PaperLens: Advanced Magic Lens Interaction Above the Tabletop

Martin Spindler, Sophie Stellmach, Raimund Dachselt

User Interface & Software Engineering Group
University of Magdeburg, Germany

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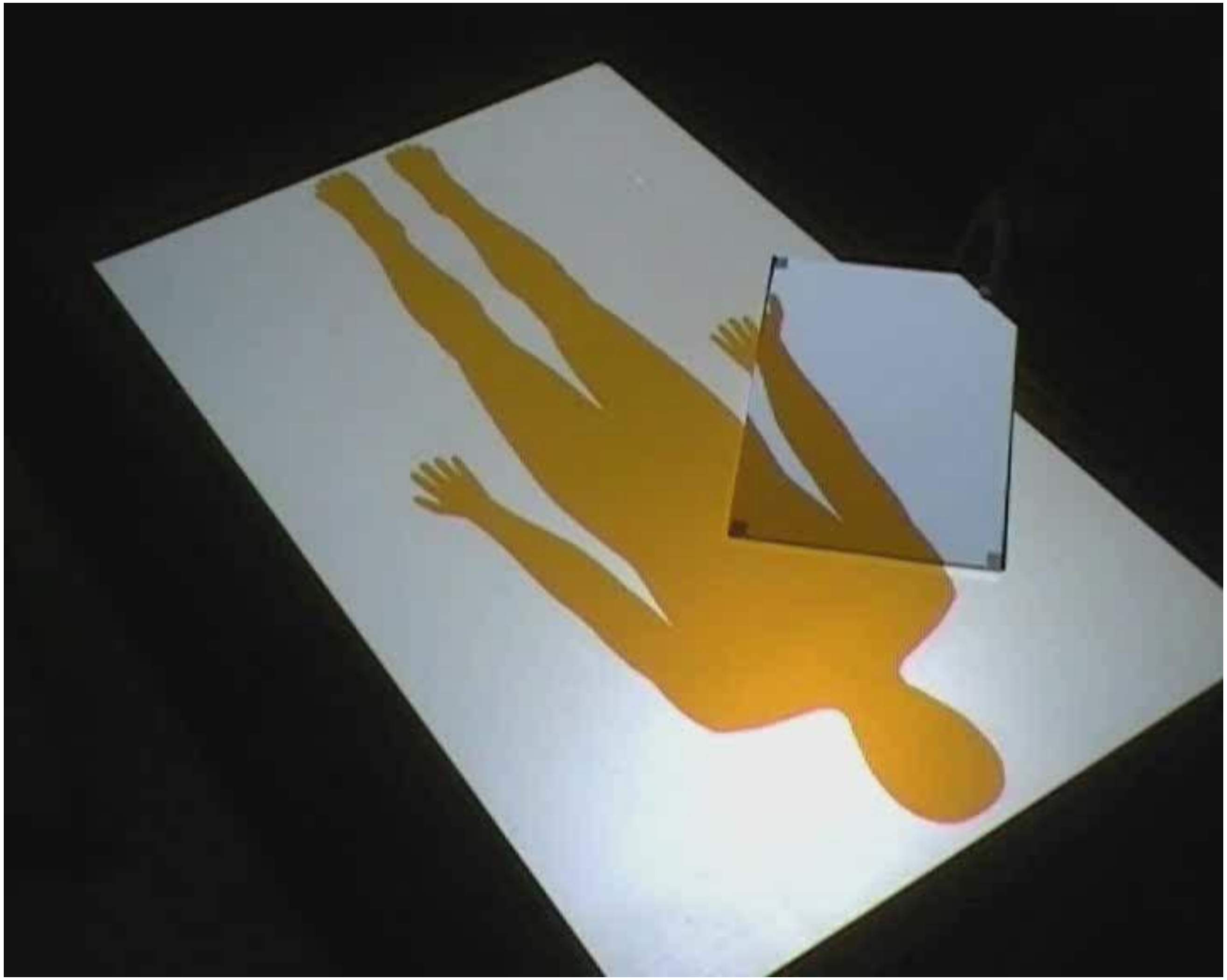
Outline

- Motivation and Approach
- Related Work
- Spaces and Applications
- Technical Approach
- Evaluation
- Conclusion

Motivation

- Information Spaces
  - Increasingly larger and more complex
  - Examples
    - Sets of volumetric data, e.g. CT and MRI Scans
    - Geographic Information Systems
    - High resolution imagery, e.g. Gigapixel pictures
- Improved Displays
  - Huge interactive Displays
  - Multiple Display Environments
- Problems
  - Limited display size for data exploration
  - Interaction techniques mostly limited to 2D surfaces
    - Multitouch, digital pens, tangibles, …

Our Approach in a Nutshell

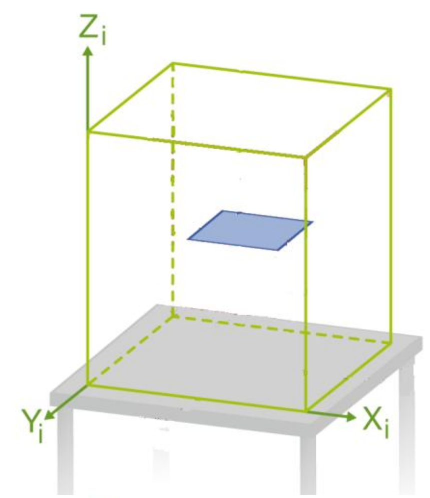


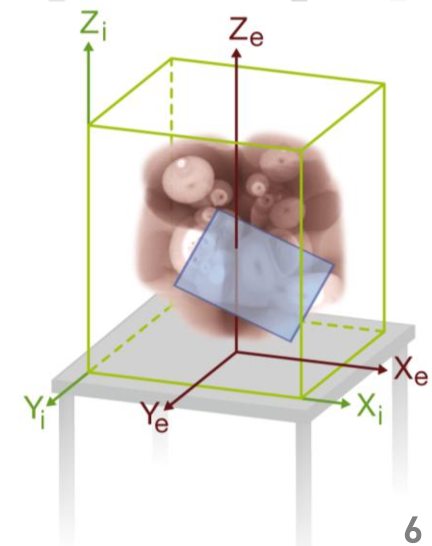
Selected Related Work

- GUI Magic Lenses [Bier et al. SIGGRAPH 93]
- Tangible Magic Lenses: metaDESK [Ullmer & Ishii UIST 97]
- Active Lenses [Fitzmaurice 93, Small & Ishii CHI 97, Yee CHI 03, …]
- Passive Display Approaches
  - Top-projected paper: e.g. Paper Windows [Holman et al. CHI 05]
  - Switchable Diffuser: Second Light [Izadi et al. UIST 08]
  - Optical superimposition: UlteriorScape [Kakehi & Naemura TT 08]
- Shortcomings
  - Often complicated, expensive or heavy hardware
  - Volume above displays rarely used
- Pen Interaction above the Surface
  - Multi-Layer Interaction [Subramanian et al. UIST 06]

Concept of PaperLens Interaction

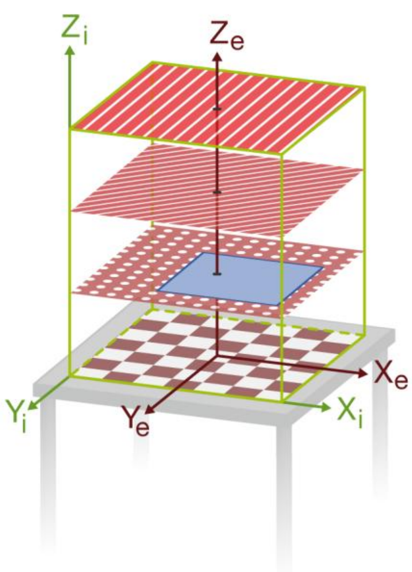
- Lightweight Magic Lens as a window into virtuality
  - With tabletop display: detail & context
- Interaction Space
  - Real 3D interaction volume
  - Moving a tracked lens (sheet of paper)
    - Translation on XY plane
    - Depth translation along Z axis
    - Tilting (Rotation in XYZ space)



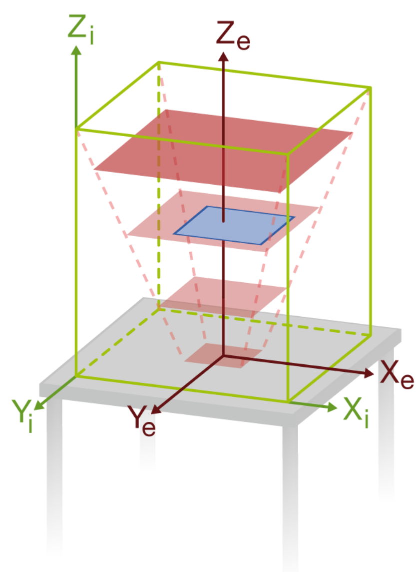


- Explorable Information Space
  - Virtual volume for various types of data
  - 2D and 3D information spaces

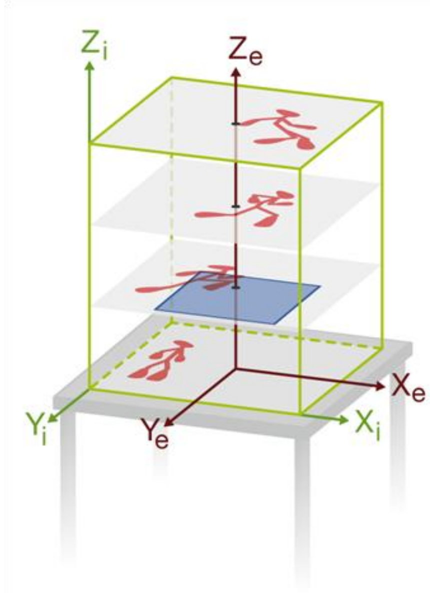
Classification of Explorable Information Spaces



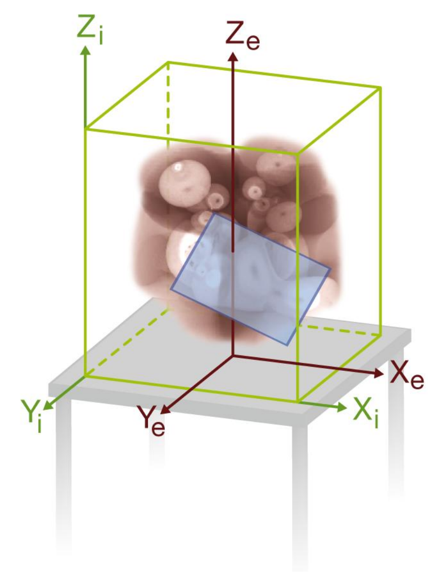
Layered



Zoomable



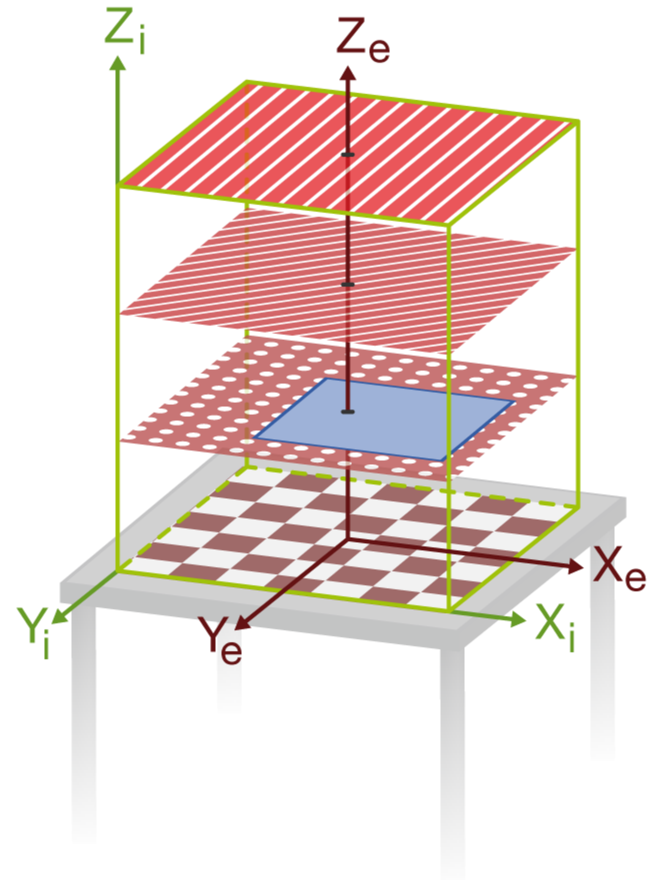
Temporal



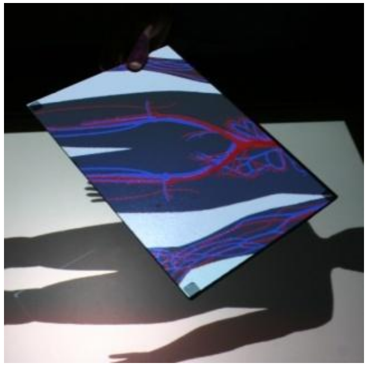
Volumetric

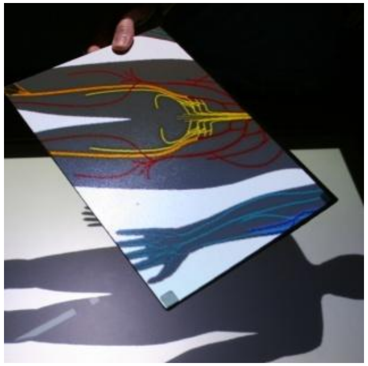
Layered Information Space

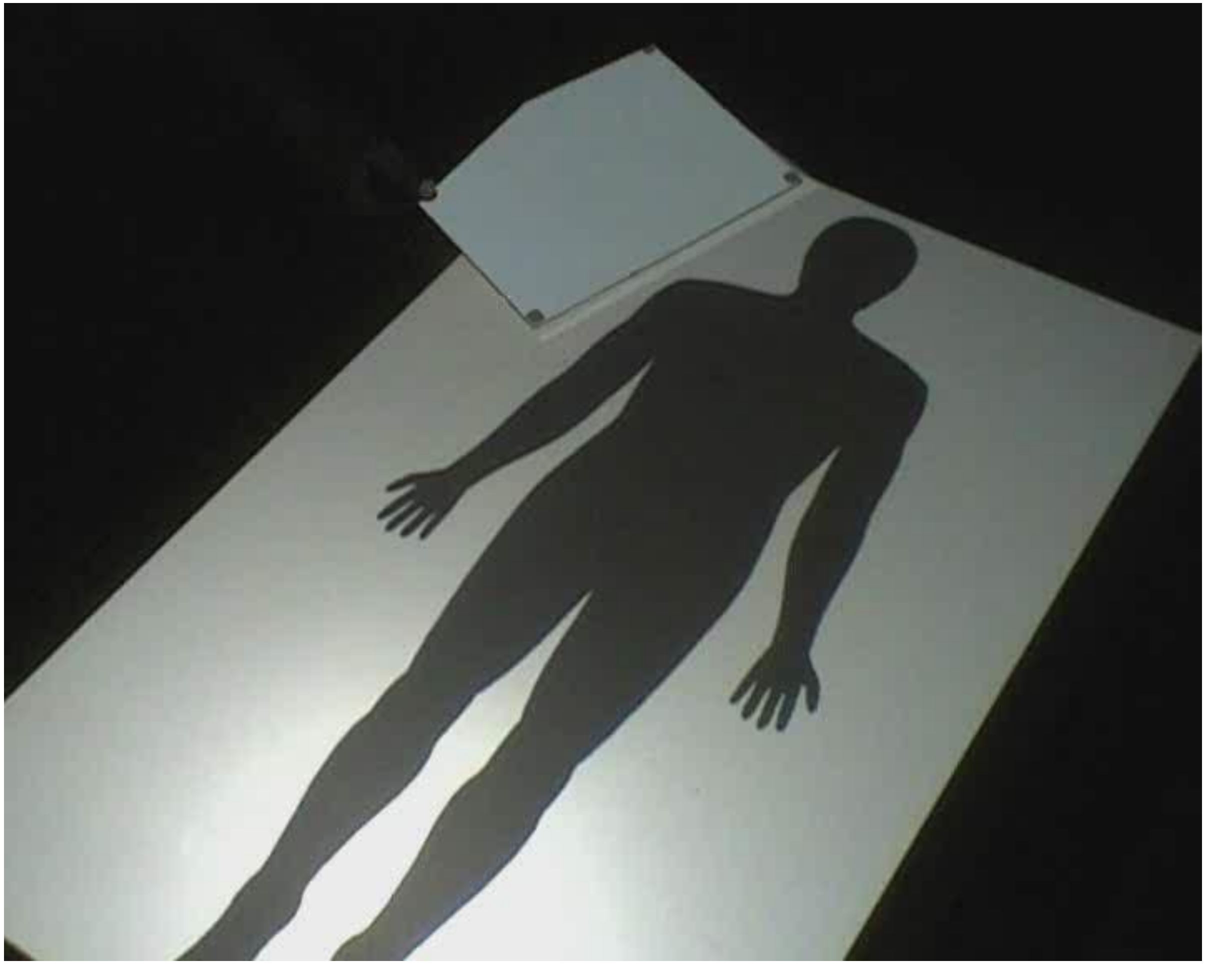
- Layered Data
  - Set of layered 2D data
  - Continuous within 2D plane
  - Each layer represents a unique feature of a contextual model
  - Construction of a “layered volume”
- Application Scenarios
  - Geographic Information Systems
  - Different filter types or rendering styles



Layered Information Space: Prototype

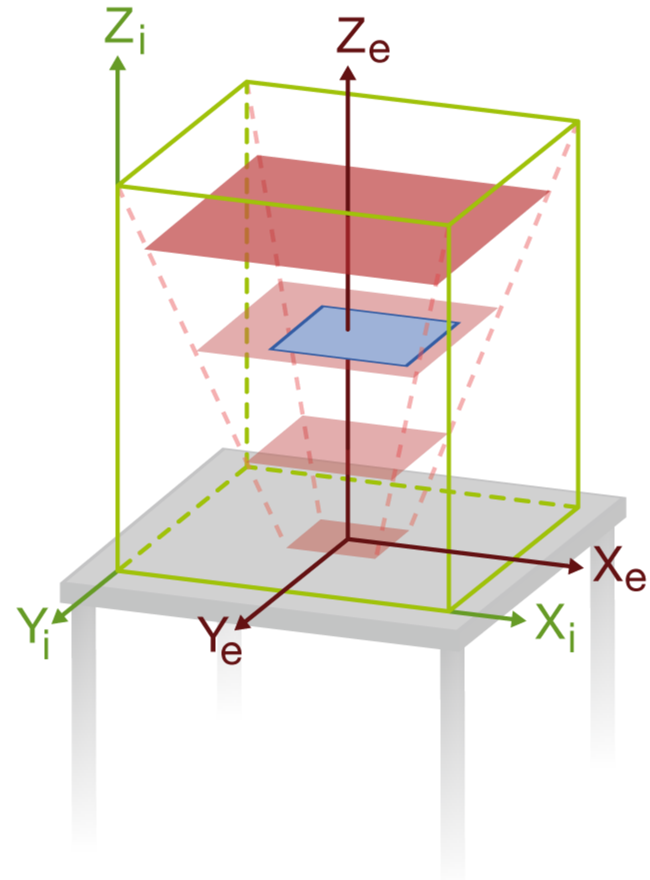






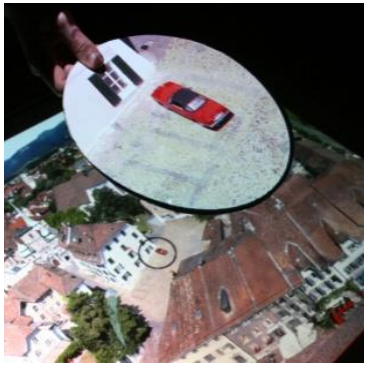
Zoomable Information Space

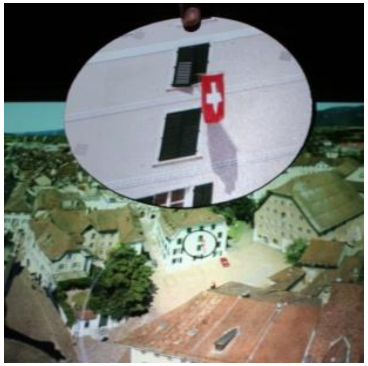
- “Zoomable” Data
  - Large continuous 2D worlds
  - Usually extend far beyond tabletop
  - Space-scale diagrams as in [Furnas and Bederson 1995]
  - Pyramidal representation of data

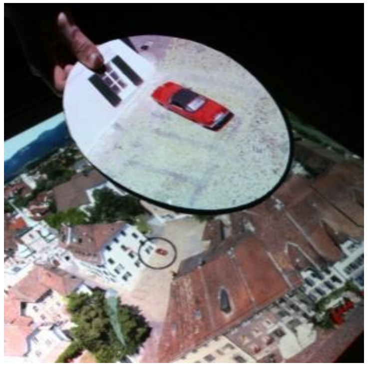


- Application Scenarios
  - High resolution imagery, e.g.
  - Satellite pictures
  - “Gigapixel” images

Zoomable Information Space: Prototype

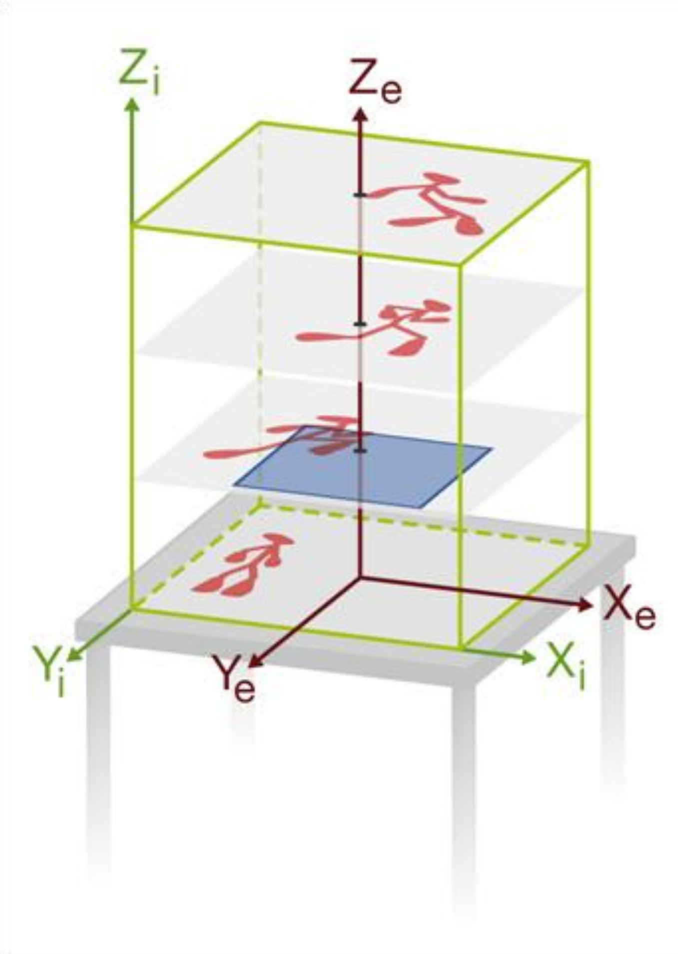




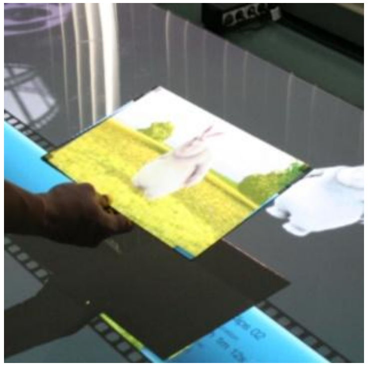


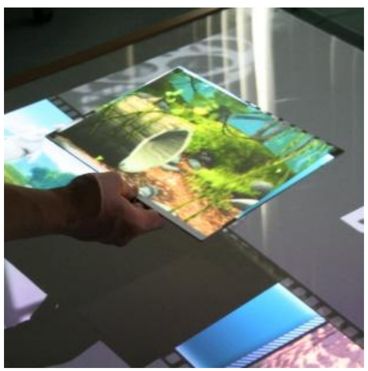
Temporal Information Space

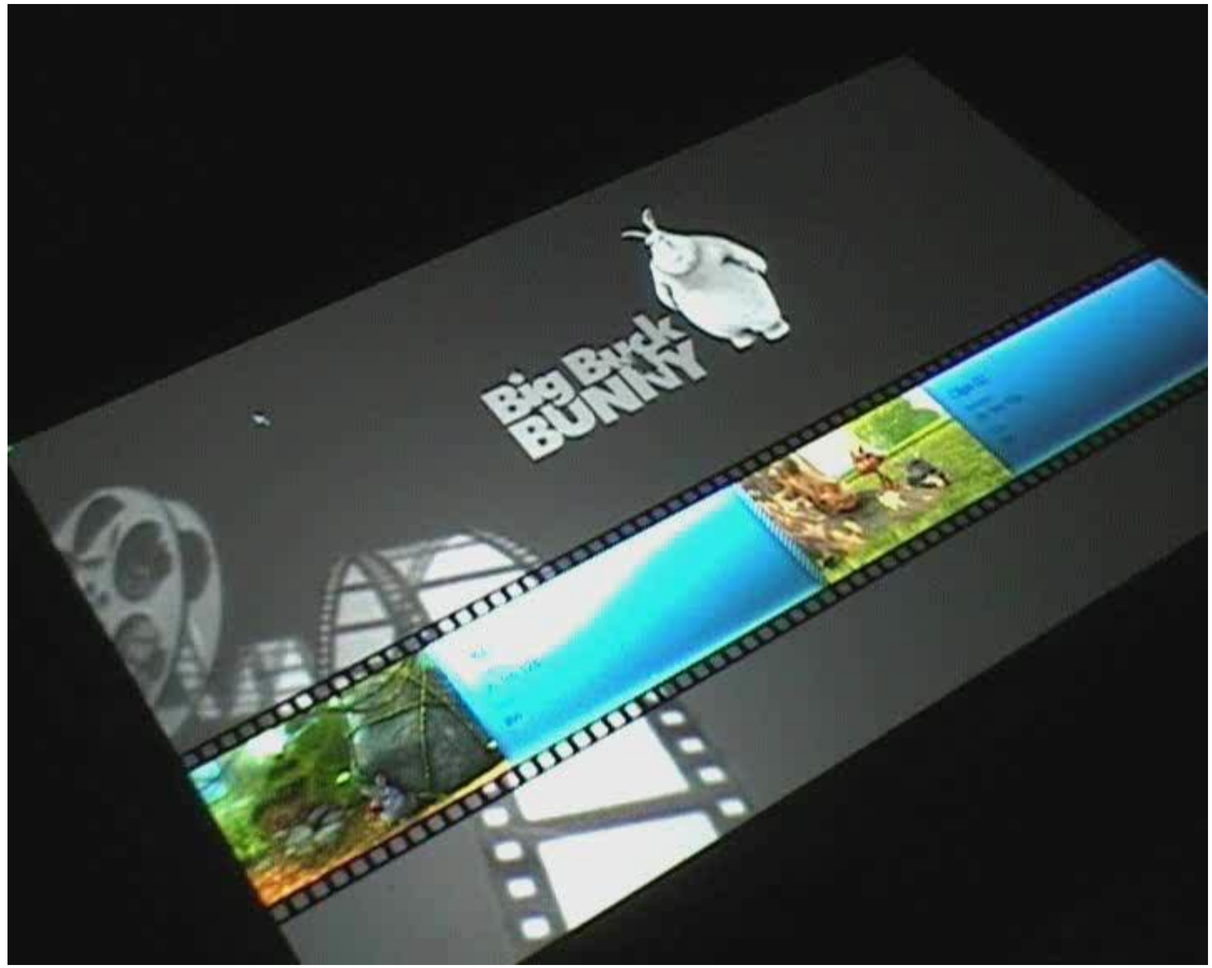
- Temporal Data
  - Time-dependent 2D data
  - Creating a “time volume” by stacking time frames
  - Z-axis represents time
- Application Scenarios
  - Explore video snippets, e.g. surveillance videos
  - Study more abstract time data, e.g. weather data



Temporal Information Space: Prototype

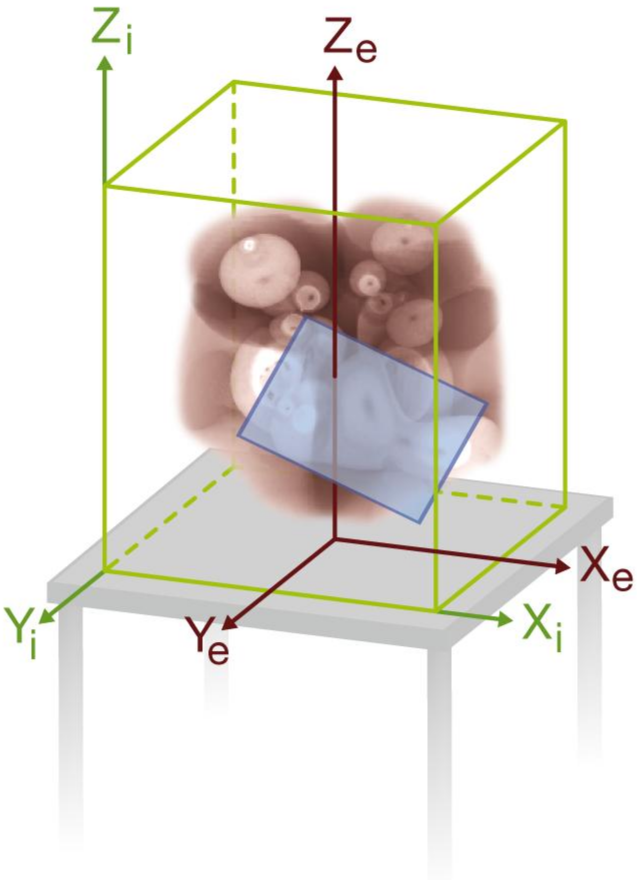




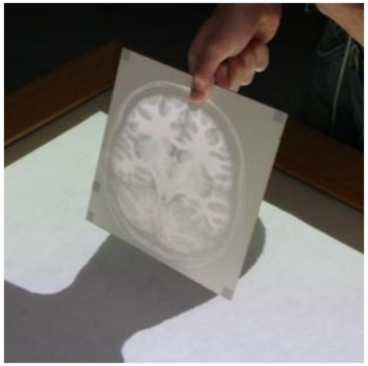


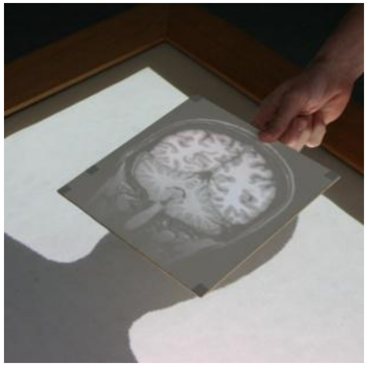
Volumetric Information Space

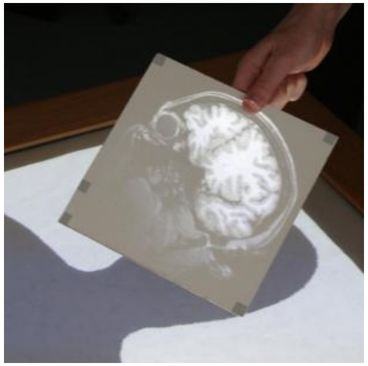
- Volumetric Data
  - Set of 3D samples (voxels)
  - Continuous in all 3 dimensions
  - Inherent volume
- Application Scenarios
  - Typical 3D data from medical or geological domain, e.g. CT scans
  - Pre-surgery planning
  - Detecting oil or gas reservoirs

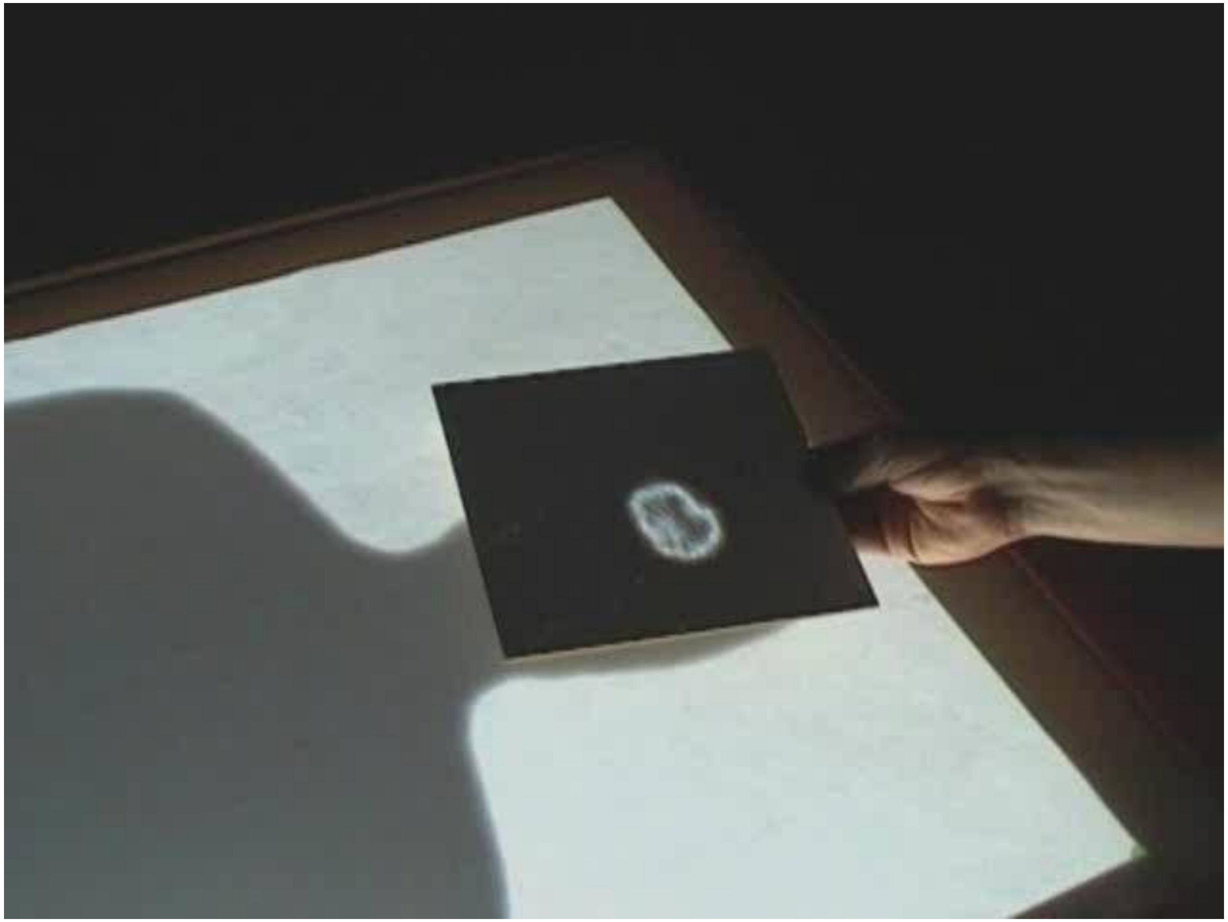


Volumetric Information Space: Prototype



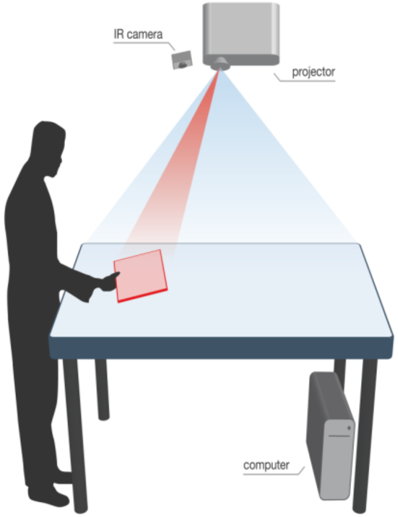




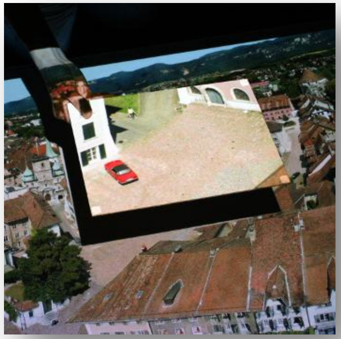


Technical Approach

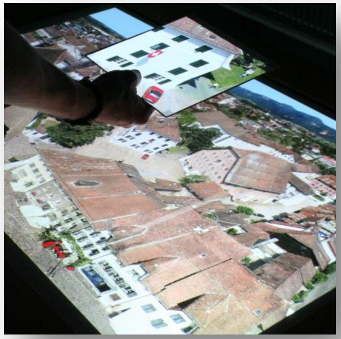
- Principle setup
  - Tabletop
  - Tangible Magic lens
  - Infrared (IR) camera
  - Top-projector



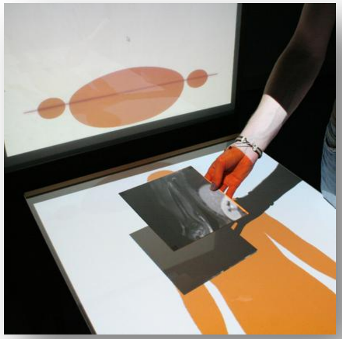
- Display configurations
  - Lens is always top-projected



Top-projected tabletop (with shadow)



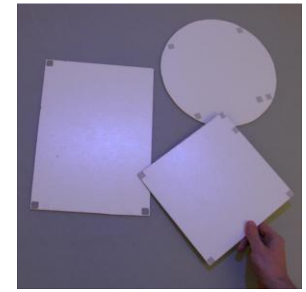
Back-projected tabletop (without shadow)



Additional vertical display

Technical Approach

- Lens design
  - Piece of paper or pressboard
  - Cheap and lightweight
  - Arbitrary shapes: rectangle, circle, square, …
  - IR-reflective markers



- Tracking
  - IR-camera: Optitrack Flex V 100
  - Three-marker tracking (no tilting)
  - Four-marker tracking (limited tilting)

- Perspective correction
  - Real world technical setup is modeled in OpenGL
  - Lens content using textures

Evaluation

- User study design
  - Formative users study, within-subjects design, 12 participants
  - Tasks: explore information spaces (without explanation)
- Results
  - Easy to learn, easy to use
  - Problems with keeping height in a particular layer
    - *"Selected Layer should be thicker"* (N=3)
    - Complaints about *"abrupt and unpredictable changes of layers"* (N=7)
    - Request of *"blending of layers"* (N=4)
  - Tilting of lens with increasing height
- Proposed navigational aids and layer techniques
  - Several layer arrangements (see paper)
  - Projected contour lines, Height indicator (see poster)

Conclusion

- Contributions
  - Cheap, lightweight and robust tangible display solution
  - Classification of explorable information spaces: *layered, zoomable, temporal, and volumetric*
  - Metaphor: height above tabletop + visual context
  - Various application prototypes
  - Proposed navigational aids and layer techniques

- Future Work
  - Follow-up study on navigational aids and layer techniques
  - Multiple lenses for collaborative work
  - Selection and manipulation techniques (see poster)

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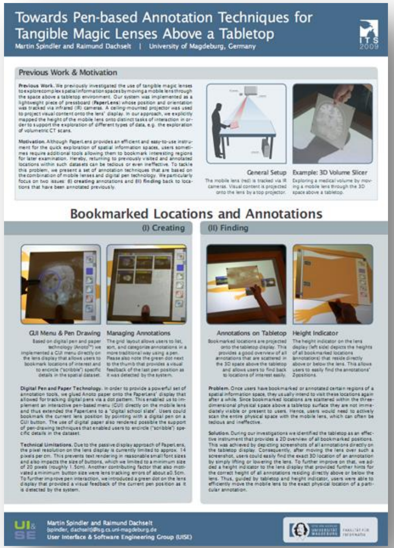
Martin Spindler: spindler@ovgu.de
Raimund Dachselt: dachselt@acm.org
http://wwwisg.cs.ovgu.de/uise/


Towards Pen-based Annotation Techniques for Tangible Magic Lenses Above a Tabletop

Martin Spindler and Raimund Dachselt | University of Magdeburg, Germany

Previous Work & Motivation

Bookmarked Locations and Annotations

(I) Creating

(II) Finding

Also see our poster!

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