

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

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## ABSTRACT

Mobile lenses above a tabletop are a powerful instrument for the quick exploration of spatial or volumetric information spaces (e.g. MRT data). During exploration, users occasionally want to capture and annotate parts of the dataset. However, 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.

## Author Keywords

Spatially aware displays, digital pen interaction, multi-layer interaction, three-dimensional space, tangible interaction

## ACM Classification Keywords

H.5.2.i Information Interfaces and Representation (HCI): Interaction Styles

## INTRODUCTION

A new trend in surface interaction aims at leaving the two-dimensional surface in order to employ the 3<sup>rd</sup> dimension as a novel mean of interaction. For example, Subramanian et al. [3] extended the design space of digital tables by dividing the room between user and tabletop into multiple parallel planes with each plane corresponding to a single layer. These layers could then be interacted with via spatially aware digital pens, while the tabletop provided a visual feedback.

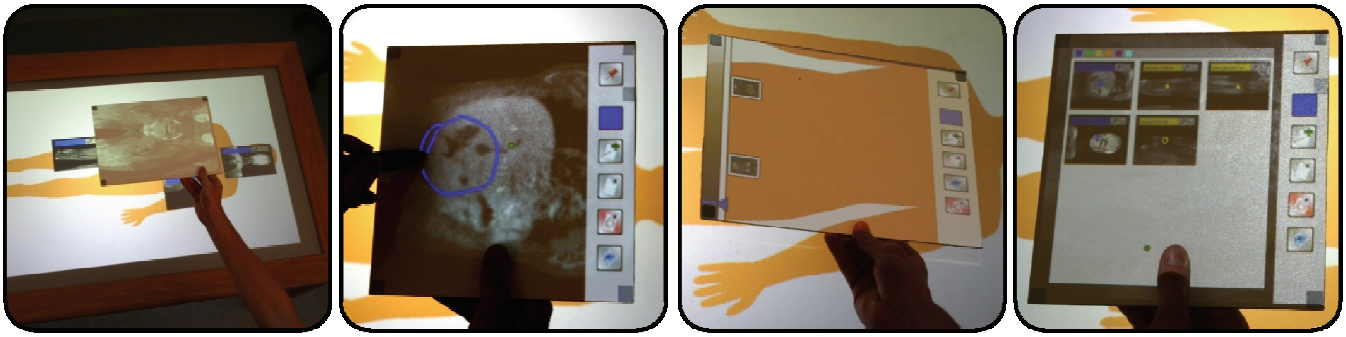
In [2], we investigated the use of tangible magic lenses to explore complex spatial information spaces by moving a mobile lens (PaperLens) through the space above a tabletop environment (see Figure 1a). The PaperLens was implemented as a lightweight piece of pressboard whose position and orientation was tracked via an infrared (IR) camera and IR-reflective markers attached to the lens. A ceiling-mounted projector was used to project visual content onto the lens' display (passive 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. These tasks comprised the exploration of volumetric (CT scans), layered (geographic information systems), zoomable (Gigapixel images), as well as temporal (videos) information spaces.

Although these techniques provided an efficient and easy-to-use instrument for the quick exploration of such information spaces, users sometimes require additional tools allowing them to bookmark interesting regions for later examination. Surgeons, for instance, might want to quickly earmark potential tumor areas in a volumetric CT scan and then, later on, analyze these sections more thoroughly. Hereby, usually two major tasks play an essential role: (I) to bookmark certain locations of interest and to annotate them, and (II) to find back to these locations afterwards. In the following, we will briefly introduce a set of interaction techniques that will address both issues.

## CREATING BOOKMARKS & ANNOTATIONS

When exploring spatial information spaces, users often examine specific locations in more detail and therefore must hold the mobile lens stable in a certain position over a longer period of time. Hereby, the problem of fatigue can diminish the overall user experience. To compensate for that, a "freeze" mode can allow users to move a mobile lens without changing its content. Beyond that, it is not very unlikely that users intend to examine previously visited locations of interest again after a while and thus need to be able to bookmark them. Furthermore, besides simply bookmarking locations, users casually want to be able to emphasize potentially small features in the dataset, add further comments, or presort regions into distinct categories for later elaboration.

In order to provide a powerful set of annotation tools that meets these requirements, we glued Anoto paper [5] onto the PaperLens' display [2] that allowed for tracking digital pens via a dot pattern. This enabled us to implement an interactive pen-based menu directly on the mobile lens and thus extended the PaperLens to a "digital school slate", similar to [4]. As depicted in Figure 1b, we added a GUI menu to the right side of the lens' display, with which users could freeze/unfreeze or bookmark the current lens location by pointing with a digital pen on a GUI button. In a similar manner, category selection was provided. Here, six categories were represented by color-coded buttons that the user could choose from. 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 with a pen (see Figure 1b, middle). Beyond that, we also provided handwritten pen-based text input allowing users to enter small fragments of text (comments and titles).



(a) Tabletop display showing a screenshot for each annotation to indicate their projected location (b) GUI menu and pen-drawing interaction on lens display based on digital paper technology [5] (c) Height indicator (left) depicting heights of all annotations residing directly above/below lens (d) The grid layout allows users to list, sort, and categorize annotations

**Figure 1: Mobile lens annotation techniques for spatial information spaces in a tabletop environment**

However, due to the passive display approach of PaperLens (see [2]), the pixel resolution on the lens 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 was lens tracking errors of about  $\pm 0.5$ cm. To further improve pen interaction, we introduced a green dot on the lens display (see Figure 1d, bottom, left to thumb) that gave a visual feedback of the current pen position as it was detected by the system.

#### FINDING BOOKMARKS & ANNOTATIONS

Once users have bookmarked or annotated certain regions of a spatial information space, they usually intend to visit these locations again after a while. For instance, a surgeon might want to discuss a potential tumor area with colleagues or wants to show it to the patient prior to surgery. Since bookmarks and annotations are scattered within the three-dimensional physical space above a tabletop surface, they are not immediately visible or present to users. Hence, users are either required to memorize all bookmarked locations or they need to scan the entire physical space again with the mobile lens, which can be tedious and ineffective. To tackle this problem, users need to be guided in order to find previously annotated locations more easily.

The approach we implemented first allowed users to actively scan the physical space for annotations by moving the lens. However, during our investigations we identified the tabletop as a more effective instrument that could be used for providing a 2D overview of the locations of all annotations. This was achieved by depicting screenshots of all annotations directly on the tabletop display (see Figure 1a). 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 (see Figure 1c). This technique was inspired by the concept of footprint scrollbars [1]. Thus, guided by screen-

shots and height indicator, users were able to efficiently move the mobile lens to the exact physical location of a particular annotation.

We also implemented other, more traditional techniques that aimed at providing a tool for listing, sorting and categorizing annotations. For this purpose, miscellaneous annotation properties – such as category color, timestamp, title/comment, and screenshot – are displayed directly on the lens display in various list and grid layouts that users could select from by using menu and pen techniques as described earlier (see Figure 1d). Hereby, annotations are dynamically arranged as intended by users, who, for instance, could choose to only show annotations of a certain category or to sort annotations according to the creation time.

#### CONCLUSION

In order to allow users to bookmark and annotate regions of interest in spatial information spaces, we have integrated digital pen and paper technology into PaperLens (mobile lens above a tabletop). We also implemented a set of navigational aids that help users finding back to previously bookmarked regions. For future work, we plan to improve our techniques by conducting a series of user studies.

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