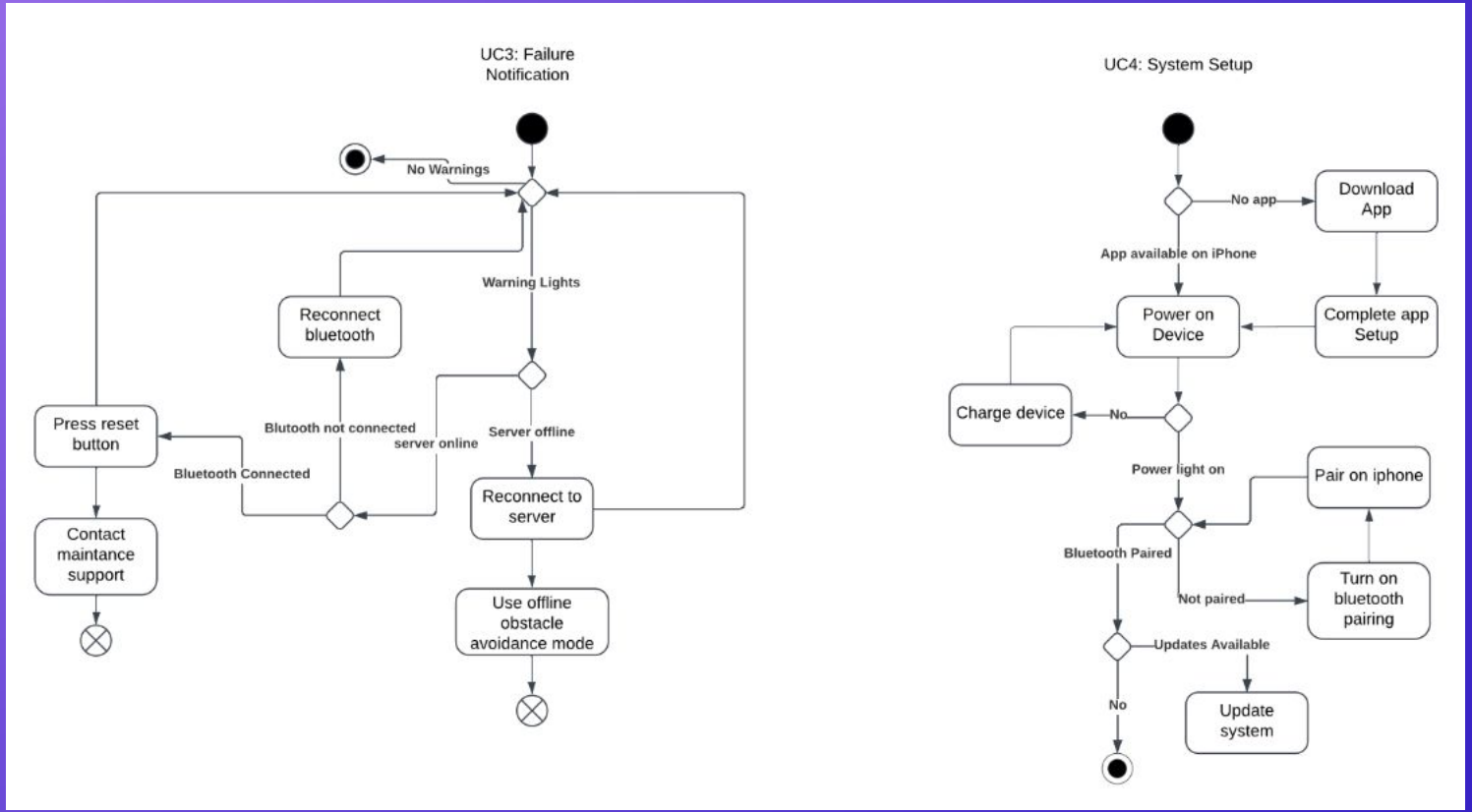
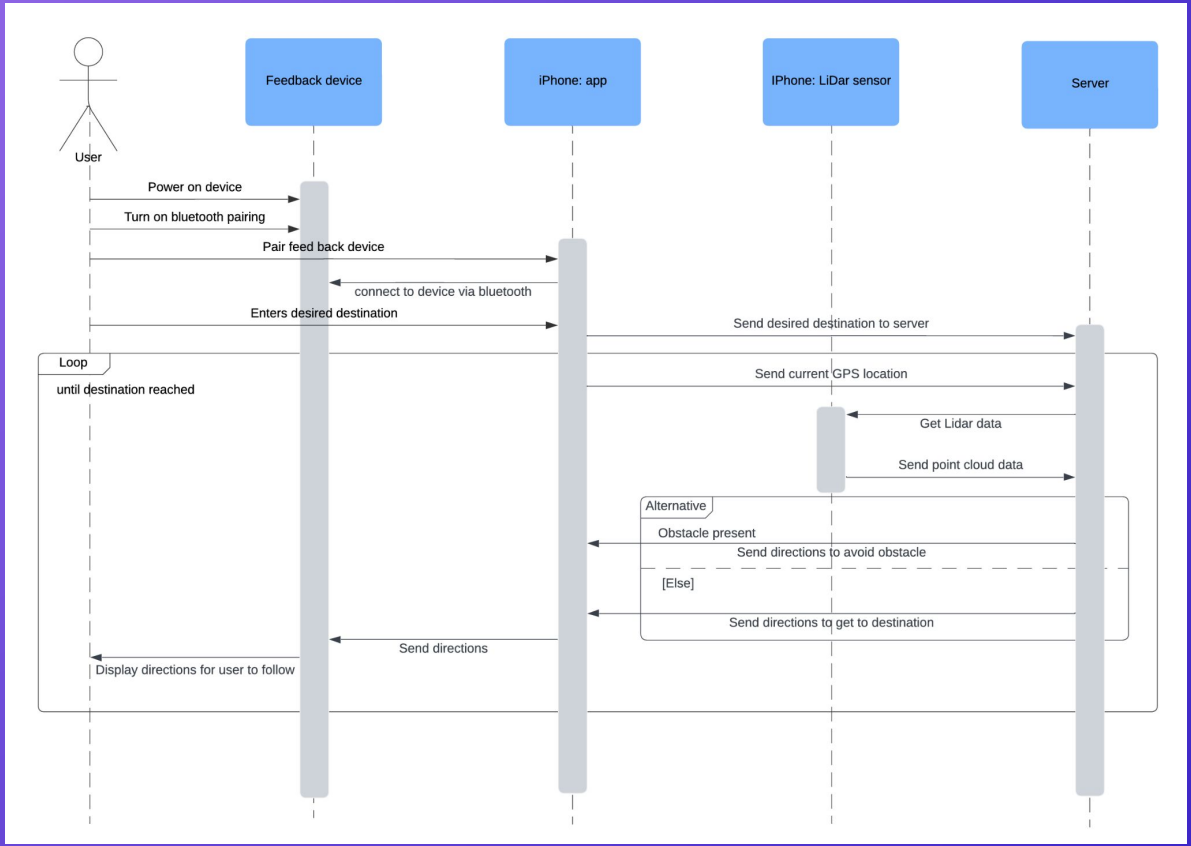
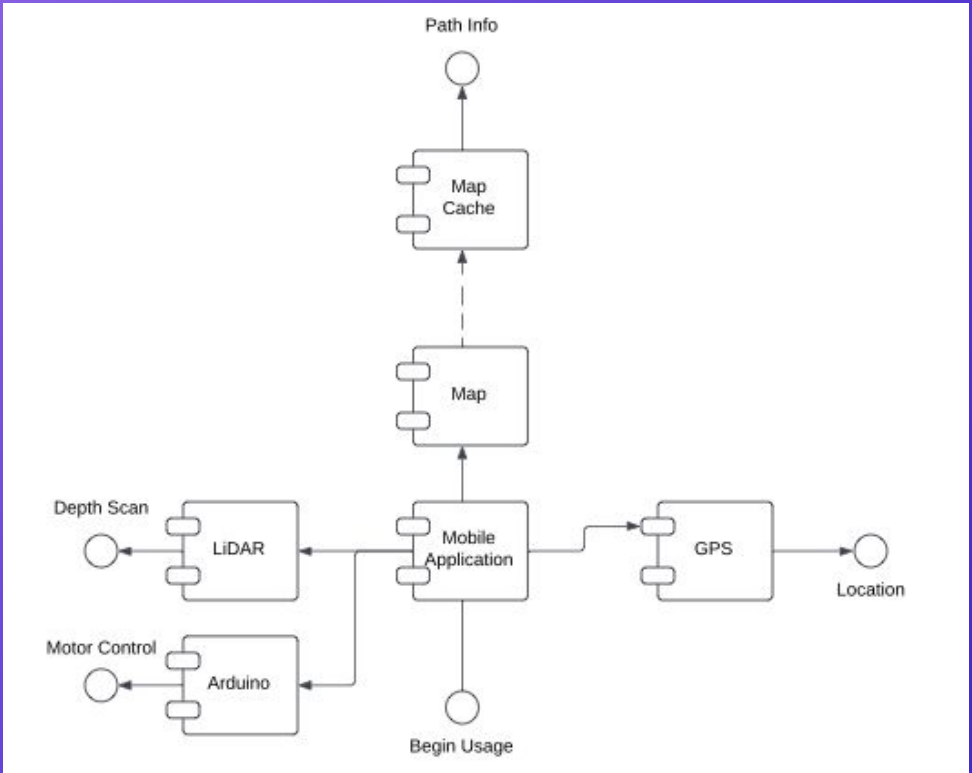


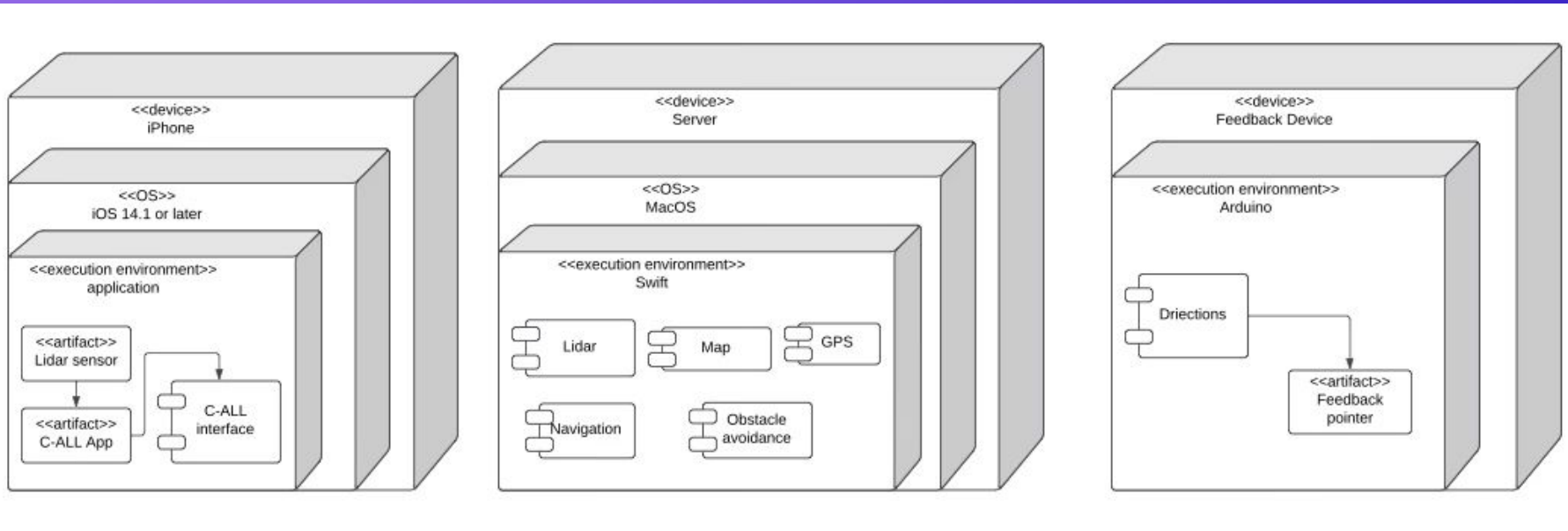
Process View: Sequence Diagram



Development View: Component Diagram



Physical View: Deployment Diagram



Thank you!

Any Questions?