VisionStick

Intelligent Guidance for the Visually Impaired

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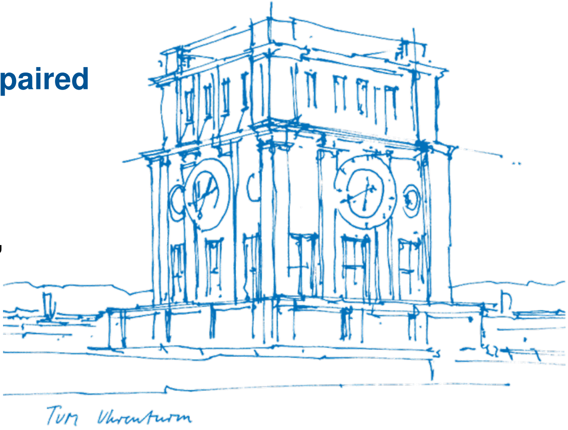
September 2th, 2025



Outline

Project Background
Motivation

- **Motivation**: Urban navigation in cities is challenging for visually impaired people due to dynamic obstacles.
- **Goal**: Build an **affordable**, **real-time** assistive add-on for a white cane that detects obstacles and guides the user via **haptic feedback**.

User Research & Insights

- **Method**: Interview and field trip with the local association (Blinden- und Sehbehindertenverband Württemberg e.V., Heilbronn).
- **Key insights**:
  - Audio cues are unreliable in noisy environments; **vibration is preferred**.
  - Upper-body obstacles are **hard to detect** with a traditional cane alone.
  - Hardware must be **lightweight**, **robust**, and mounted on the **upper part of the lower third** of the cane.
  - Suggestions from users: device should be **detachable**, provide vibration to wrists/shoulders, and detect objects approaching from **front and back**.

Blinden- und
Sehbehindertenverband
Württemberg e. V. (BSVW)

Outline

VisionStick's Vision

- **Core Idea**: Provide visually impaired people with a **smart extension** of the traditional white cane.
- **Mission**: Enable safer, faster, and more independent navigation in urban and natural environments.
- **Approach**:
  - Integrate **computer vision** (stereo cameras + object detection) with **ultrasonic sensors** for reliable obstacle awareness.
  - Translate this awareness into **intuitive haptic feedback** via vibration motors.
- **Impact**: Increase confidence, reduce reliance on companions, and promote accessibility and inclusion.

Outline

System Design

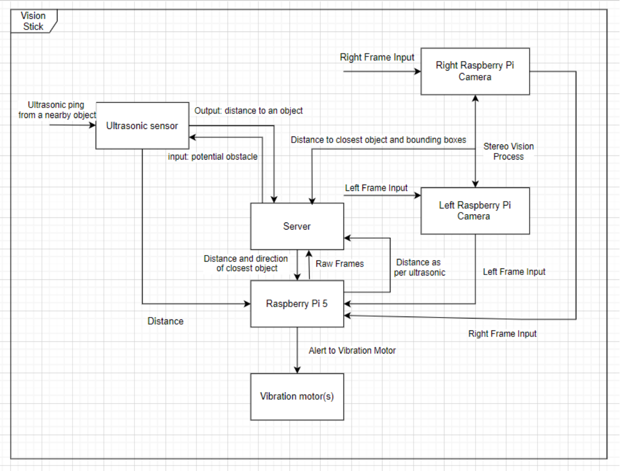
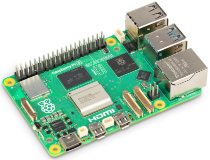
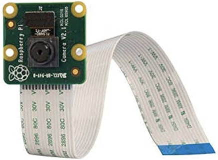


Figure 1 Overview of Vision Stick

Hardware Components

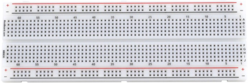


1x Raspberry Pi 5

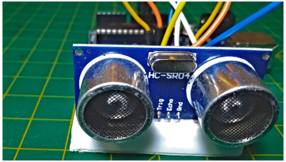


2x Pi Camera

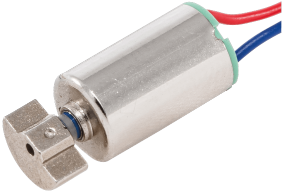
1x White Cane



1x Breadboard



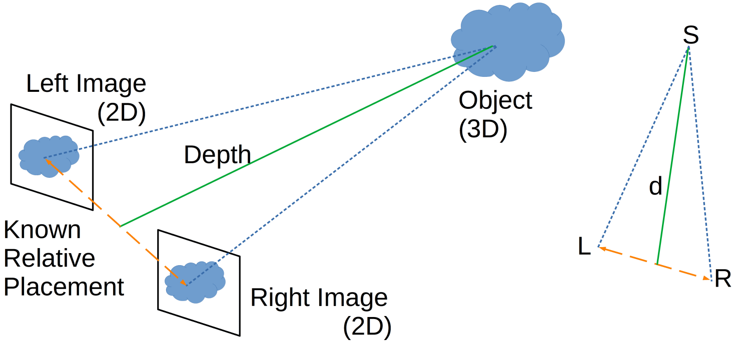
2x Ultrasonic Sensor (HC-SR04)



2x Vibration Motors

Outline

Computer Vision: Stereo Vision



[1]

[1] Source: https://www.baeldung.com/cs/stereo-vision-3d

Computer Vision

START: Single camera calibration of each camera

→ Stereo calibration of two cameras, where focal length and baseline are calculated

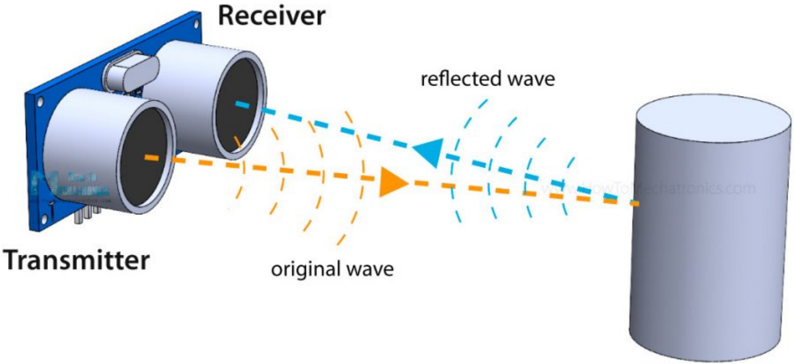
→ Create the disparity map

→ Apply the WLS filter on disparity map to reduce noise

→ Detect objects in a single frame using YOLO

→ END: Calculate distance of camera to object (depth)

Ultrasonic Sensor and Vibration Motors



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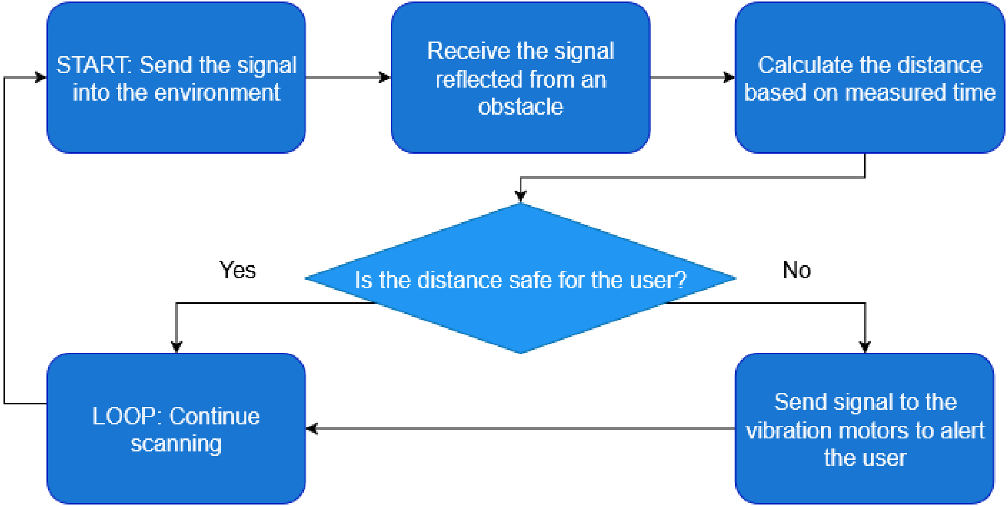
[2] Source: https://truyenhinhcapsongthu.net/

Alerting the User



Server

- Real-time processing - YOLO object detection + stereo vision for distance measurement
- HTTPS API - Accepts stereo/mono frames from Pi, returns bounding boxes and distances
- Live monitoring - Always-on-top preview window with performance metrics
- Thread-safe - Concurrent request handling with GPU acceleration support

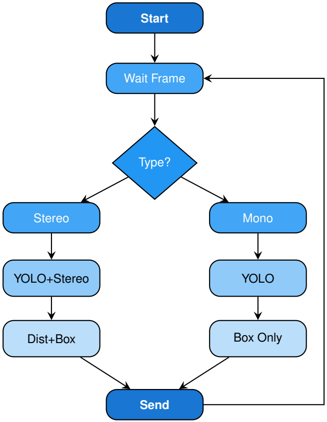


Figure 2 Server Overview

Outline

Challenges Faced

- No electrical engineering/robotics experience on the team, which made physical system design an arduous challenge.
- Limited access to hardware resources, which made time management in laboratories of utmost importance, and teamwork and coordination the key to success.
- Time constraints with procurement of all hardware parts, other coursework, exams, and team member commitments were also a formidable challenge in the completion of the vision stick.

Outline

Future Implementation

- Implementation of a central server that serves multiple different vision sticks and enables city-wide mobility for the vision stick holder.
- Implementation of an iOS/Android application to serve as a middleman between the Server and stick for efficient/logged communication, sending and receiving
- Implementation of a central database for event logging and persistent feedback from all stick modules.
- GPS/Google Map API connection with said application, enabling location tracking services and navigation services for patients using the VisionStick
- Better hardware management for a cleaner and safer design with no exposed wires and a casing for the Raspberry Pi, as well as the power source.
- Implementing a better power source.

Outline

Conclusions

Demonstrated real-time object detection, enhancing mobility and independence for the visually impaired.

Next steps

Future work will focus on optimising power efficiency and preparing for wider deployment.

Q & A

Thank you for your attention and we would be happy to answer any questions!

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