The Chandra Project

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Purpose and Goal Statements

- Purpose: to assist visually impaired individuals with robotics and multimodal AI.
- Goal Statements:
  - Develop a modular attachment for robots to empower people by enabling voice-command navigation and real-time object detection with audible notifications.
  - Create a universally adaptable hardware and software module that minimizes reliance on specific robot sensors, ensuring compatibility with a wide range of robot platforms and accessibility to diverse users.
  - Deliver an open-source solution that prioritizes affordability and inclusivity, enabling widespread adoption and improving the quality of life for visually impaired individuals through innovative assistive technology.

Members and Advisors

- Members:
  - Cat Luong - Computer Science ‘25
  - Phan Anh Duong - Computer Science ‘26
- Advisor:
  - Justin Zhan - Department Head, Department of Computer Science
  - Arnav Komaragiri - Solution Architect, NVIDIA
  - Bryan Kowalczyk - Co-director of Applied Autonomy Lab

Abstract

This project aims to develop a modular attachment for robots to assist visually impaired individuals by enhancing their ability to navigate and interact with their surroundings. The attachment will integrate an audio module, a camera module, and an NVIDIA Jetson to enable the robot to process voice commands, detect objects in real-time, and provide audible notifications. Designed for universal compatibility, the module minimizes reliance on proprietary sensors, ensuring adaptability across various robot platforms. By prioritizing affordability, accessibility, and open-source development, the project seeks to create a practical, impactful solution that improves independence and quality of life for visually impaired users.

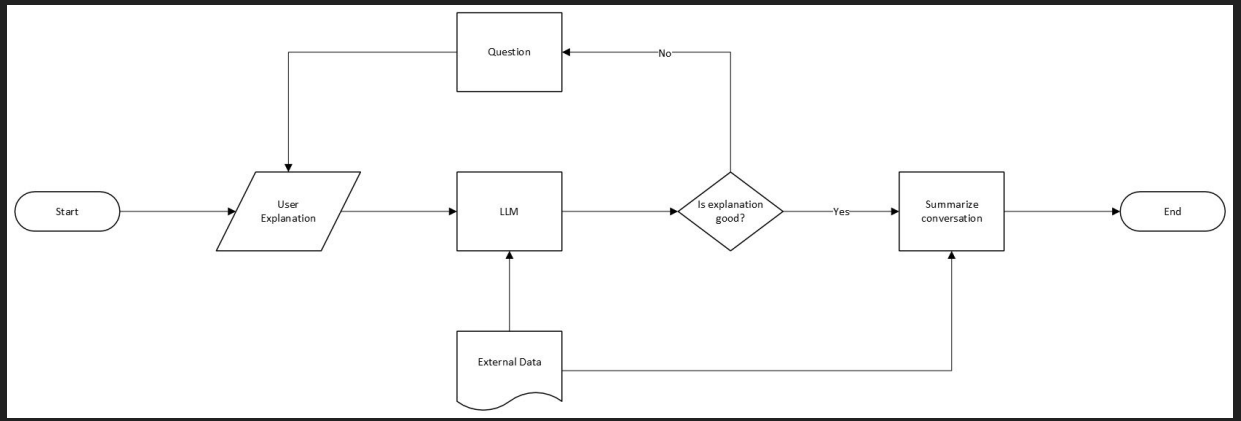
User Stories

- As a visually impaired individual, I want the robot to understand my voice commands, so that I can navigate my environment more easily and independently.
- As a mobility trainer for visually impaired individuals, I want to customize the robot's voice responses and notification settings, so that I can tailor its functionality to different users' needs.
- As a researcher in assistive technology, I want the robot to announce objects it detects in real time, so that I can evaluate its potential to enhance accessibility and situational awareness.
- As a robotics engineer, I want to test the modular attachment on different robot platforms, so that I can ensure compatibility and adaptability across various hardware setups.
- As a caregiver for a visually impaired person, I want the robot to detect and alert users to potential obstacles, so that I can trust it to provide an additional layer of safety.

Design Diagrams

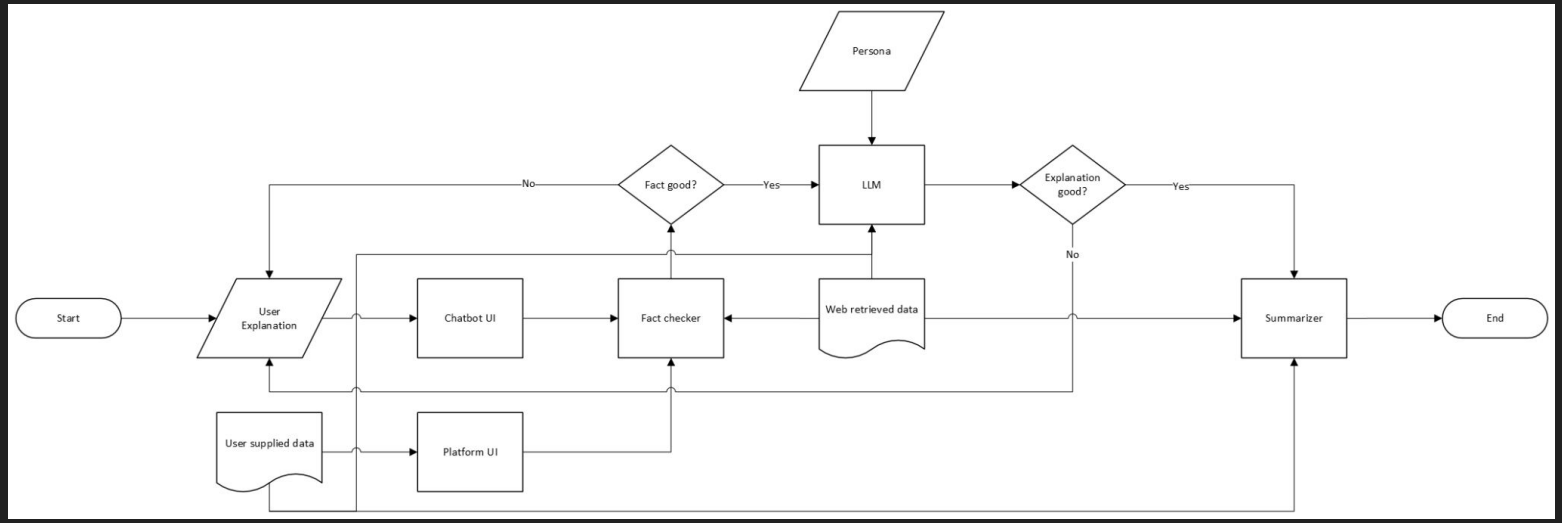
High-level Diagram:

Elaborated Diagram:



Design Diagrams

Detailed Diagram:



Project Constraints

- **Economic:**
  - Limited financial resources require reliance on open-source libraries and consumer-grade hardware.
  - Emphasis on affordability to ensure the solution is replicable and accessible.
- **Ethical:**
  - Ensuring user safety through accurate object detection and voice command interpretation.
  - Prioritizing privacy by processing data locally whenever possible.
- **Social:**
  - Aiming to enhance accessibility and independence for visually impaired users.
  - Open-source design to maximize societal impact and inclusivity.
- **Diversity and Cultural:**
  - Accounting for cultural and linguistic variations in voice command patterns.
  - Ensuring the system is unbiased, adaptable, and inclusive across diverse contexts.

Current Progress

- Acquired NVIDIA Jetson AI hardware for attachment development.
- In talks with the Applied Autonomy Lab for robot access.
- Conducting research on the robotic technology stack.
- Identifying compatible multimodal technologies for integration with the Jetson Dev Kit.
- Analyzing stakeholder needs to refine project goals.
- Defining metrics to evaluate project success.

Expected Accomplishments

- **Modular Attachment Development:** Designed and built a hardware module integrating NVIDIA Jetson, audio, and camera modules, ensuring intergratibility with ROS 2 compatible robots.
- **Voice Command System:** Developed a robust audio capturing and natural language processing system to interpret and execute voice commands for navigation and assistance.
- **Object Detection and Notification:** Implemented a real-time object detection system with audible notifications to assist visually impaired users.
- **Open-Source Solution:** Delivered a cost-effective, open-source design to enable widespread adoption and replication of the module.
- **User Testing and Refinement:** Conducted real-life field tests, gathered feedback from stakeholders, and refined the system for safety, reliability, and inclusivity.

Division of Work

Cat Luong	**Phan Anh Duong**
Hardware Development	Systems Setup and Integration
Computer Vision Development	Natural Language Processing & Voice
Software Documentation	Hardware & Integration Documentation
Planning & Feature Specification	
Testing & Validation	

Expected Demo

- The robot successfully responds to a set of predefined voice commands (e.g., "move forward," "stop," "identify objects") issued by a user, showcasing its natural language processing capabilities.
- The robot identifies objects in its environment using the camera module and announces their presence audibly to the user, demonstrating real-time object recognition and voice synthesis.
- People can interact with the demo by asking inputting arbitrary data, and the device will be able to answer in a satisfying manner.
- If the robot cannot be present due to logistical issue, the demo can be performed using only inputs with the NVIDIA Jetson and a display output.