Verbally Annotated Tactile Maps - Challenges and Approaches

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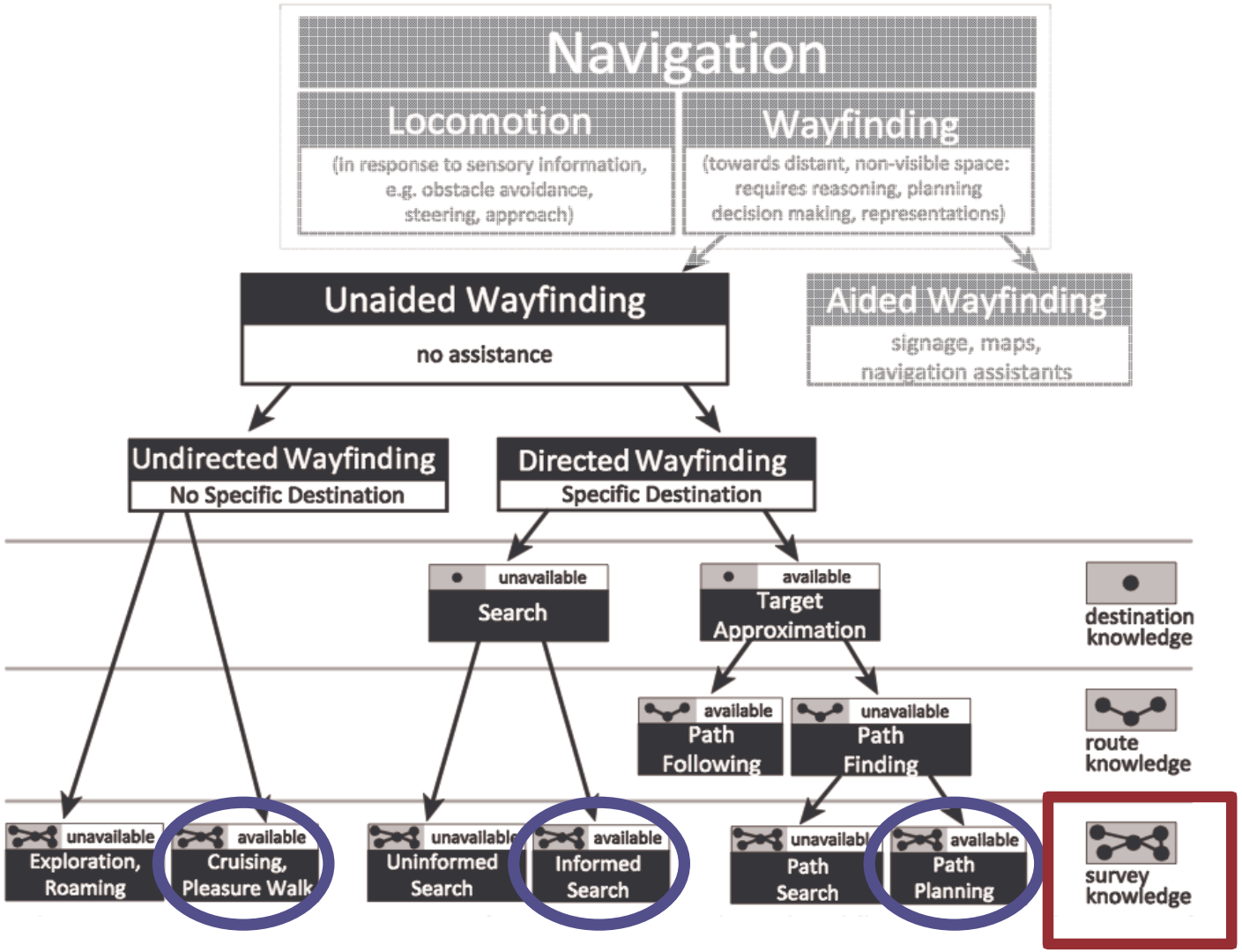
Motivation I

- Communicate qualitative *spatial knowledge* non-visually
- Functionally most generic: *survey knowledge*
- Survey knowledge conveyed *before a trip* allows for *unaided wayfinding* in formerly (unknown) environments
- GPS-based systems for *aided wayfinding* and locomotion

impair the acquisition of spatial knowledge (Burnett & Lee, 2005)

Usage of Survey Knowledge in Navigation



Wiener, Büchner, & Hölscher (2009), Fig. 1

Motivation II

- *Pre-trip preparation* by e.g. *maps*
- Non-visual maps could be tactile
- *Tactile maps* are of low resolution and very *schematic*
- Perception of a tactile medium is serial, requires high attention and causes high cognitive load for integration of the serial percepts

Examples for Hand Crafted Tactile Maps

Motivation II

- *Pre-trip preparation* by e.g. *maps*
- Non-visual maps could be tactile
- *Tactile maps* are of low resolution and very abstract
- Only limited knowledge can be communicated
- Limitation calls for augmentation
- Augmentation by spoken language, for example:

"*Verbally Annotated Tactile Maps*"

Agenda

1. The Limits of Unimodal Tactile Maps
   a) You-Are-Here Maps as Examplary Class of Maps
   b) A Pilot Study on Using Computer Generated Tactile YAH Maps for Survey Knowlede Acquisation
2. Proposal for Multi-modal Verbally-Annotated Tactile Maps
3. Conclusion

1a. You-Are-Here Maps as Examplary Class of Maps

- Stationary in some environment, map-user co-located
- Overview of the proximate surrounding
- Constitutent element: YAH Location Symbol

A Visual You-Are-Here Map

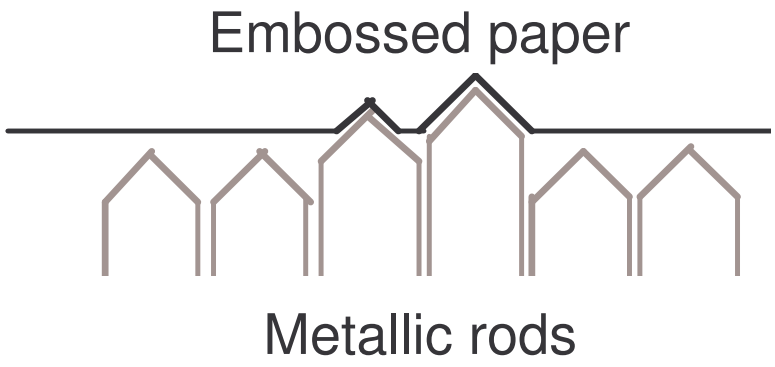
YAH Location Symbol

1a. You-Are-Here Maps as Examplary Class of Maps

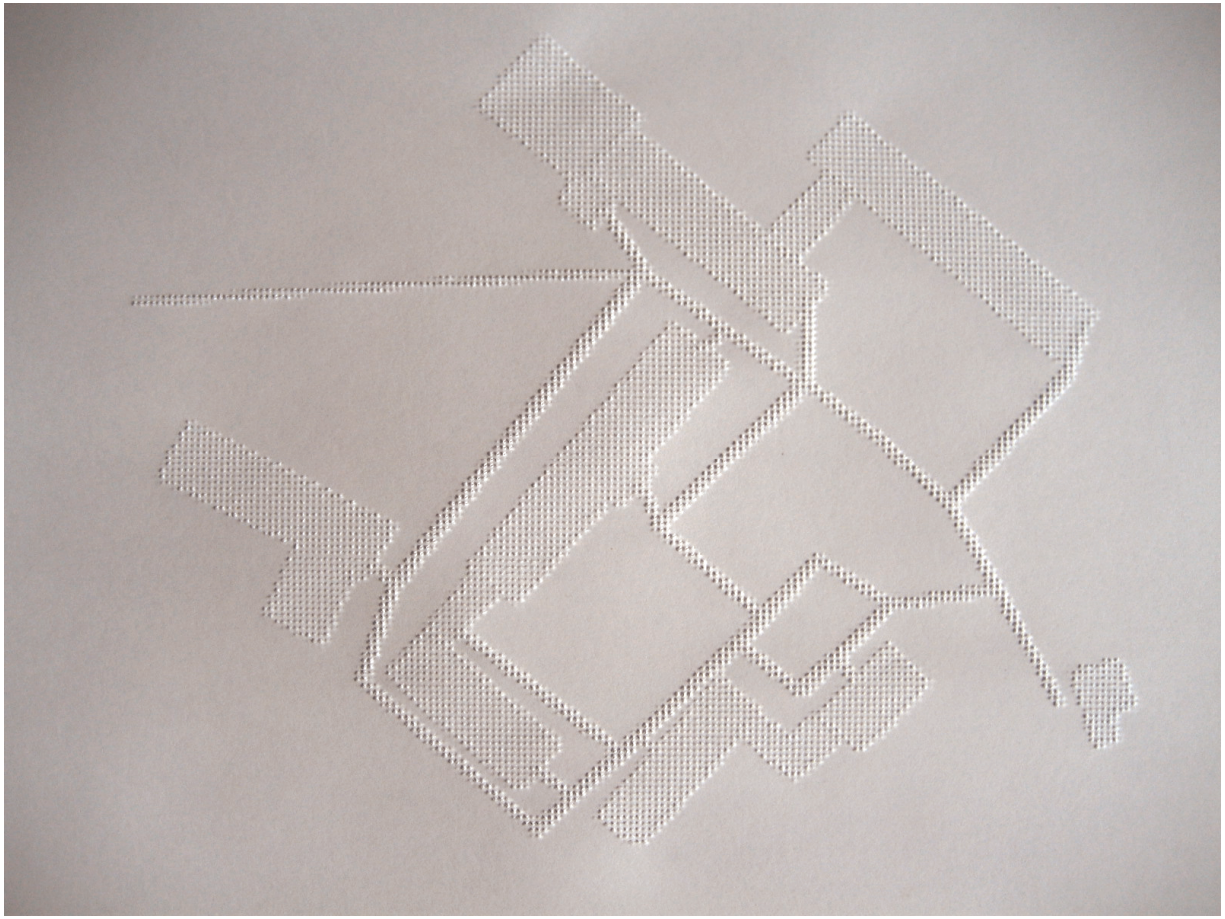
- Stationary in some environment, map-user co-located
- Overview of the proximate surrounding
- Constitutent element: YAH Symbol
- One-to-many relations (multi-purpose map)
- 2-step usage: pre-trip learning, recall in the field
- Enables wayfinders to
  - Localize themselves
  - Get an overview of the area
  - Find specific routes

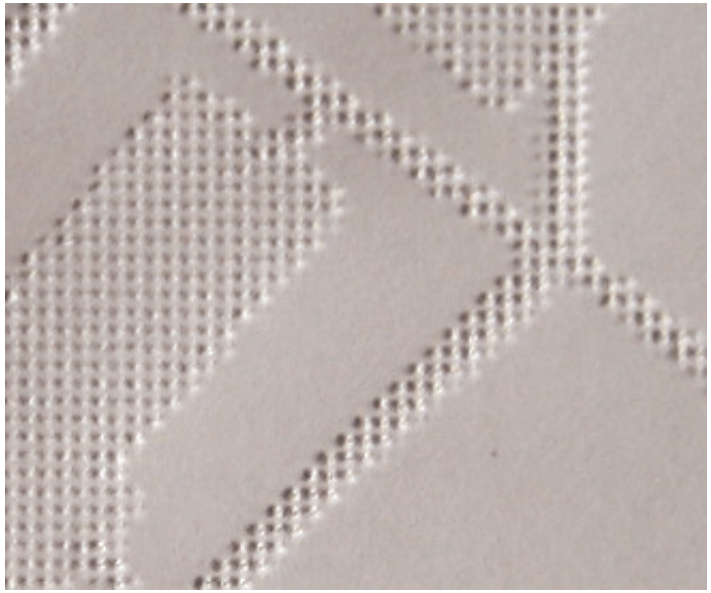
Tactile Maps Generated with Computer Technology

- Tactile maps as *aspect maps* (Barkowsky & Freksa, 1997): geographic entities (tracks and buildings), no cartographic entities (labels)
- Tactile maps that can be printed with embosser



Example for a Computer Generated Tactile Map





1b. A Pilot-Study on Using Computer Generated Tactile YAH Maps for Survey Knowledge Acquisation

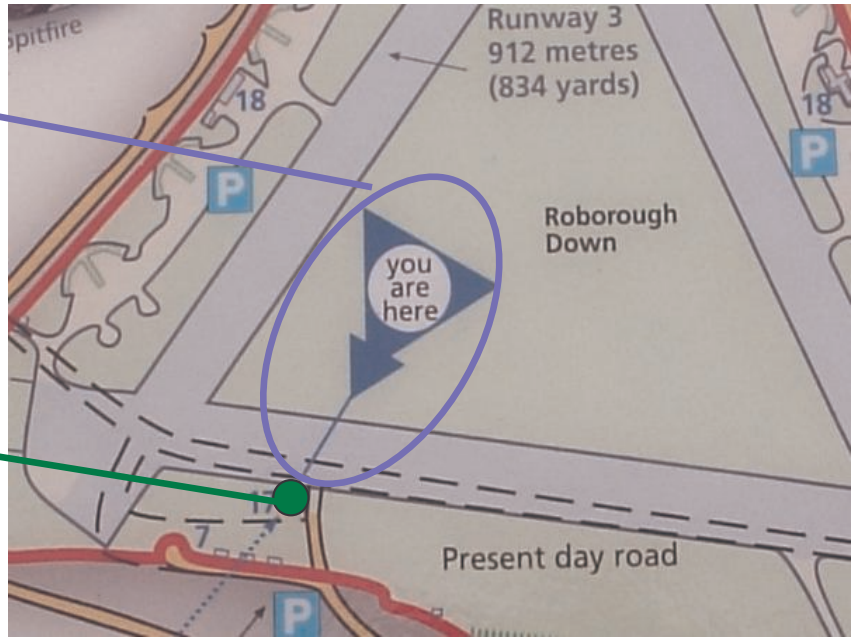
- Motivation
  - Knowing the affordances and limits of computer generated tactile unimodal maps can guide problem-specific, multimodal solutions
- Goals
  - Evaluate Cognitive Adequacy of the map usage
  - Evaluate Efficiency of YAH location indicators
- Participants for now
  - Sighted, blind-folded people (as stand-in for late-blind people)

YAH Symbol vs. YAH Location Indicator and YAH Location Symbol

- YAH Symbol is unspecific: any entity guiding or signifying the position of the YAH Point in map space

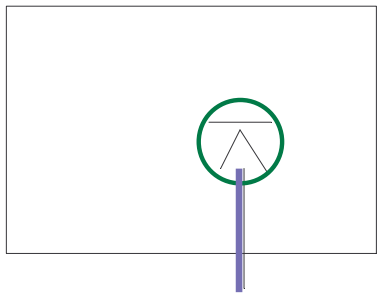
YAH Location Indicator
guides to the position of the signifier of the YAH Position

YAH location symbol
signifies the YAH Position in map space

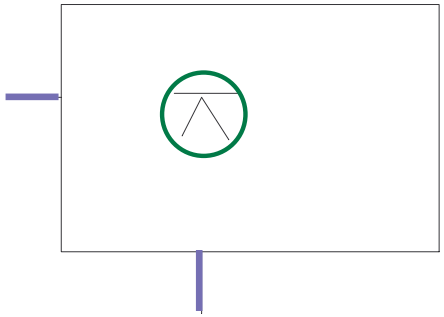


YAH Location Indicators: Support to Find the YAH Symbol

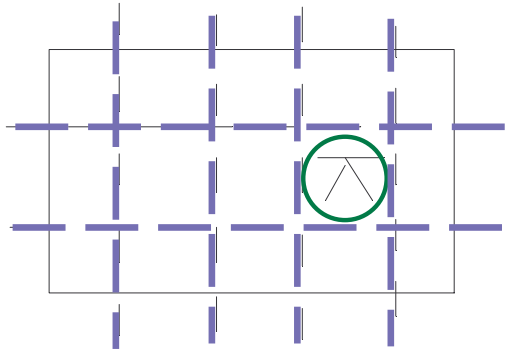
- YAH Location Indicators guide to the position of the YAH Symbol in three different conditions:



Indicator line



Frame marks



Grid

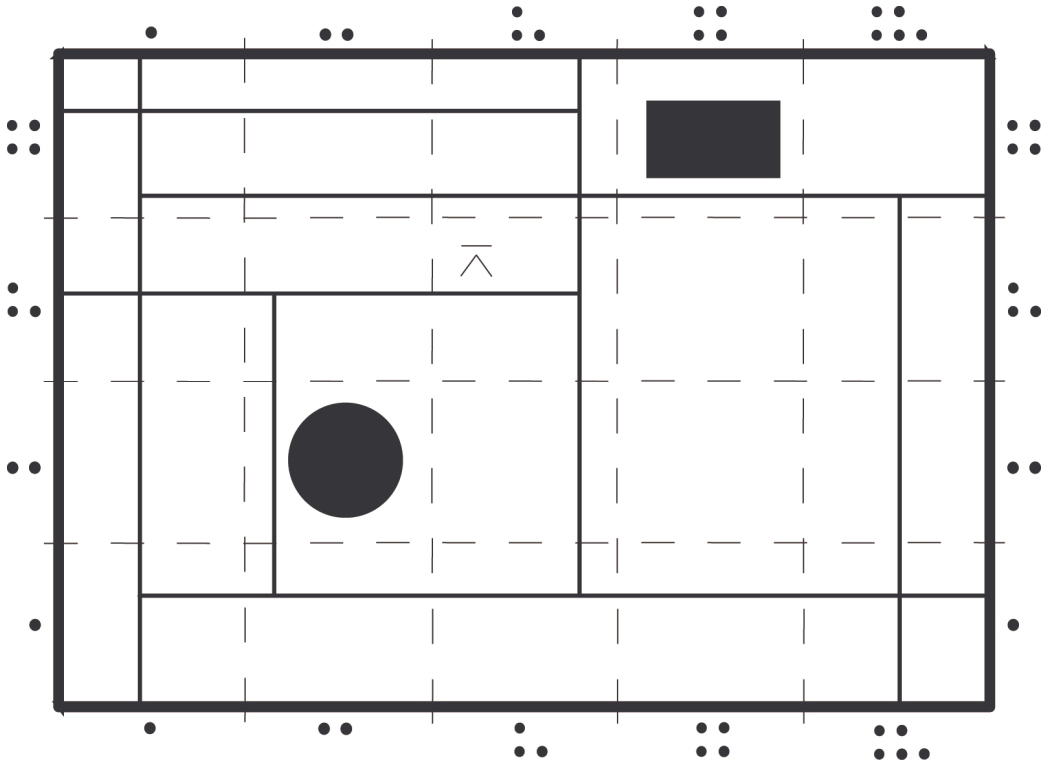
YAH Symbol

YAH Location Indicator

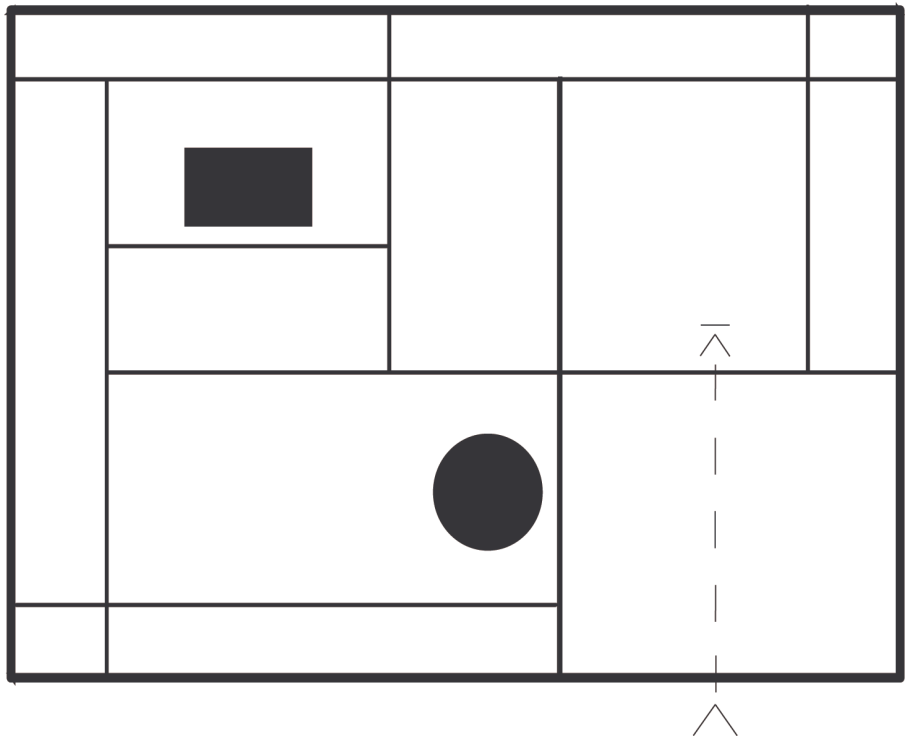
Research Questions

- Evaluate Efficiency of YAH location indicators: Which (tactile) guide type to the You-Are-Here point in a tactile map is the most effective, i.e. has the shortest search time?
- Evaluate Cognitive Adequacy of the map:
  Which guide type is the least hindering when exploring the map to build up some survey knowledge in terms of objective time needed for exploration, objective quality of acquired survey knowledge, and subjective judgments of the map?

Selected Materials & Tasks



Condition Grid



Indicator Line

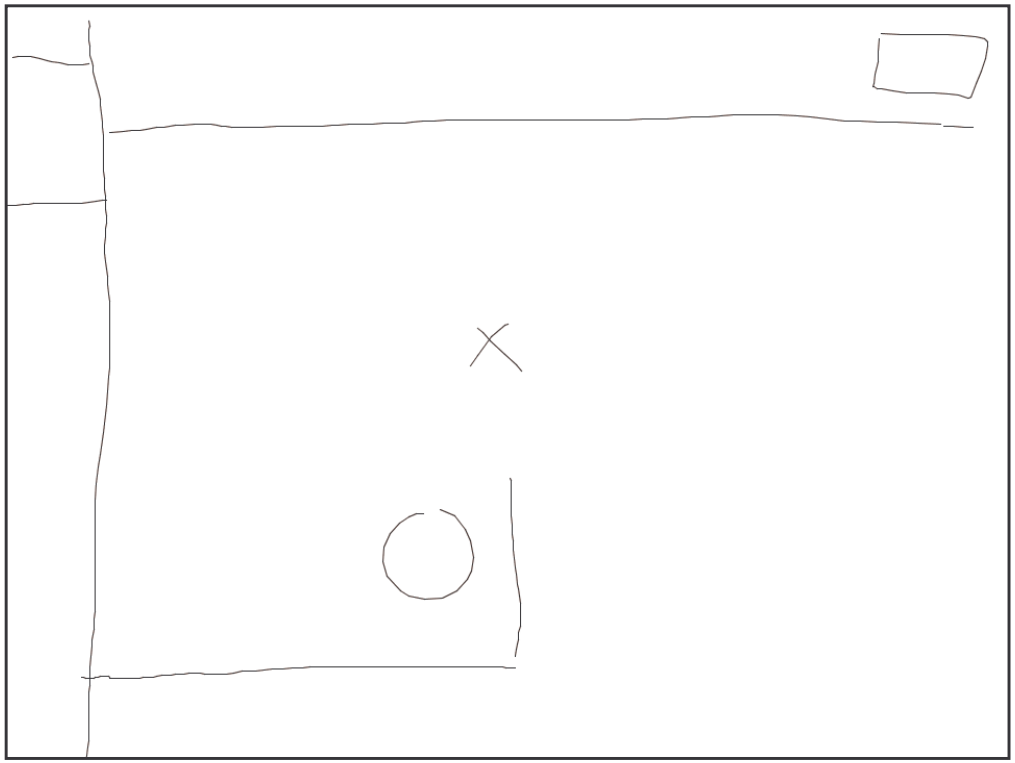
1. Find the YAH Symbol as fast as possible!
2. Memorize the map during exploration!

Selected Results

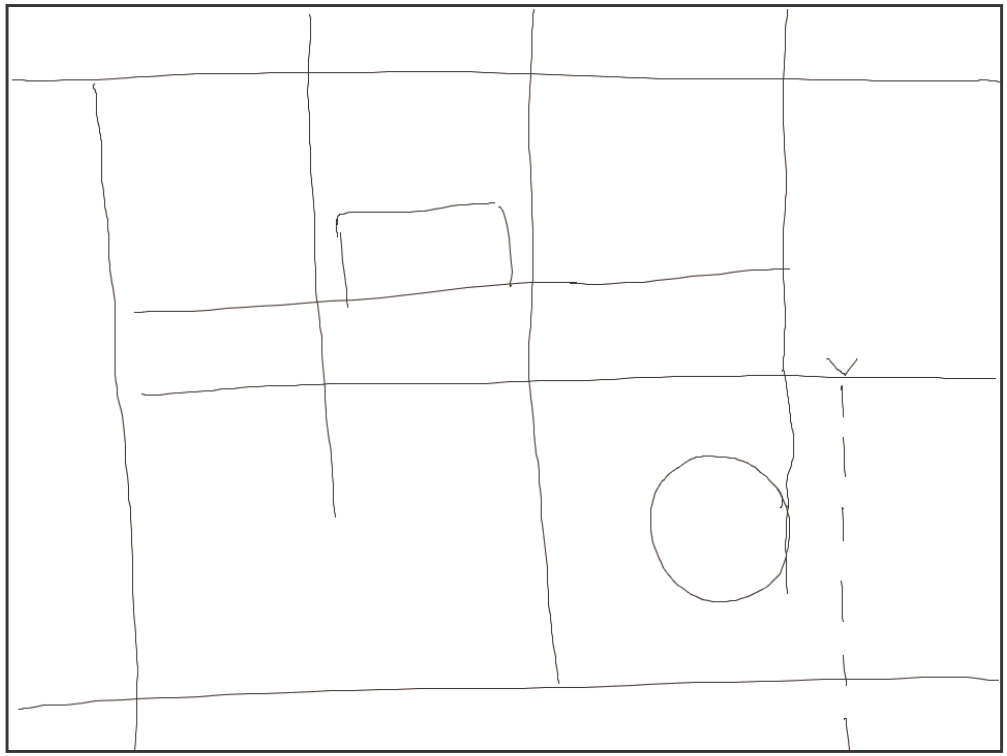
- Grid indicator significantly worst in finding the YAH Symbol, best is Indicator Line
- Map with grid significantly worst in exploration times
- Survey knowledge acquisition impaired, worst in the Grid condition

(the exact figures, confidence levels, *F*-values etc. are in the paper)

Two Examples of Externalized Survey Knowledge



Route



Survey

Selected Results

- Grid indicator significantly worst in finding the YAH Symbol, best is Indicator Line
- Map with grid significantly worst in exploration times
- Survey knowledge acquisition impaired, worst in the Grid condition
- Grid conditions subjectively ranked lowest

(the exact figures, confidence levels, *F*-values etc. are in the paper)

Interpretation of Results

- Tactile maps pose some problems
  - Finding the YAH Point in YAH maps with certain indicators
  - Getting an overview

- Other modalities could help in the knowledge acquisition process with tactile maps

3. Proposal for Multi-modal Verbally-Annotated Tactile Maps

- State of the Art: Audio-tactile Maps equipped with
  - Sound
  - Verbal labels
- Disadvantages: point-like information, little support in building relations between objects of the scene
- Suggestion to combine tactile map and description of the map: "*Verbally Annotated Tactile Maps*"

Verbally-Annotated Tactile Maps as Multi-modal Artifact

- Prior Work: Positive learning outcomes with geographic (visual) maps in conjunction with an explanatory text (e.g. Verdi & Kulhavy, 2002)
- Prior Work: Functionally equivalent representations on different inputs, independent of perceptual or linguistic production (e.g. Loomis et al. 2007)
- Assumption: *cross-modal integration* of different representations contributes to a common representation
- Integration of *representational modalities*: propositional and spatial (Habel & Graf, 2008) → VAT as multimodal artefact
- Verbal Annotation System to augment the tactile map

Guiding Questions to the Conceptual Design of a Verbal Annotation System

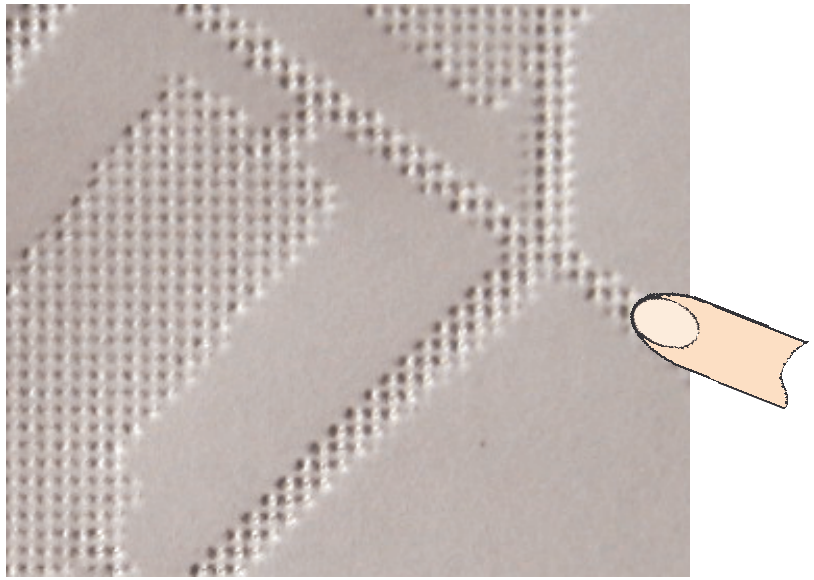
- Mechanism to connect verbal annotation and tactile map
  - References to Points-of-Interest or Areas-of-Interest
  - Activation by approaching, passing or leaving
  - Annotations could be dynamically creating based on a rule system
    - With a history of actions done before
    - On the probability what could be done next
- The map-reader could be supported by different presentation strategies along two considerations:
  - Which and how much content to choose?
  - How to structure the content and present it?

Content and Form of Annotations

- Rule system & database: content of the annotations and how they could be presented
  - Redundant or complementary object & relations information
  - Meta-information to guide the user's exploration strategies
- Redundant: Knowledge is encoded in the map but would need further exploration effort to be conveyed
- Complementary: Knowledge not encoded in the map
- Meta-information: Knowledge about the exploration process (for example, which parts has been missed out)

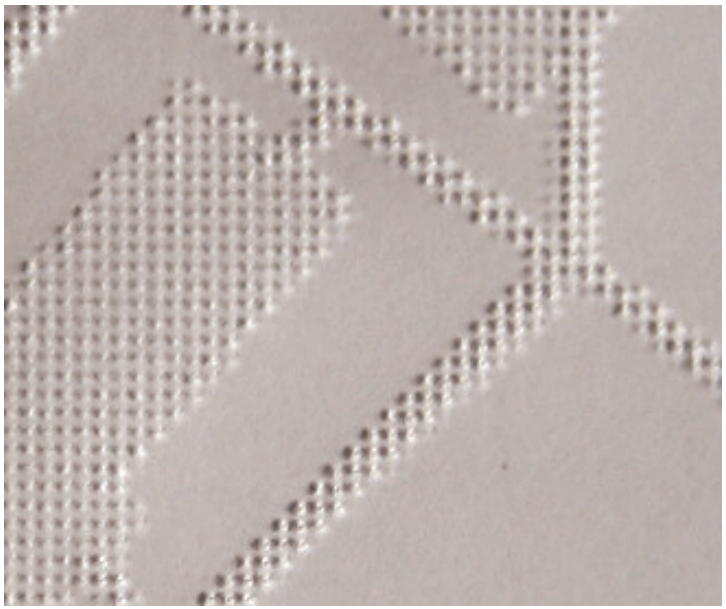
Approaches to VAT Maps

- Tactile map and verbal annotation system are independent in its respective realization
- Tactile map either physical (real) or simulated (virtual)



Physical-and-Speech Approach

- Physical tactile map in combination with touch tracker (for sensing the position of the finger) and synthesized speech



Physical tactile map

+

Touch Tracker

+

Synthesized speech

Simulation-and-Speech Approach

- Virtual Map + Force-Feedback Device (produces impression of tactile map as simulation) in combination with synthesized speech

Review of Approaches to VAT Maps

Physical-and-Speech	**Simulation-and-Speech**
+ Easy modeling of new maps as digital images	- New virtual maps need modeling which costs time
- Production and distribution to end-user needs offline infrastructure	+ No (physical) production; distribution may happen electronically
+ Size of the map can be flexible and covers the whole touch space	- Size of the map quite limited by today's small actuator range
+++ Real touch (kineasthetic + proprioception) with multiple fingers	+ Touch is mediated (kineasthetic sense often neglected) and point-like

Open Issues with VAT Maps

- Influence of granularity of the verbal descriptions
  - Coarse survey descriptions vs. many descriptions of local details
- Influence of verbal description on the map user's exploration strategies
- Investigation of the factors with determine a limitation of communication with unimodal tactile maps
- Studies with late-blind people (they are the biggest population among the legally blind)

Conclusion

- The communication of spatial knowledge with tactile maps suffer from different limitations.
- Verbally annotated tactile maps could have the potential to solve some of them.
- Further investigations about the integration of a verbal annotation system and (physical or virtual) tactile maps need to be done.

Thank you for your attention.

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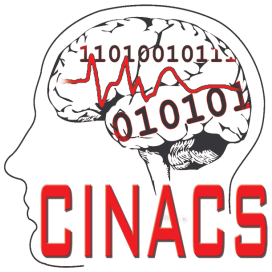

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