Evaluating Motion Constraints for 3D Wayfinding in Immersive and Desktop Virtual Environments

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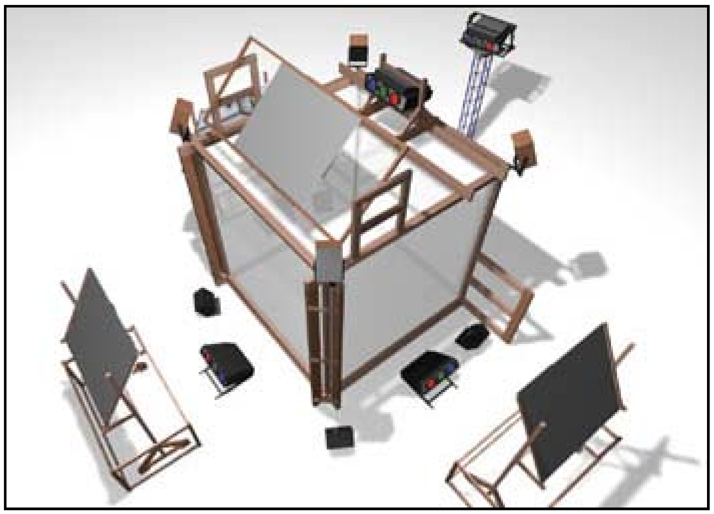
The Challenge



vs

- 3D motion constraints!

Outline

- Problem
- Design space: Wayfinding in 3D
- Solution: Motion constraints
- User study
- Results and discussion
- Conclusions and future work

Problem

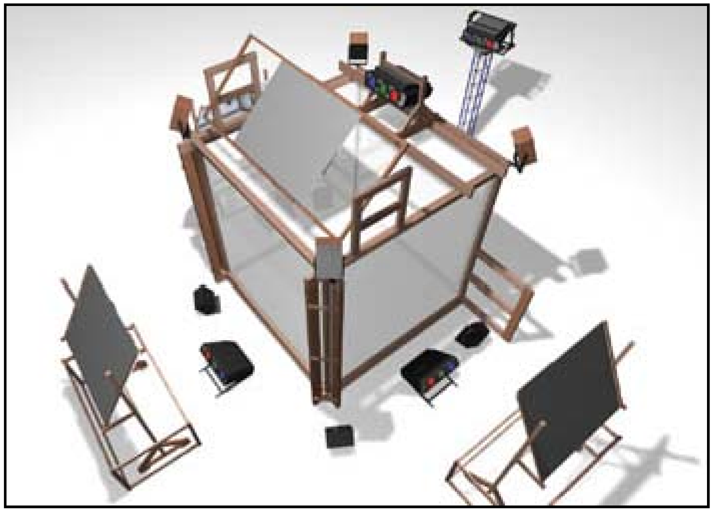
- **Wayfinding**: navigation to solve specific task
  - Performed on cognitive map
  - Poor map leads to poor performance
- **Objective**: support wayfinding by aiding cognitive map building
  - Motion constraints and guides
  - **Example**: sightseeing tour of new city

Virtual vs. Physical Worlds

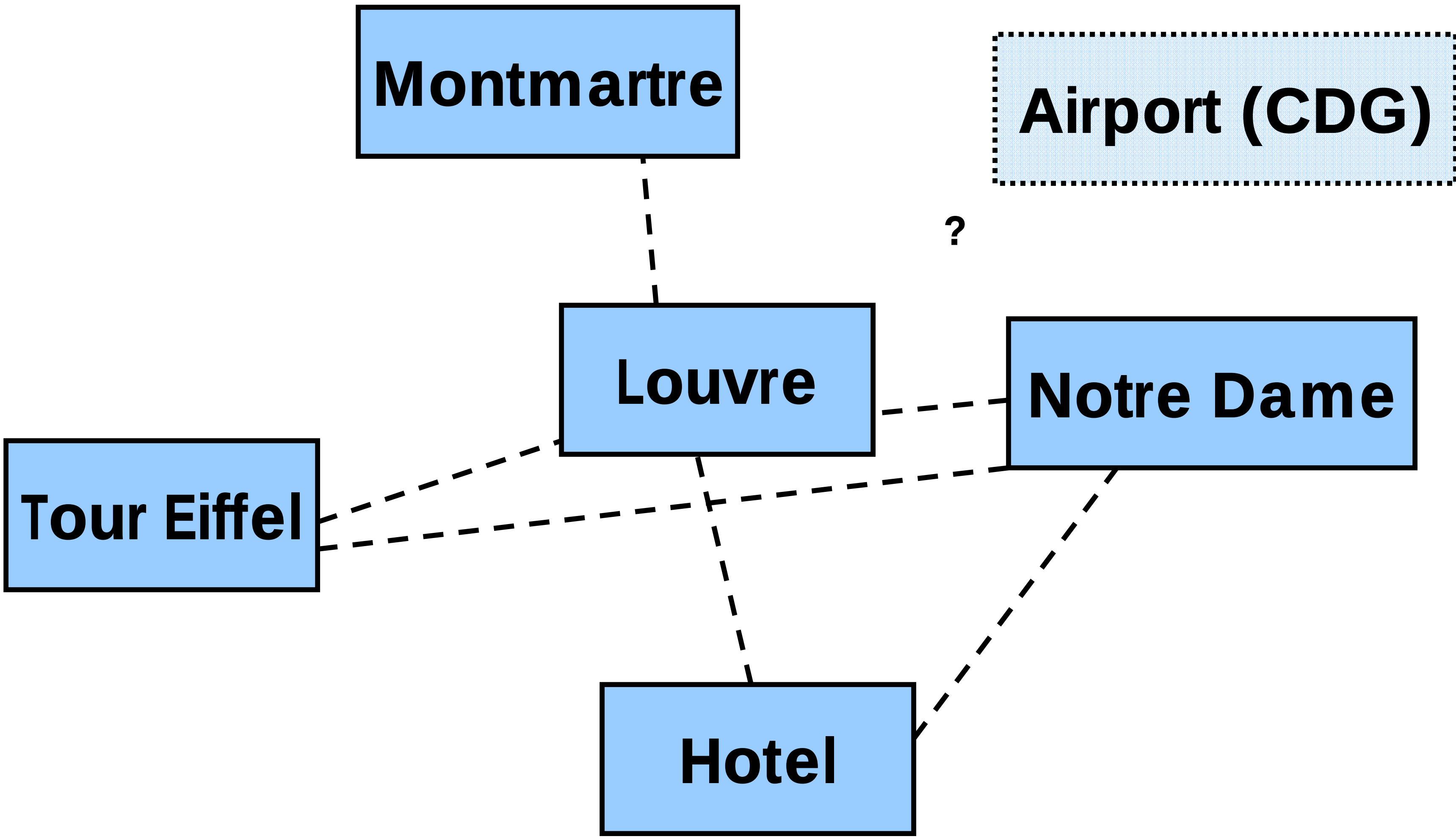
- Why is wayfinding more difficult in virtual worlds?
  - Low visual fidelity
  - Mouse and keyboard poorly mapped to 3D navigation
  - Lack of sensorial cues
- High cognitive load on users

Reducing Cognitive Load

- **Method**: Immersive Virtual Reality
  - Full 3D input
  - Full 3D output
- **But**: No widespread use, expensive (?)
- Mouse and keyboard are standard
  - Even for 3D games!

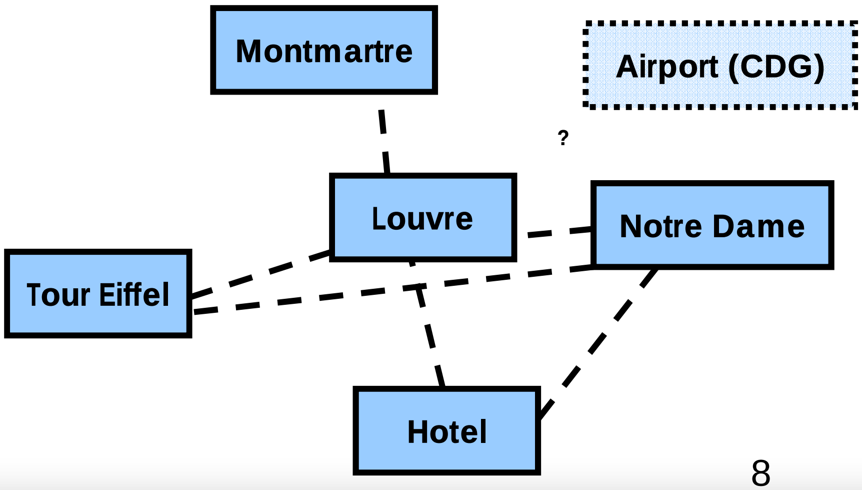


Cognitive Maps



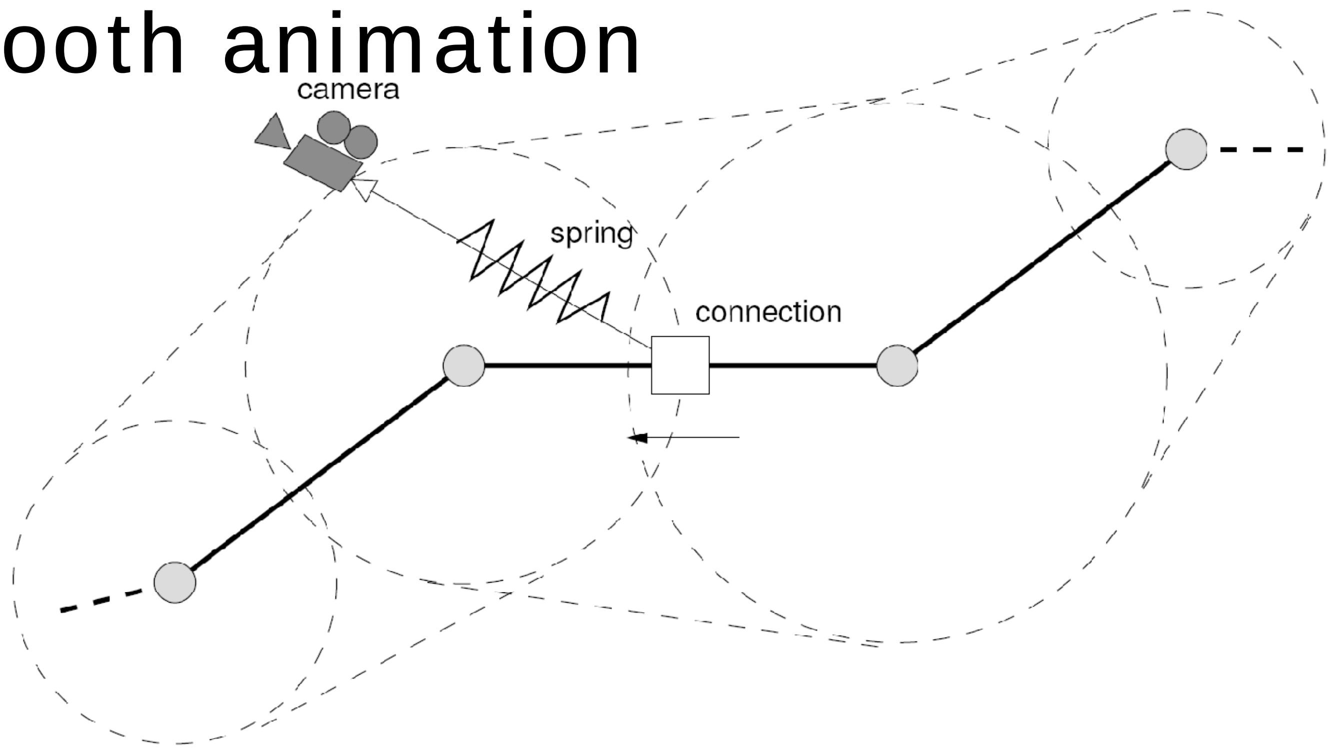
Supporting Cognitive Maps

- Global coverage
  - Expose viewer to whole environment
- Continuous motion
  - Support spatial relations
- Local control
  - Learning by doing



3D Motion Constraints

- Tour-based motion constraints
- Spring-based control
- Smooth animation

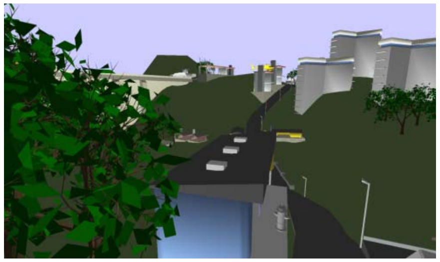


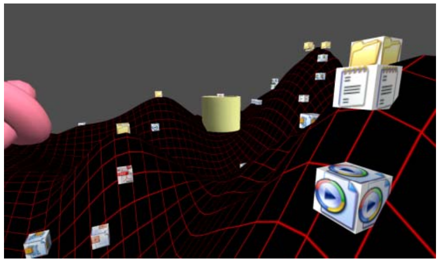
User Study

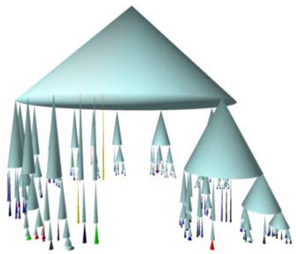
- Predictions
  - **P1**: Guiding navigation helps wayfinding
  - **P2**: User control will improve familiarization
  - **P3**: More improvement for desktop
- Controlled experiment
- Two experiment sites
- 35 participants
  - 16 (4 female) on desktop computer
  - 19 (2 female) on CAVE system

Experimental Conditions

- **Platform (BS)**: desktop or CAVE
- **Navigation (BS/WS)**: free, follow, spring
- **Scenario (WS)**: outdoor, indoor, infoscape, conetree
- Collect distance, error, and time





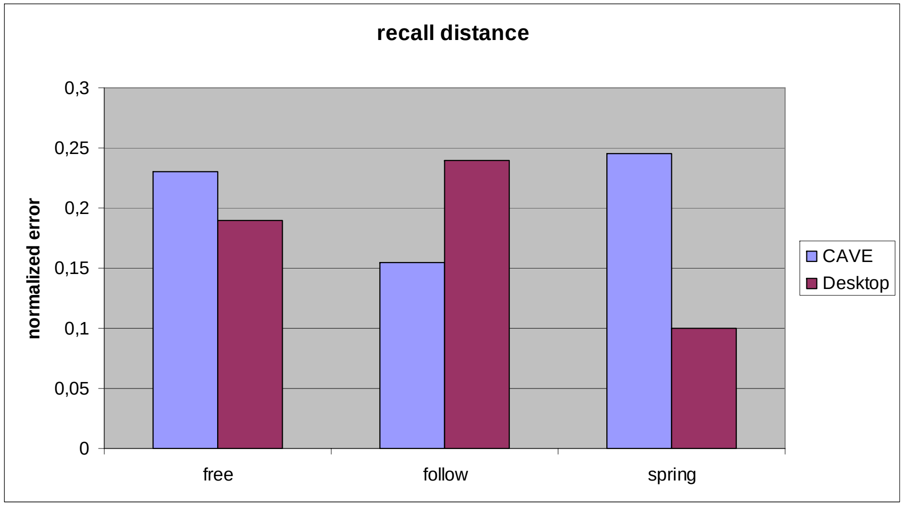


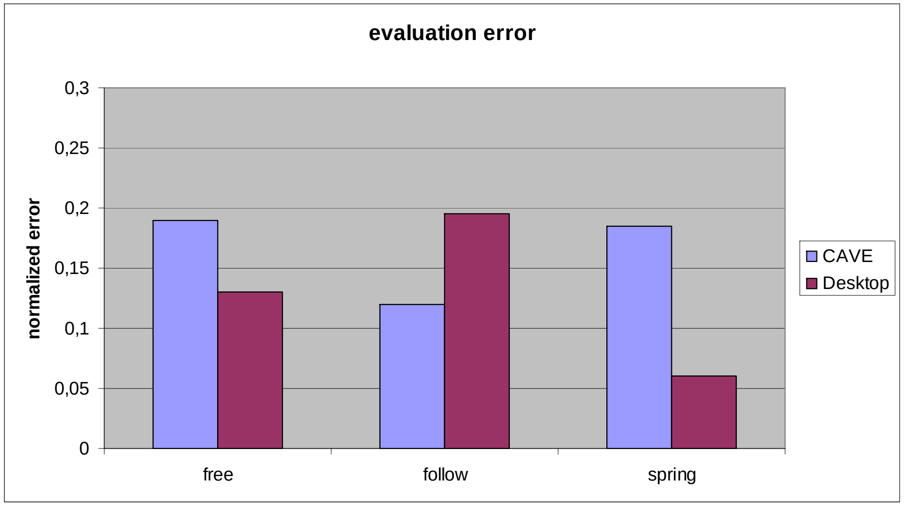
Procedure

- **Phase I**: Familiarization
  - Create cognitive map (5 minutes)
  - Supported by guidance technique
  - Three target object types
- **Phase II**: Recall
  - Locate two targets on overhead map
- **Phase III**: Evaluation
  - Collect target in world
  - No navigation guidance

Results

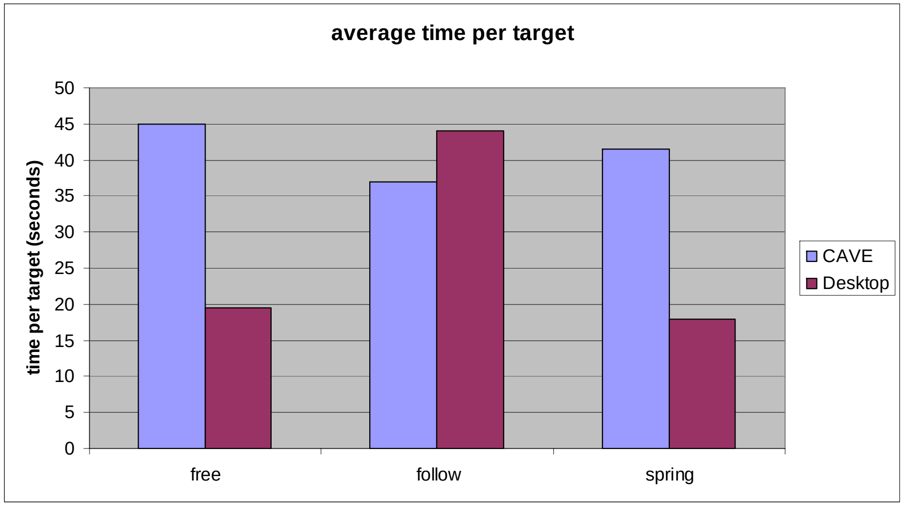
- **Navigation method**:
  - Free navigation: CAVE better
  - Motion constraints: desktop significantly better ($p < 0.05$)





Results (cont'd)

- **Desktop platform**:
  - Spring-based guidance gave better accuracy than other methods
  - Navigation guidance more efficient than none



Discussion

- Unaided navigation easier in CAVE
- Guidance improved performance (P1)
  - Guidance reduces cognitive load
- Local control improved accuracy (P2)
  - Learning by doing works for desktops
- CAVE performed worse with guidance
  - Motion constraints work against
  - Partial confirmation of P3

Conclusions and Future Work

- Navigation guidance based on tours
  - Improve cognitive map building
  - Improve visual search
- Evaluation on desktop and CAVE
  - Navigation guidance on desktop outperforms CAVE
  - Less focus on interaction mechanics

Questions?

- **Main findings:**
  - Free-flight best on immersive platforms
  - Motion guidance helped desktop users outperform CAVE users
  - Allowing local deviations improved correctness for desktop

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