GLOBAL RESEARCH IMMERSION PROGRAM
FOR YOUNG SCIENTISTS

Creating Accessibility Navigation:

The Guide Dog Project

Yorick Behme: Tecnical University Dresden and Malek Arous: Ludwig-Maximilians-University Munich

The Project

Our project team aims to develop the optimal guide dog robot, an independent autonomous robot that assists visually impaired or blind individuals in both familiar and unfamiliar environments. To maximize the potential of the Lite 3 from DeepRobotics, four essential features are being developed, with our focus on the last two.

- **Controlling: Navigate the robot along a predefined path.**
- **Scanning and Mapping: Calculate a safe path through the environment.**
- **Tactile Display: Explore unknown environments.**
- **Settings App: Configure and customize the guide dog.**

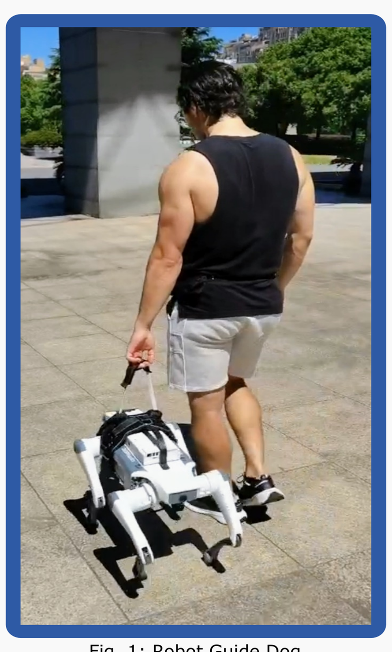

Fig. 1: Robot Guide Dog

OVERVIEW

Rationale

- **Global Impact:** 253 million people worldwide live with visual impairments or blindness.
- **Accessibility:** Meeting existing accessibility requirements (Fig. 3) is crucial.
- **Affordability:** Provide an affordable alternative to traditional guide dogs.
- **Independence:** Empower visually impaired individuals to perform daily activities independently (Fig. 2).

Requirement	Practice	Source
Text Alternatives	Text alternative for visual elements	[7]
Time-based Media	Subtitles for videos and transcription for audio	[7]
Customizable	Customizable display	[7], [4]
Distinguishable	Sufficient contrast between elements	[7]
Operable	All functions accessible via gesture control	[7]
Sufficient Time	No unavoidable time limits for interactions	[7]
Seizures and Physical Reactions	Avoid blinking and flashing elements	[7]
Navigable	Consistent and understandable navigation	[7], [4]
Cognitive Load	Simple and clear texts	[7], [4]
Consistency	No unexpected content changes	[7], [4]
Compatibility	Compatible with TalkBack	[7], [4]

Fig. 3: Requirements

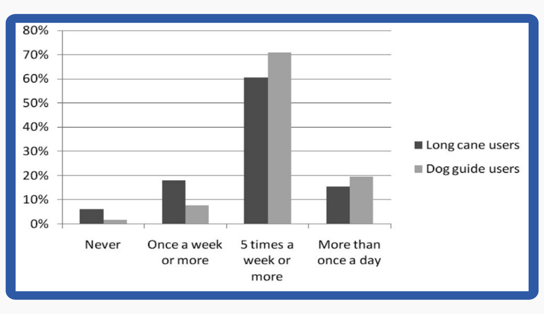

Fig. 2: Frequency of outdoor activities

Technologies

Settings App:

- Android platform using Java/XML
- Client-server architecture
- Accessibility via TalkBack
- Communication through UDP messages

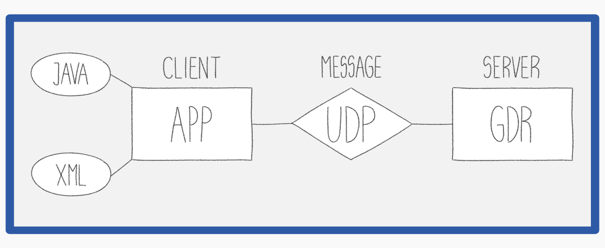

Fig. 4: Technological Overview

Tactile Display:

- electric push rod telescopic for tactile feedback (Fig. 5)
- Hbridge for controlling the pin's state(UP/DOWN) (Fig. 6)
- Arduino Script for controls pin movement (Fig. 7)
- Arduino Uno R4 Wi-Fi to receive map data from the robot dog

Fig. 5: Electric push rod telescopic

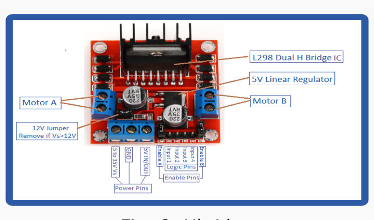

Fig. 6: Hbridge

Fig. 7: Arduino

Settings App

The task is to develop an Android smartphone app that allows visually impaired individuals to access and adjust the settings and functions of their guide dog robot. The app should be user-friendly, accessible, and innovative. Key steps include:

- **User-Centered Design:**
  - Developed personas to understand user needs and preferences (Fig. 11)
  - Identified key settings users want to configure (Fig. 10)
- **Prototyping:**
  - Began with paper mockups (Fig. 8)
  - Transitioned to final app development (Fig. 9)

Fig. 9: Final App Interface

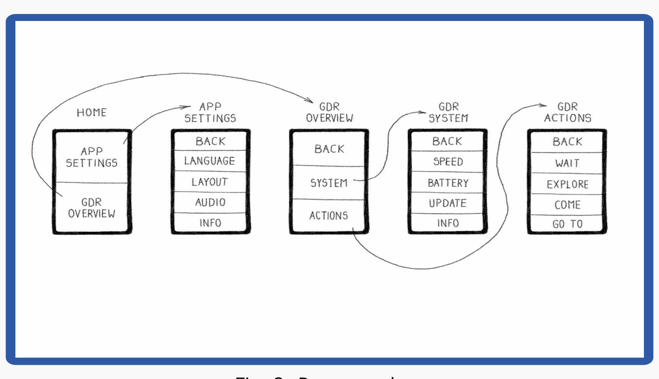

Fig. 8: Paper mockup

App-Settings	GDR-Settings	GDR-Actions
Language	Speed	Wait
Layout	Battery	Explore
Audio	Updates	Come
App-Infos	GDR-System-Infos	Go-to
Notifications	Safety Protocols	Recharge
User Profile	Path Recording	Return Home
Theme	Companion Settings	Public Transfer Settings
Support/Help	Obstacle Sensitivity	Play Sound

Fig. 10: Settings Overview

Fig. 11: Persona

Tactile Display

The task is to develop a tactile display made of pins that can convey information about the environment through their position (up or down). This aims to give blind or visually impaired individuals an impression of their surroundings to enhance the guide dog experience. The approach involved the following steps:

Step 1: Hardware Assembly:

- Connected each H bridge to 2-3 pins, ensuring proper wiring for cohesive operation.

Step 2: Arduino Script Development:

- Created a script to control the speed and direction of pins, enabling them to move up or down based on input.

Step 3: Robot Mapping:

- Robot used ray-casting and the OctoMap 3D library to scan the environment, creating a 3D occupancy grid.

Step 4: Communication:

- Robot dog transmitted map data via Wi-Fi to the Arduino Uno R4 Wi-Fi board.
- Arduino updated the pins based on obstacles, guiding users to avoid them by indicating the correct path (forward, left, right).

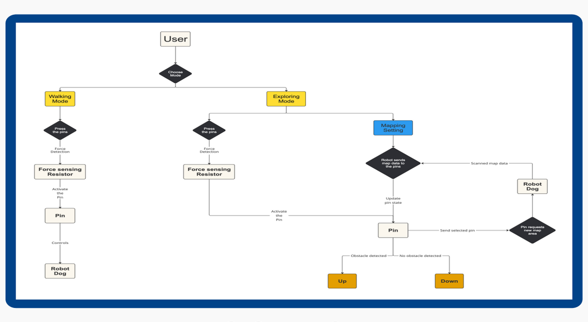

Fig. 12: Concept Overview

IMPLEMENTATION

[1]: Rodriguez-Sanchez, M. C., Moreno-Alvarez, M. A., Martín, E., Borromeo, S., & Hernandez-Tamames, J. A. (2014). Accessible smartphones for blind users: A case study for a wayfinding system. Expert Systems with Applications, 41(16), 7210-7222.

[2]: Milne, L. R., Bennett, C. L., Ladner, R. E., & Azenkot, S. (2014, October). BraillePlay: educational smartphone games for blind children. In Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility (pp. 137-144).

[3]: Jain, M., Diwakar, N., & Swaminathan, M. (2021, May). Smartphone usage by expert blind users. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (pp. 1-15).

[4]: Khan, A., Khusro, S., & Alam, I. (2018). BlindSense: An Accessibility-inclusive Universal User Interface for Blind People. Engineering, Technology & Applied Science Research, 8(2).

[5]: Khan, A., & Khusro, S. (2022). A mechanism for blind-friendly user interface adaptation of mobile apps: a case study for improving the user experience of the blind people, vol. 13, no. 5.

[6]: Chen, H. E., Lin, Y. Y., Chen, C. H., & Wang, I. F. (2015, April). BlindNavi: A navigation app for the visually impaired smartphone user. In Proceedings of the 33rd annual ACM conference extended abstracts on human factors in computing systems (pp. 19-24).

[7]: W3C (2024) WAI. http://www.w3.org/WAI/. Accessed 07/31 2024

[8]: L. Zeng and G. Weber, "Exploration of Location-Aware You-Are-Here Maps on a Pin-Matrix Display," in IEEE Transactions on Human-Machine Systems, vol. 46, no. 1, pp. 88-100, Feb. 2016, doi: 10.1109/THMS.2015.2477999.

[9]: Zeng, L., Einert, B., Pitkin, A., Weber, G. (2018). HapticRein: Design and Development of an Interactive Haptic Rein for a Guidance Robot. In: Miesenberger, K., Kouroupetroglou, G. (eds) Computers Helping People with Special Needs. ICCHP 2018. Lecture Notes in Computer Science(), vol 10897. Springer, Cham. https://doi.org/10.1007/978-3-319-94274-2_14

[10]: Zeng, Limin, Alexander Pitkin, and Björn Einert. "Haptic Human-Robot Interfaces on Guide Robots for Visually Impaired People." (2018).

Contact:

yorick.behme@tu-dresden.de
malek.arous@lmu.de

Conclusion

Our research presents innovative solutions for challenges in guide dog robot development. The tactile display aids visually impaired individuals in navigating indoor environments by integrating real-time spatial information through a dynamic pin system, offering significant improvements over traditional obstacle detection methods. The combination of haptic feedback mechanisms, including force sensors and vibrators, enables intuitive and efficient exploration, enhancing spatial awareness and addressing challenges such as navigating unfamiliar areas.

The settings app addresses a gap in guide dog robot technology by introducing an innovative interface operable with and without screen reader software. It will eventually provide a speech interface and explore AI usage. Additionally, it consolidates essential requirements, serving as a basis for future developments. This research paves the way for more accessible and user-friendly technological advancements.