

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

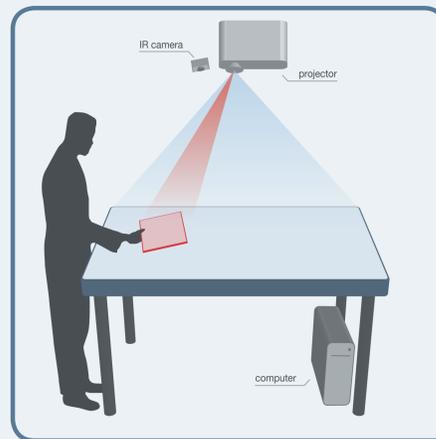
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## Previous Work & Motivation

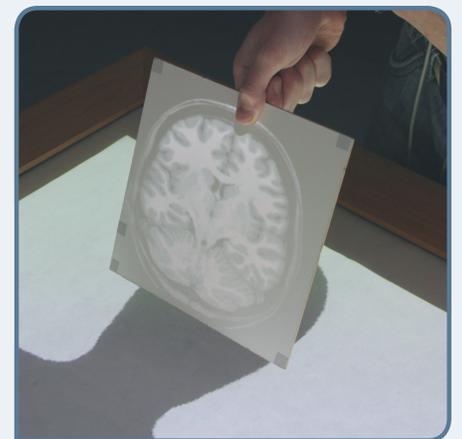
**Previous Work.** We previously investigated the use of tangible magic lenses to explore complex spatial information spaces by moving a mobile lens through the space above a tabletop environment. Our system was implemented as a lightweight piece of pressboard (**PaperLens**) whose position and orientation was tracked via infrared (IR) cameras. A ceiling-mounted projector was used to project visual content onto the lens' display. In our approach, we explicitly mapped the height of the mobile lens onto distinct tasks of interaction in order to support the exploration of different types of data, e.g. the exploration of volumetric CT scans.

**Motivation.** Although PaperLens provides an efficient and easy-to-use instrument for the quick exploration of spatial information spaces, users sometimes require additional tools allowing them to bookmark interesting regions for later examination. Hereby, returning to previously visited and annotated locations within such datasets can be tedious or even ineffective. To tackle this problem, we present a set of annotation techniques that are based on the combination of mobile lenses and digital pen technology. We particularly focus on two issues: **(I) creating** annotations and **(II) finding** back to locations that have been annotated previously.



### General Setup

The mobile lens (red) is tracked via IR cameras. Visual content is projected onto the lens by a top projector.



### Example: 3D Volume Slicer

Exploring a medical volume by moving a mobile lens through the 3D space above a tabletop.

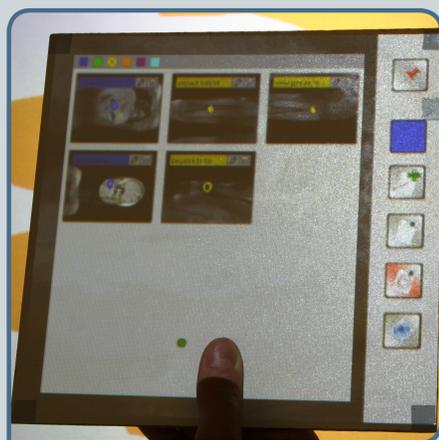
## Bookmarked Locations and Annotations

### (I) Creating



#### GUI Menu & Pen Drawing

Based on digital pen and paper technology (Anoto™) we implemented a GUI menu directly on the lens display that allows users to bookmark locations of interest and to encircle ("scribble") specific details in the spatial dataset.



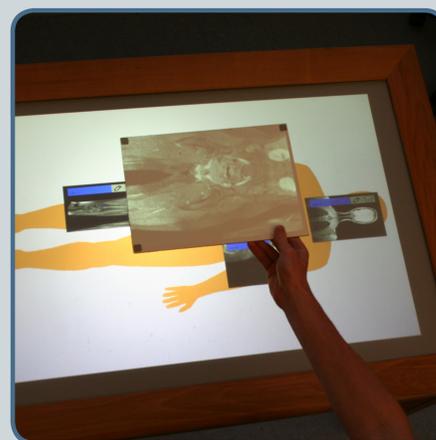
#### Managing Annotations

The grid layout allows users to list, sort, and categorize annotations in a more traditional way using a pen. Please also note the green dot next to the thumb that provides a visual feedback of the last pen position as it was detected by the system.

**Digital Pen and Paper Technology.** In order to provide a powerful set of annotation tools, we glued Anoto paper onto the PaperLens' display that allowed for tracking digital pens via a dot pattern. This enabled us to implement an interactive pen-based menu (GUI) directly on the mobile lens and thus extended the PaperLens to a "digital school slate". Users could bookmark the current lens position by pointing with a digital pen on a GUI button. The use of digital paper also rendered possible the support of pen-drawing techniques that enabled users to encircle ("scribble") specific details in the dataset.

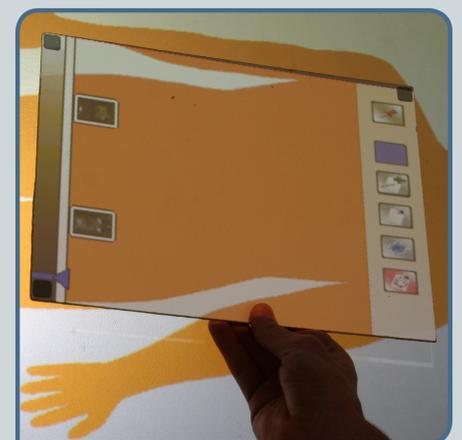
**Technical Limitations.** Due to the passive display approach of PaperLens, the pixel resolution on the lens display is currently limited to approx. 14 pixels per cm. This prevents text rendering in reasonable small font sizes and also impacts the size of buttons, which we limited to a minimum size of 20 pixels (roughly 1.5cm). Another contributing factor that also motivated a minimum button size were lens tracking errors of about  $\pm 0.5$ cm. To further improve pen interaction, we introduced a green dot on the lens display that provided a visual feedback of the current pen position as it is detected by the system.

### (II) Finding



#### Annotations on Tabletop

Bookmarked locations are projected onto the tabletop display. This provides a good overview of all annotations that are scattered in the 3D space above the tabletop and allows users to find back to locations of interest easily.



#### Height Indicator

The height indicator on the lens display (left side) depicts the heights of all bookmarked locations (annotations) that reside directly above or below the lens. This allows users to easily find the annotations' Z-positions.

**Problem.** Once users have bookmarked or annotated certain regions of a spatial information space, they usually intend to visit these locations again after a while. Since bookmarked locations are scattered within the three-dimensional physical space above a tabletop surface they are not immediately visible or present to users. Hence, users would need to actively scan the entire physical space with the mobile lens, which can often be tedious and ineffective.

**Solution.** During our investigations we identified the tabletop as an effective instrument that provides a 2D overview of all bookmarked positions. This was achieved by depicting screenshots of all annotations directly on the tabletop display. Consequently, after moving the lens over such a screenshot, users could easily find the exact 3D location of an annotation by simply lifting or lowering the lens. To further improve on that, we added a height indicator to the lens display that provided further hints for the correct height of all annotations residing directly above or below the lens. Thus, guided by tabletop and height indicator, users were able to efficiently move the mobile lens to the exact physical location of a particular annotation.