Co-Design of an Adaptive User Interface for the Visually Impaired People

A. Ambles, D. Groux-Leclet, A. Potelle

University of Picardie Jules Verne, Amiens, France
audrey.ambles@u-picardie.fr

ACHI 2024, The Seventeenth International Conference on Advances in Computer-Human Interactions

May 26-30, 2024
Barcelona, Spain

About Me

- **Name:** Audrey Ambles
- **Designation:** Ph.D. student
- **Affiliation:** Laboratory MIS, University of Picardie Jules Verne, Amiens, France
- **Research Interests:**
  - Human-Computer Interaction
  - Human-Centered Design
  - Adaptive User Interface
  - Multisensory Experiences
  - Virtual Reality

Contents

1. Background and Research Aims
2. Co-Design Method
3. Our Proposed Interface
4. Evaluation
5. Results
6. Conclusion and Future Work

1. Background and Research Aims

- Heritage digitization is increasing, the visually impaired do not have access to it
- We plan to create a multisensory device that allows access to 3D models
- We started with the sense of sight because it is the dominant sense
- The visually impaired are a heterogeneous population due to the various visual conditions and pathologies

Figures – Various pathologies, from left to right: glaucoma, age-related macular degeneration, cataracts, diabetic retinopathy, retinitis pigmentosa from https://www.unadev.com/le-handicap-visuel/les-principales-pathologies/

- **Aim:** Utilize the residual vision of the visually impaired to improve 3D object recognition
- **How:** Develop an alternative device adapted for all the visually impaired, based on the use of an ordinary 2D screen

Background → Co-Design → Interface → Evaluation → Results → Conclusion

2. Co-Design Method

- Co-Design
  - User-Centered Design
  - Gather user inputs and convert them into design choices
  - Four phases
    - Analysis
      - Questionnaires, interviews, observation methods
    - Ideation
      - Brainstorming, brainwriting, focus group
    - Design
      - Mock-ups (paper, video, digital)
    - Evaluation
      - User-centered, heuristic, analytical evaluation
- Co-Design with Visually Impaired
  - Adapt interactions, workshops and tools

| Background | Co-Design | Interface | Evaluation | Results | Conclusion |

2. Co-Design Method

- Co-Design
  - User-Centered Design
  - Gather user inputs and convert them into design choices
  - Four phases
    - Analysis
      - Questionnaires, **interviews**, **observation methods**
    - Ideation
      - **Brainstorming**, brainwriting, focus group
    - Design
      - **Mock-ups** (paper, video, **digital**)
    - Evaluation
      - **User-centered**, **heuristic**, analytical evaluation
- Co-Design with Visually Impaired
  - Adapt interactions, workshops and tools
    - Meet in the morning for an hour and a half, in a small group
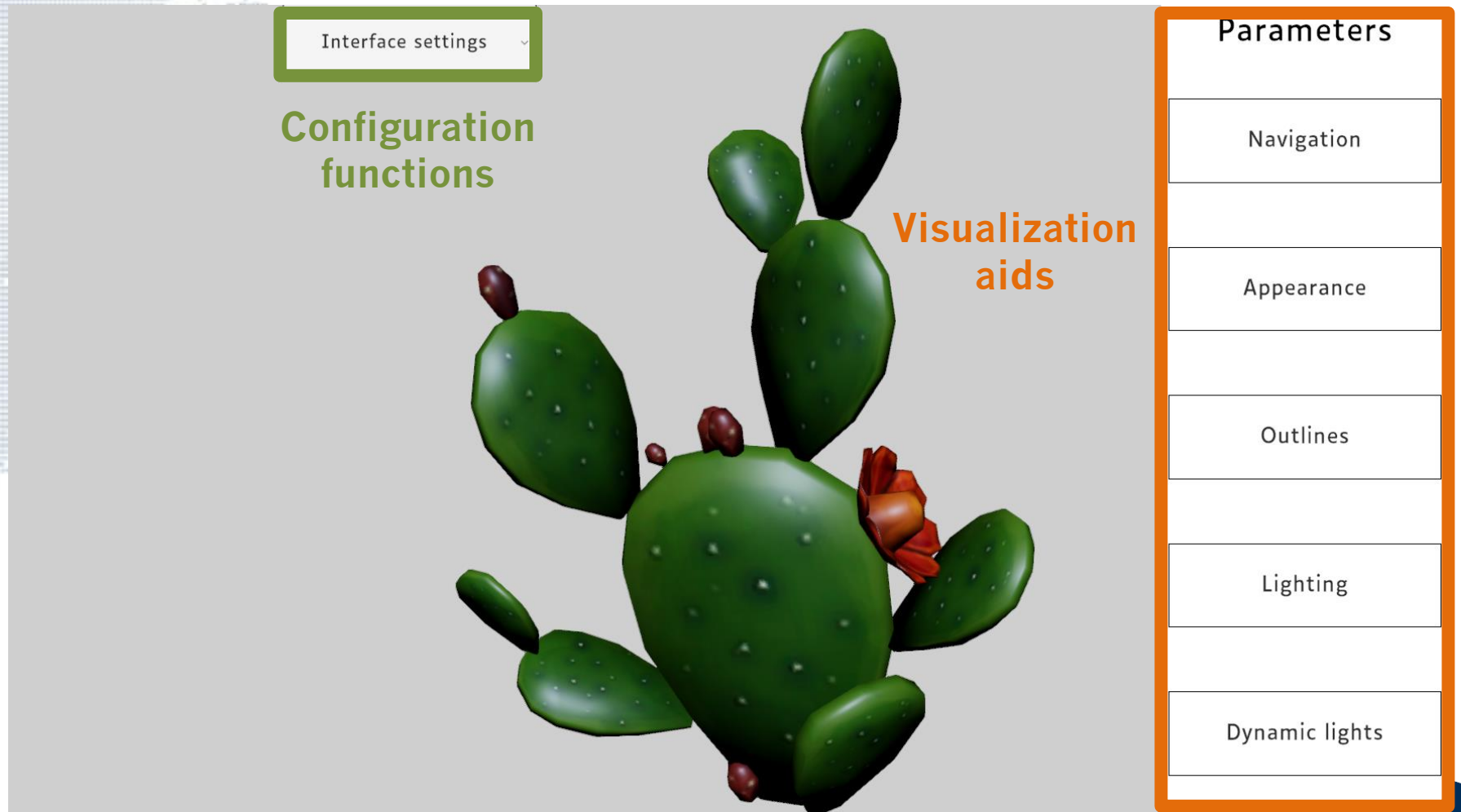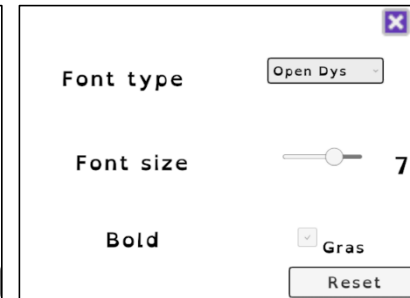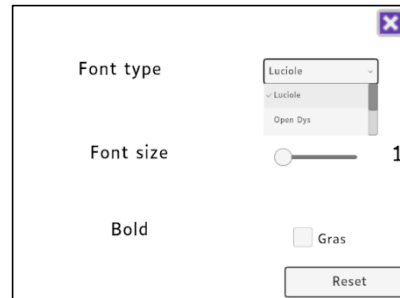   - Select tools that depend on hearing

Background → Co-Design → Interface → Evaluation → Results → Conclusion

3. Our Proposed Interface

Configuration functions

Interface settings

Visualization aids

Parameters

Navigation

Appearance

Outlines

Lighting

Dynamic lights

Figure – Our 2D visualization interface for 3D objects. The 3D object shown here is a cactus.

Background → Co-Design → Interface → Evaluation → Results → Conclusion

3. Our Proposed Interface

Configurations functions

- **Font** Menu
  - Type
  - Size
  - Bold

- **Menu** Menu
  - Theme
  - Borders
  - Position

- **Background** Menu
  - Background contrast

Figures – Examples of font configurations.
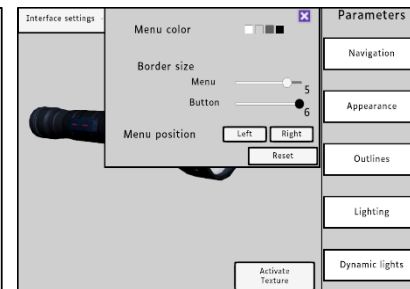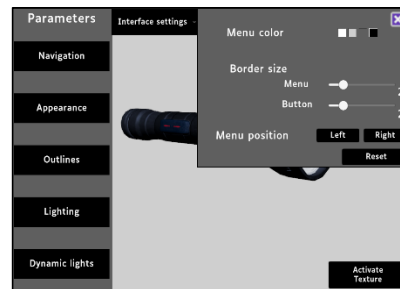
Figures – Examples of menu configurations.
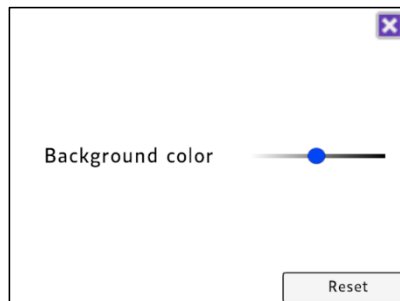
Figures – Left: the background menu. Right: A high-contrast background.

| Background | Co-Design | Interface | Evaluation | Results | Conclusion |

3. Our Proposed Interface

Visualization aids

- Zoom and object navigation
- Appearance adjustment
    - Sharpness
    - Contrast
    - Brightness
    - Saturation
- Texture substitution
    - Striped texture
- Outlines
    - Depth
    - Normal
    - Color
- Lighting effects
    - Static
    - Dynamic

Figure – When handled, a cylinder turns out to be a soda can.

Figure – A travel mug without and with appearance adjustment.

Figure – A plate with a striped texture accentuates the concave areas.

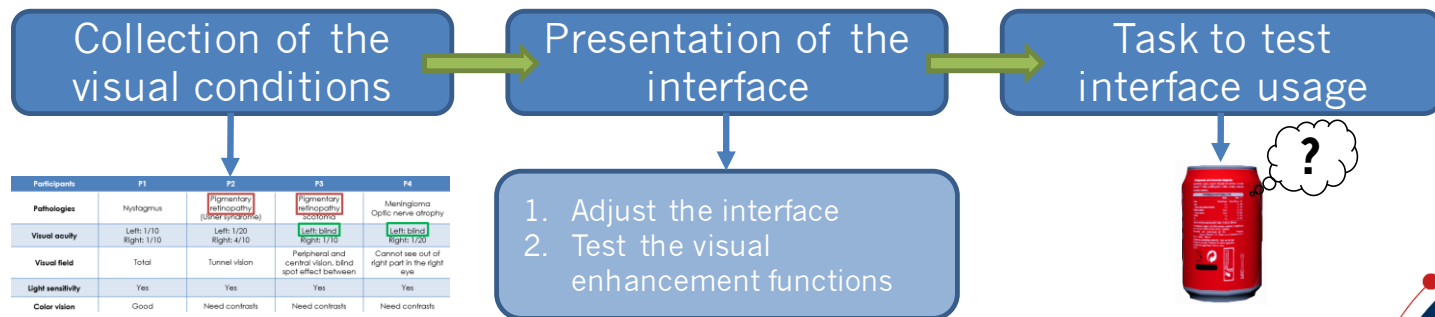Figure – A flashlight with normal outlines, highlight the object's relief.

Background → Co-Design → Interface → Evaluation → Results → Conclusion

4. Evaluation

- Participants

Participants	P1	P2	P3	P4
Pathologies	Nystagmus	Retinitis Pigmentosa (Usher syndrome)	Retinitis Pigmentosa Scotoma	Meningioma Optic nerve atrophy
Visual acuity	Left: 1/10 Right: 1/10	Left: 1/20 Right: 4/10	Left: blind Right: 1/10	Left: blind Right: 1/20
Visual field	Total	Tunnel vision	Peripheral and central vision, blind spot effect between	Cannot see out of right part in the right eye
Light sensitivity	Yes	Yes	Yes	Yes
Color vision	Good	Need contrasts	Need contrasts	Need contrasts

Table – Four visually impaired, each with distinct pathologies and visual conditions.

- Protocol

| Collection of the visual conditions | → | Presentation of the interface | → | Task to test interface usage |

1. Adjust the interface
2. Test the visual enhancement functions

| Background → Co-Design → Interface → **Evaluation** → Results → Conclusion |

5. Results

- 80 questions evaluated for usability
- Usability is highly satisfactory
  - "yes" responses exceed 75% for all criteria
- Difficulties encountered generally correspond to the visual conditions of the participants
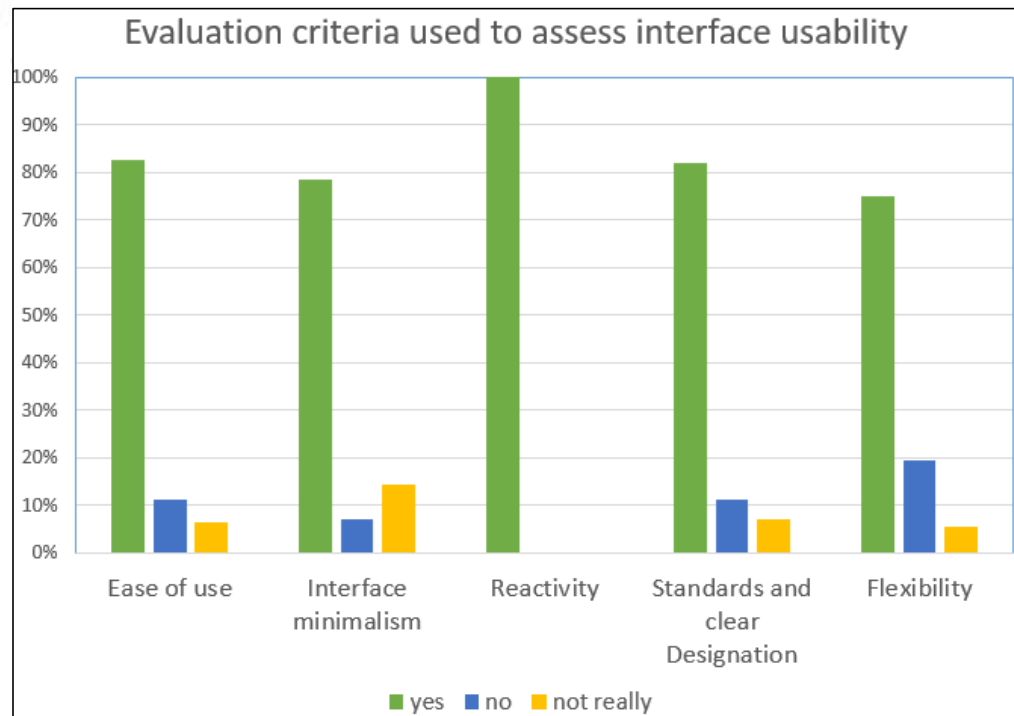

Figure – The response rate of participants per evaluation criterion.

Background → Co-Design → Interface → Evaluation → Results → Conclusion

5. Results

- Participants could customize the interface according to their preferences
- Each configuration varied
  - This demonstrates the link between the participant's visual conditions and their needs

Elements		P1	P2	P3	P4
Font	Type	Luciole	Luciole	Luciole	Luciole
	Size	4	10 (max)	10 (max)	10 (max)
	Bold	No	No	Yes	Yes
Menu	Theme	White	Black	Black	White
	Menu borders	5 (max)	2	5 (max)	5 (max)
	Button borders	5 (max)	1 (min)	5 (max)	5 (max)
	Menu position	Left	Left	Left	Right
3D model background		White	Dark grey	Black	White

Table – Interface settings chosen by each participant.

- These settings highlight the importance of customizing interfaces

Background → Co-Design → Interface → Evaluation → Results → Conclusion

6. Conclusion and Future Works

- Conclusion
  - We present a visualization interface for 3D objects recognition designed for visually impaired, using a 2D standard screen
  - The interface provides both configuration functions and visualization aids to assist users with their residual vision
  - It was evaluated by participant with various visual conditions, and the usability is satisfactory
  - We need to adjust the interface based on the participants' feedback
  - There are configuration similarities among people with similar conditions

- Future Works
  - Complete visually impaired users' profile
  - Focus on other visualization aid functionalities
  - Add other senses to our device

Background → Co-Design → Interface → Evaluation → Results → Conclusion

Thank you for your attention