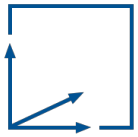
Module IN 2018

3D User Interfaces
- Dreidimensionale Nutzerschnittstellen -

Prof. Gudrun Klinker



Interaction Techniques: Wayfinding

SS 2023

Agenda

1. Definition
2. Theoretical Foundations
3. User-centered Wayfinding Support
4. Environment-centered Wayfinding Support
5. Evaluating Wayfinding Aids
6. Design Guidelines

1. Definition

- Cognitive process of defining a path through an environment,
  - Using and acquiring spatial knowledge,
  - Aided by both natural and artificial cues.
- Often done unconsciously
- Purposes
  - Transferring spatial knowledge to the real world
  - Navigation through complex environments in support of other tasks
- Significant differences between wayfinding in real and virtual environments (due to unconstrained movement)
- Groups of wayfinding aids:
  - User-centered aids (presence)
  - Environment-centered aids

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2. Theoretical Foundations

2.1 Wayfinding Tasks (Similar to Travel Tasks)

- Exploration
  - Acquisition of spatial knowledge
- Search
  - Use of pre-existing spatial knowledge
  - Acquisition of further spatial knowledge
    - Naive target-based search
    - Primed target-based search
- Maneuvering
  - Small-scale movements, e.g., for the identification of landmarks
- Specified trajectory movement (a tour)
  - Automatic guidance through an environment along predefined path in order to obtain an broad overview of the environment.

2.2 Types of Spatial Knowledge

- Landmark knowledge
  - Visual characteristics of the environment
- Procedural knowledge (route knowledge)
  - Sequence of actions
- Survey knowledge
  - Topological knowledge of an environment (map)

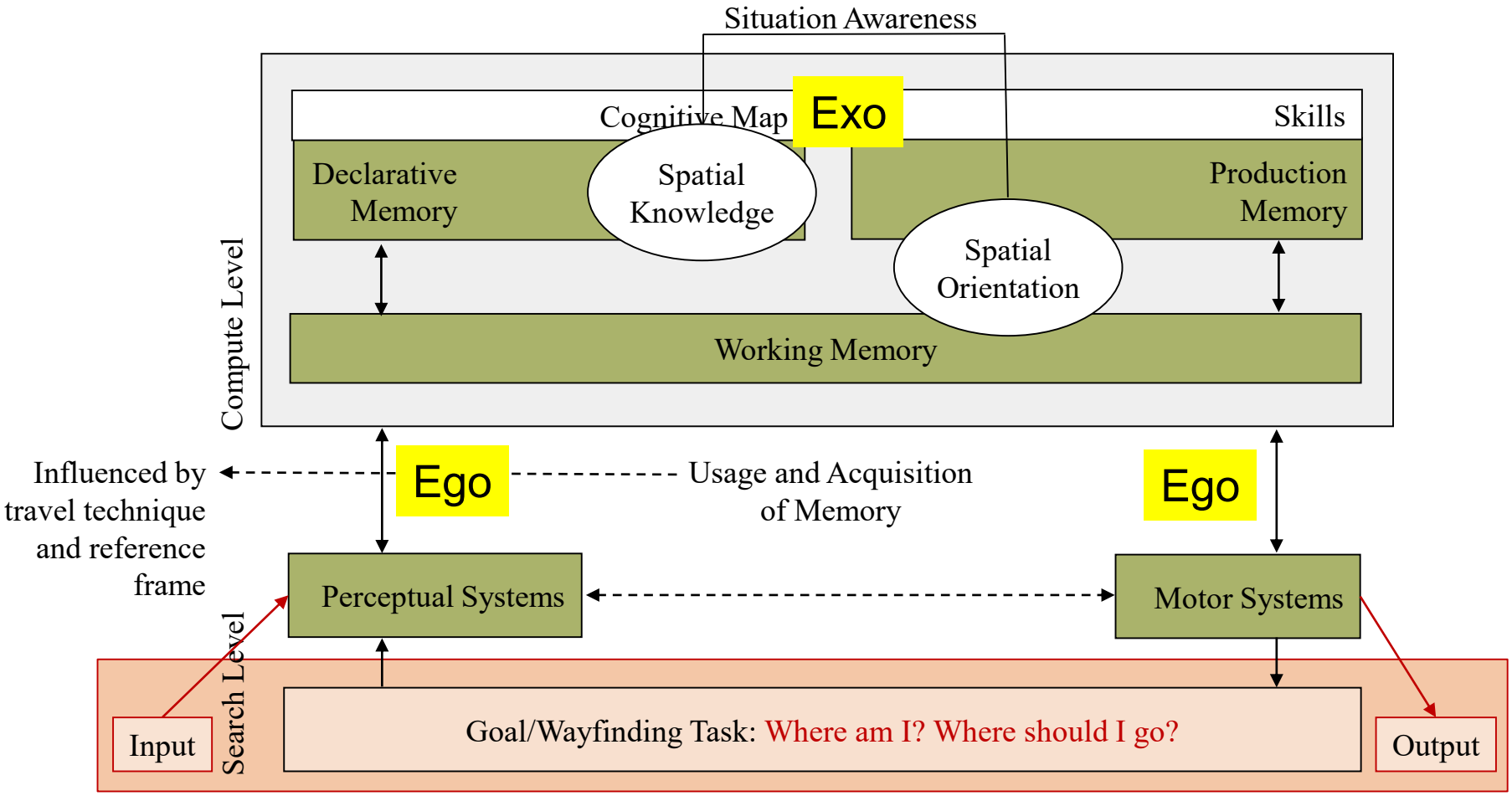
  - Highest level of knowledge
  - Takes the longest time of acquisition

2.3 Egocentric and Exocentric Reference Frames

- Egocentric: relative to a certain part of the human body
  - Headcentric
  - Stationpoint (nodal point of the eye)
  - Retinocentric
  - Bodycentric
  - Propriocentric (visual and non-visual cues)
- Exocentric: relative to a foreign object or the world

- Transition: egocentric → exocentric
  - In a new environment: egocentric (landmarks, procedural knowledge: route)
  - After a while: exocentric (survey knowledge: map)

2.4 Decision-Making Process



[adapted from: Laviola et al 2017]

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3. User-centered Wayfinding Support

User-centered wayfinding cues:

- Targeted to human sensory systems
- Technology-oriented
  - Negative impact from non-perfect output (discrepancies between quality of signals and the capabilities of the human perceptual system)

3.1 Field of View
3.2 Motion Cues
3.3 Multisensory Output
3.4 Presence
3.5 Search Strategies

Cue = Aufruf, Fingerzeig, Stichwort
Clue = Anhaltspunkt, Schlüssel, Verständnishinweis

3.1 Field of View

Negative side-effects of small FOV

- Many repetitive head rotations
- Lack of significant optical-flow fields in peripheral vision
  - Loss of strong motion cues (information on user‘s motion direction, velocity, orientation)
- Cyber sickness

Goal: provide large FOVs!

- HMD or desktop VEs vs. Surround-screen displays

3.2 Motion Cues

Useful

- For judging depth and direction of movement
- As information for dead reckoning

Vestibular system:
- labyrinth in the inner ear
- contributes to
  - balance
  - spatial orientation

Can be obtained from

- Peripheral vision
- Vestibular cues
  (important to avoid intersensory conflicts: cyber sickness, wrong estimation of ego motion)
- [Usoh et al 99]: walking (> walking in place) > pointing
- [Harris et al 99]: vestibular cues ≥! ¼ optical cues

3.3 Multisensory Output

- Audio
  - Sounds of environmental objects → sense of direction
  - Volume of environmental objects → sense of distance
- Tactile map (map with raised contours)
  - For visually impaired people
  - For car drivers???

  - Additional support using spatial memory

3.4 Presence

- The feeling of „being there“
- Assumed to have an impact on spatial knowledge:
  - If a user feels more present,
  - Then real-world wayfinding cues will be more effective
- Sense of presence depends on
  - Sensory immersion
  - Proprioception
  - Immersive tendency of the user
- Successful means
  - Egocentric representation of the user (at least hands/feet) by an avatar: embodiment

3.5 Search Strategies

Teach users to use search strategies

- Skilled users (navigators) vs. Novice users
  - Skilled users: paths (e.g. coast line)
  - Novices: landmarks
- Strategies
  - Basic line search
  - Pattern search
  - Contour search
  - Fan search
  - Mentally obtain a bird‘s-eye view
- Implementations in VEs
  - „pop-up“ technique (push a button to move up above the ground)
  - Placement of a radial or rectangular grid in the environment

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Overview

4. Environment-centered Wayfinding Support

→ 4.1 Environment Design

4.2 Artificial Cues

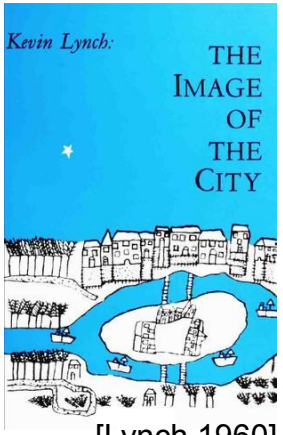
Overview

4.1 Environment Design

4.1.1 Legibility Techniques

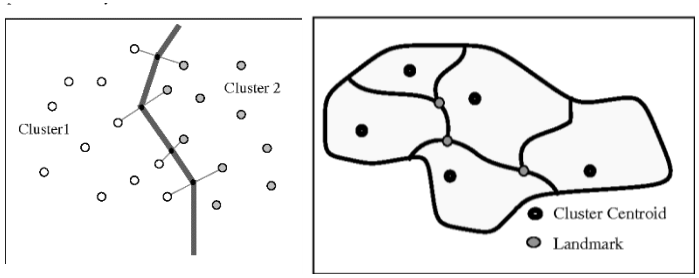
4.1.2 Real-World Design Principles

4.1.1 Legibility Techniques



[Lynch 1960]

- Use analogs to urban design principles
- Lynch's legibility techniques
  - Divide large-scale environments into parts with a distinct character.
  - Create a simple spatial organization in which the relationships between the parts are clear.
  - Support the matching process between egocentric and exocentric reference frames by including directional cues.
- Basic building blocks
  - Paths (linear movement: streets, roads)
  - Edges (bordering spaces)
  - Districts (districts with a unique style)
  - Nodes (gathering points, intersections)
  - Landmarks (distinct objects)
- Use repetitive structures and right angles!



[Ingram and Benford 1996]

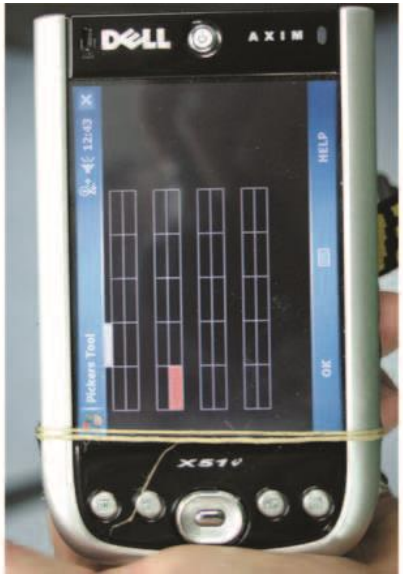
4.1.2 Real-World Design Principles

- Natural environment
  - Horizon → directional orientation information
  - Atmospheric colors, fog → distances
- Architectural design
  - Lighting, shadows → directional, depth cues
  - Special illumination → landmarks
  - Open spaces (door in the wall) → preferred direction of user motion
- Color and texture
  - Unique, contrasting colors → identification of objects, landmarks
  - Color groups → structured environments
  - Textures → depth cues, landmarks, path information (yellow brick road)

4. Environment-centered Wayfinding Support

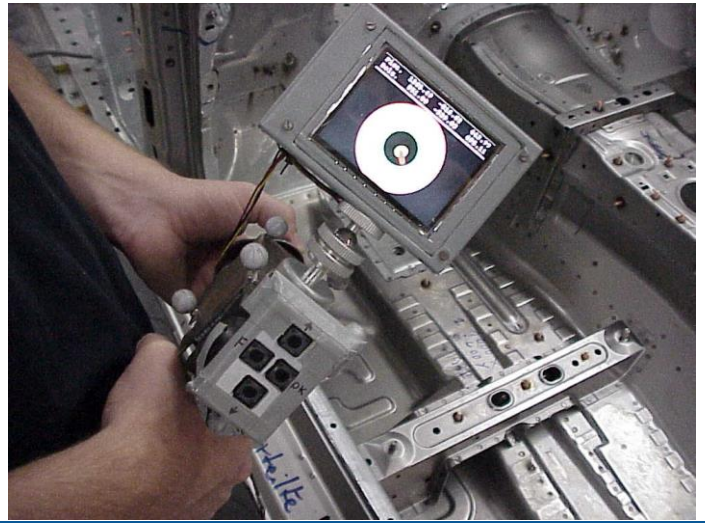
4.1 Environment Design

→ 4.2 Artificial Cues



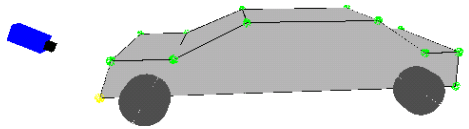
4.2 Artificial Cues

4.2.1 Maps
4.2.2 Compasses
4.2.3 Signs
4.2.4 Reference objects
4.2.5 Artificial landmarks
4.2.6 Trails
4.2.7 Audio and olfactory cues



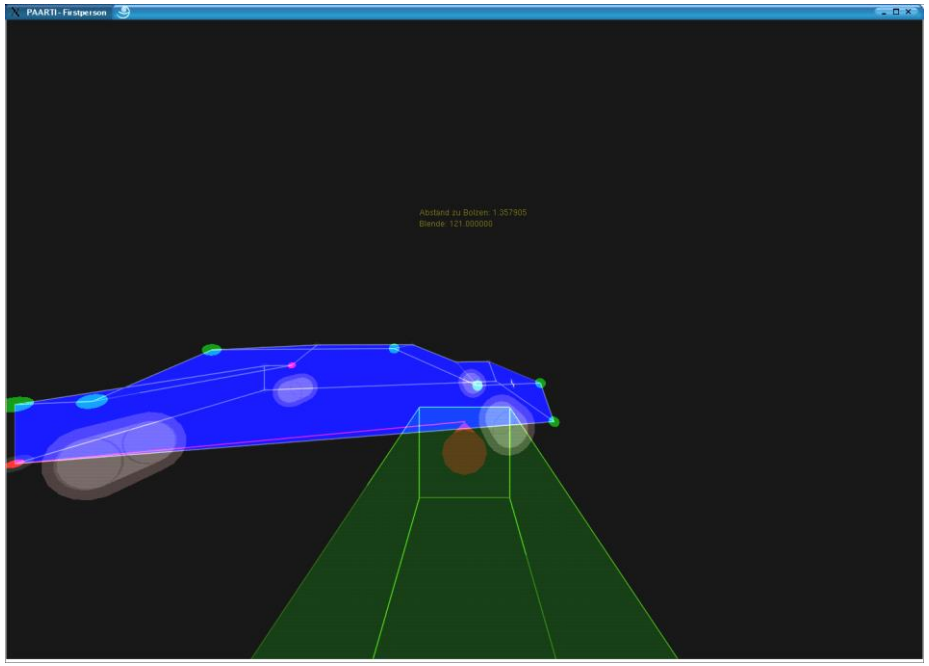
4.2.1 Maps

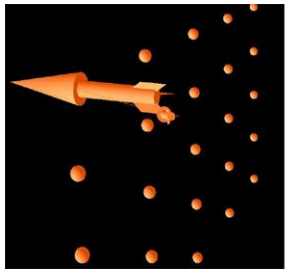
- Exocentric representation → survey knowledge
  - Traditional maps: orientation specific (north = up)
  - Map exocentric presentation with egocentric orientation
- Design guidelines for maps in VEs
  - Use you-are-here (YAH) maps – including a YAH-marker!
  - Consider multiple maps at different scales („focus plus context“)
  - Carefully choose the orientation of the map („north-up“ vs. „forward-up“)
    - Every 60 degrees of mental rotation takes 1 second
  - Make the map legible (clear graphical representation)
  - Use appropriate map size and placement (minimal occlusion)

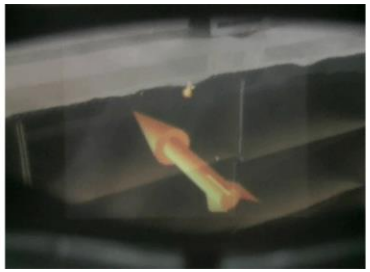


4.2.2 Compasses (Rubber Band)

- Directional cue

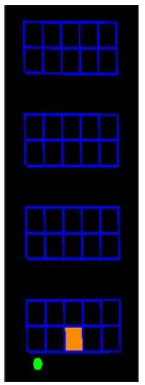


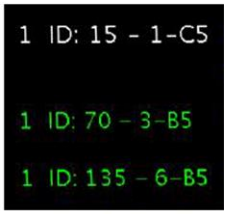


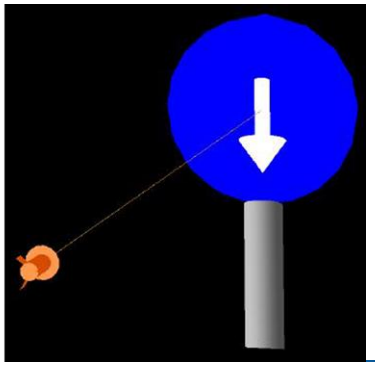


4.2.3 Signs

- Effective, if used sparingly and precisely







4.2.4 Reference Objects

- Well-known size (coin, matchbox, chair, person)
- Help in size and distance estimation

4.2.5 Artificial Landmarks

- Easily distinguishable
  - Help maintain spatial orientation
  - Help develop landmark / route knowledge
  - Foundations for distance / direction estimation
- Local vs. global landmarks
- Design guidelines
  - Use clearly distinguishable visual characteristics

4.2.6 Trails

- Help users retrace their steps

4.2.7 Audio and Olfactory Cues

- Speech to explain a route to a user (car navigation systems)
- Distinct smell of objects

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5. Evaluating Wayfinding Aids

- Time-to-target tests
  - Efficiency gains/losses due to a wayfinding aid
- Path analysis
- Layout sketches drawn by user

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6. Design Guidelines

- Match the cue to the task
- Match the cue to users‘ skill
- Don‘t make cues dominant features
- Choose input devices providing real motion cues if possible
- Avoid teleportation
- Integrate travel and wayfinding components

Thank you!