Karlsruhe Institute of Technology

Mobile Interactive Image Sonification for the Blind

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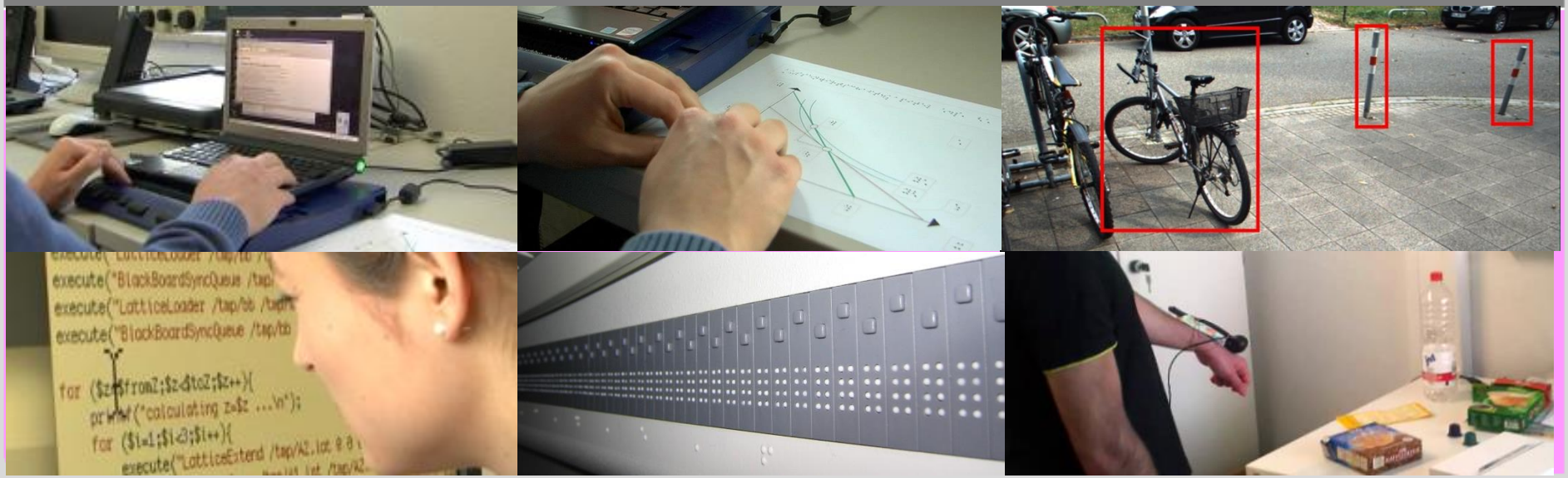
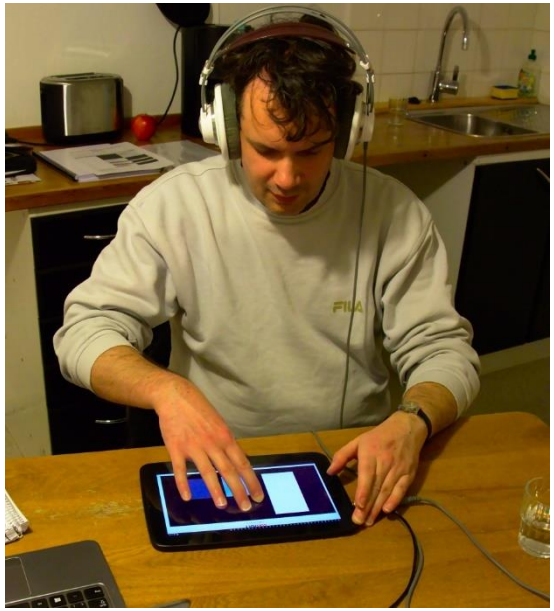


Motivation

- Worldwide 39 million blind people (WHO)
- Majority of blind people lives in developing countries
- Lower costs for mobile computers than embossers: tablet US$100-500 vs tactile embosser US$1,5K-150K

Aims

- Sonification of own images
- Accessible from everywhere
- Support for:
  - Mathematical function plots
  - Bar charts
  - Floor maps
- Investigate web-based sonification with various techniques
- Support for Web Audio and vibration API

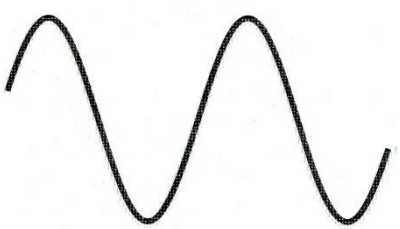


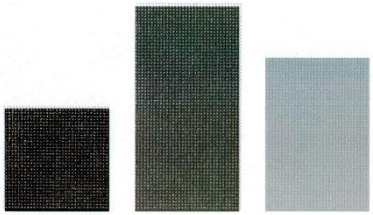
Related Work

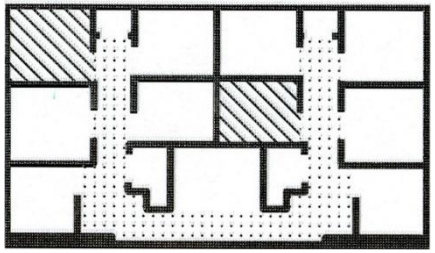
- Sonification
  - Instrumental and vocal [Banf, et al. 2012]
  - **Synthetic sound** [Cavaco, et al. 2013]
- Interaction
  - Non-interactive [Meijer, 1992]
  - **Interactive** [Hermann&Hunt, 2005]
- Method
  - Crowd sourcing [Bigham, et al. 2010]
  - **Computer vision and image processing** [Schauerte, et al. 2014, 2015]
- Medium
  - Stationary devices
  - **Mobile devices** [Bigham, et al. 2010]

Experiments

- Three tasks:
  (1) Identify or precisely describe mathematical functions
  (2) Precisely describe bar charts
  (3) Find and describe the path between two rooms
- Six blind participants
- Method
  - Baseline for time: comparison with tactile graphics



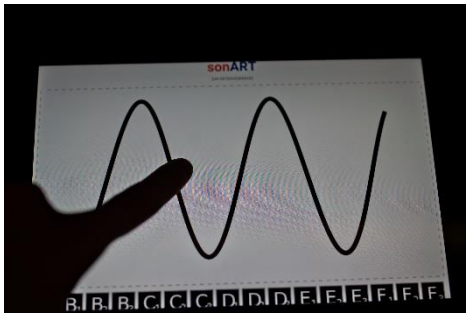




  - Two sonification methods per task in random order
  - 3 - 5 stimuli per task: in random order and with variations
- Evaluation scores: success, time, and usability

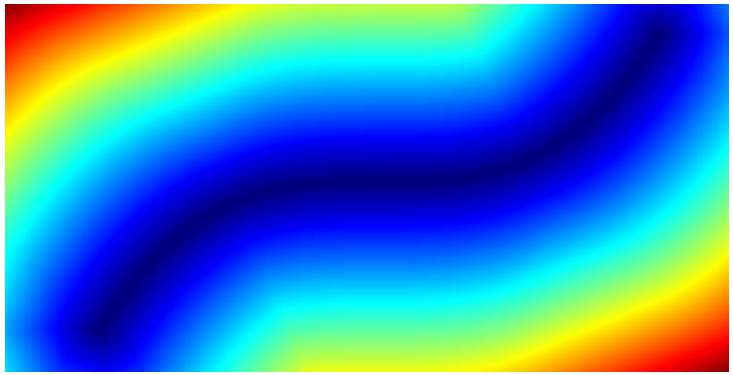
Task 1 – Identify Mathematical Functions

Used functions: linear, parabola, sine function, exponential function, hyperbolic function



Distance sonification

- Hear approximated Euclidean distance to graph
- Higher frequency, further away
- Free 2D exploration



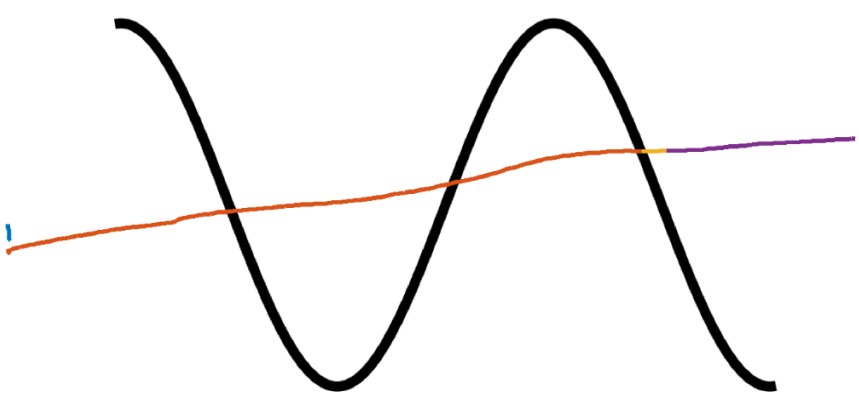
Value sonification

- Hear the function value
- Higher frequency, higher function value
- Horizontal 1D exploration

Hyperbolic function

Task 1 - Results: Identify Math Functions

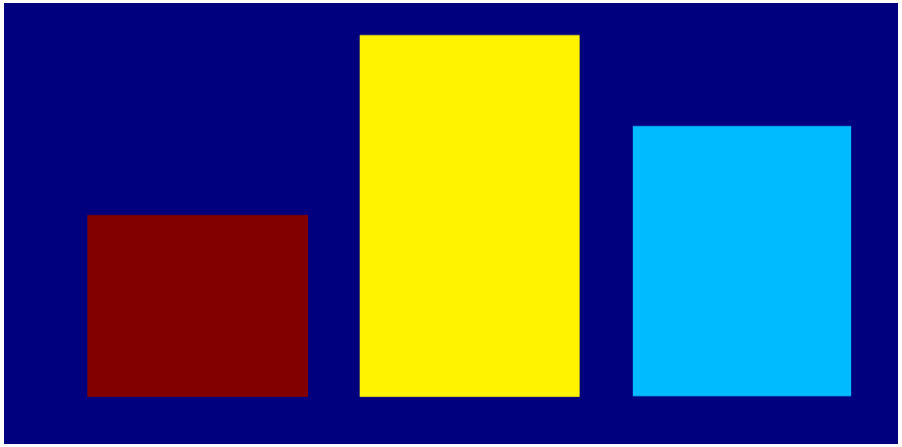
- Most participants did not know how a function "*looks*" like
- Functions: value sonification is better
  (faster, equally successful, better usability) than distance sonification



Task 2 – Describe Bar Charts

Semantic sonification

- Each bar different frequency
- Discrete frequencies
- Free 2D exploration

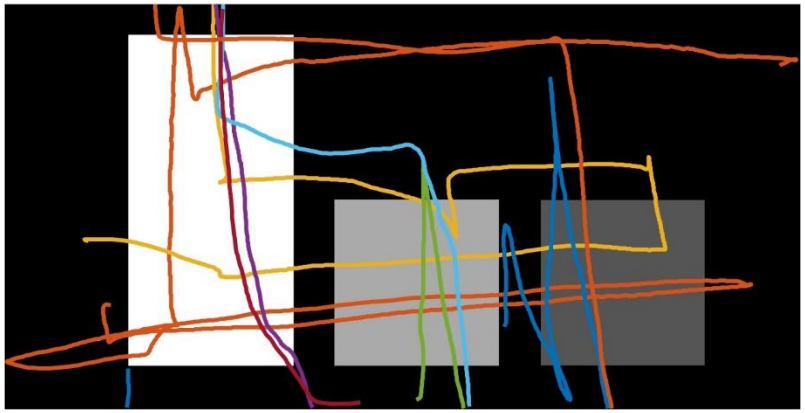


Value sonification

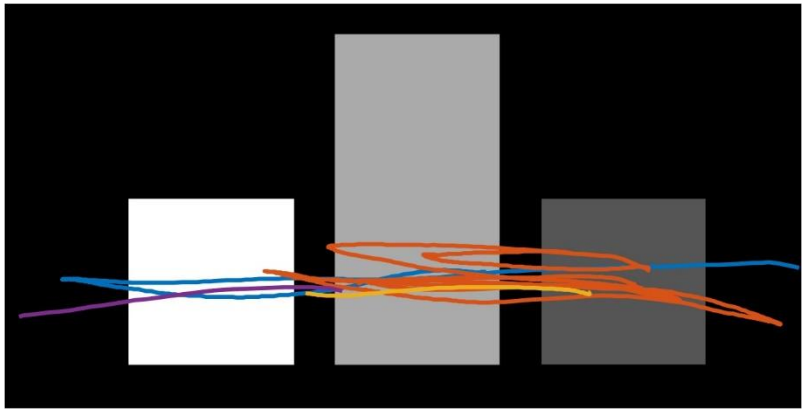
- Height of bars
- Discrete frequencies
- Horizontal 1D exploration

Task 2 – Results: Describe Bar Charts

- Semantic sonification provides all information but slow.



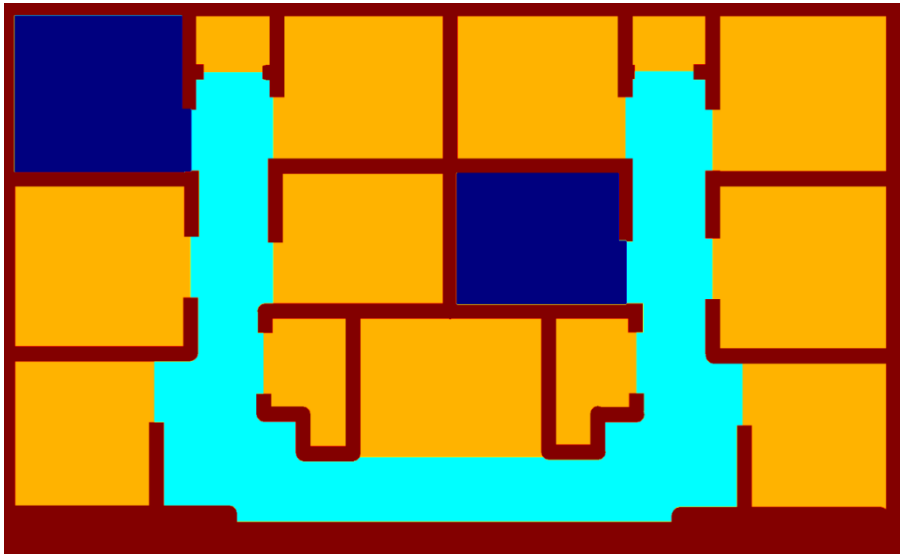
- Value sonification fast, but only rough estimation of height



Task 3 – Floor Maps: Semantic sonfication

Semantic sonification

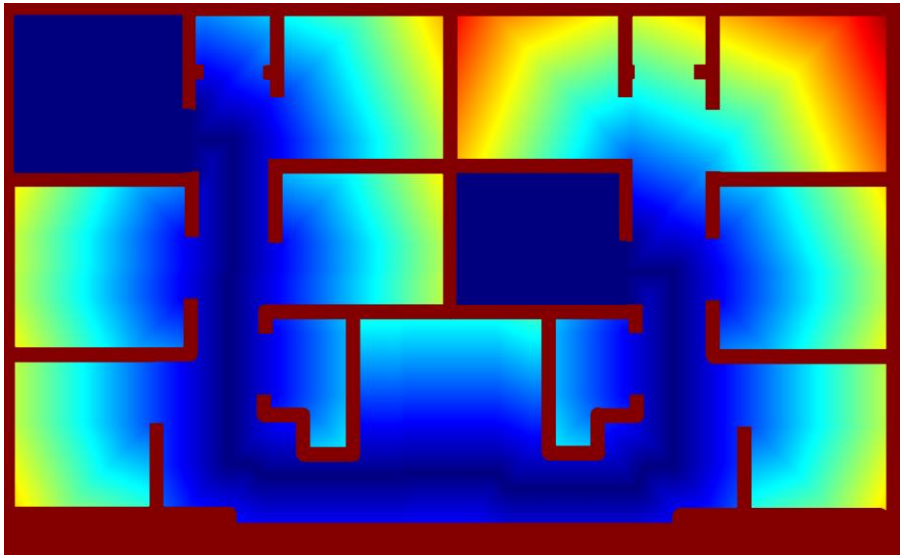
- Semantic entities (walls, rooms,…) are represented by different frequencies
- Start and target rooms share the lowest frequency
- Walls have the highest frequency
- Free 2D exploration (discrete frequencies)



Task 3 – Floor Maps: Guided sonification

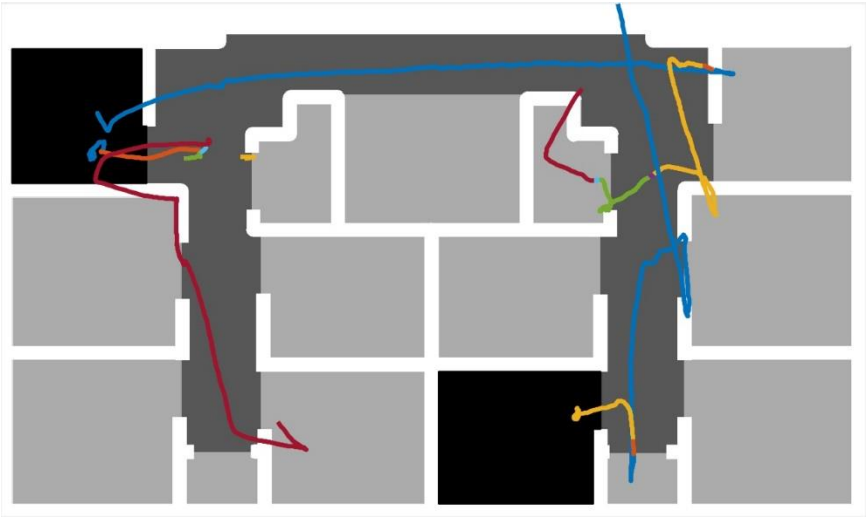
Guided sonification

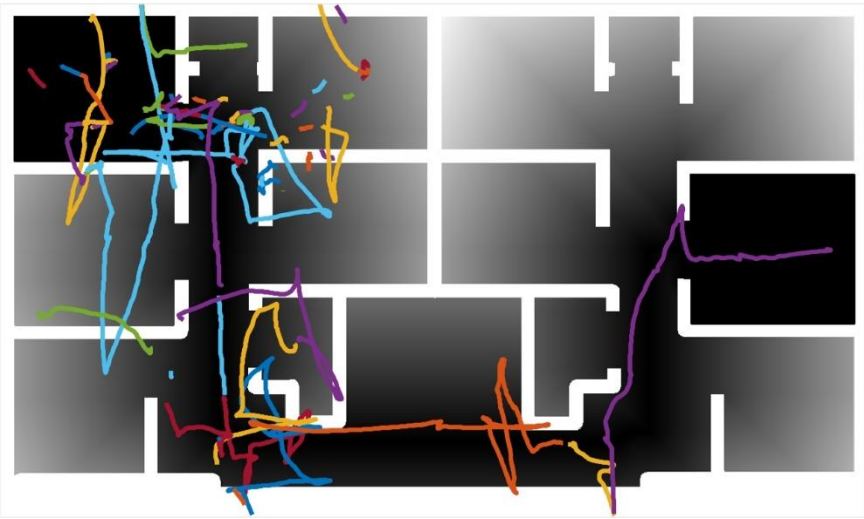
- A path between the two rooms is computed, the further you are away from the path, the higher the frequency (“the tone is guiding the way”)
- Start and target rooms and the exact path share the lowest frequency
- Walls have the highest frequency
- Free 2D exploration (continuous frequencies)



Task 3 – Results: Find a way on Floor Maps

- Floor maps: semantic sonification is faster than guided sonification





- In general, it is still a demanding task

Conclusions & Future Work

- We investigated three tasks with two sonification methods
  - Identification of mathematical functions
  - Bar charts
  - Way finding on floor maps

- Compared to the baseline (tactile graphic) – participants need more time for all tasks
- Mathematical function: value sonification is comparable
- Vibration pattern considered helpful to determine borders of image
- Trend: less degrees of freedom, better usability (1D vs. 2D exploration and discrete vs. continuous frequencies)

- Future Work: Investigate vibration patterns for other tasks; Decrease audio delay; Allow multi-touch