Interstitial Space in MDEs for Data Analysis

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ABSTRACT

Multi-display environments comprise large shared displays as well as personal devices. In this work, we discuss how the interstitial space—the space between displays and devices—can also be made into an interactive space. Such a space can support collaborative data analysis by providing a focus+context workspace; providing a means to transition between collaborative and individual work, and by providing a means to transition tasks between devices.

INTRODUCTION

Multi-display environments are rich digital workrooms comprising wall-displays, tabletop displays and personal devices. These display ecologies represent great opportunities for collaborative data analysis: shared displays can facilitate group tasks, while personal devices can support independent tasks. Figure 1 illustrates an imaginary digital workroom with the typical large, high-resolution, interactive displays to which the research community has devoted much of its recent efforts. It also shows two spaces, the interstitial space (the space between displays) that we argue represents an interesting design opportunity for the community. While considerable effort has gone into designing interaction techniques and visualizations for what we typically consider as "interactive large displays," very little work has considered the interstitial space in these rooms, and in particular, the role that the space between the displays can play. In this position paper, we consider how this space can be used to support collaborative data exploration and analysis, and present several design factors for interstitial spaces that we seek to explore.

For explanatory purposes only, we describe here an imaginary instantiation of such spaces in a digital workroom. Interstitial space is comprised of surface space between displays. In this imaginary scenario, this interstitial space is made visible through a low-resolution projection onto both the walls and the ground in this digital workroom. These projected surfaces are not touch-interactive; instead, people interact with it by using their mobile devices as a proxy. If on the floor, users can interact with such spaces with their feet or through shadows. We can already see that conceptually, the MDE becomes a Focus+Context environment, where the interactive displays are the Focus, while the interstitial space provides Context. Yet, how can this space be leveraged to support the collaborative analysis process? Let us further examine the collaborative visual analysis process.

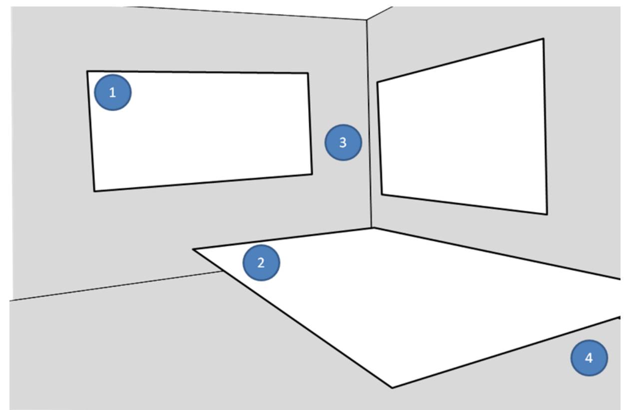

Figure 1. (1) and (2) are typical large shared displays in an MDE. (3) the wall, and (4) the ground are interstitial spaces that can be used to support auxiliary tasks or work as a scratch-pad for collaborative data analysis.

SUPPORTING COLLABORATIVE ANALYSIS

We outline three ways in which interstitial space might support collaborative analysis in MDEs. First, it may support specific "tasks" or "sub-processes" in a collaborative visual analysis process. Second, it might support transitions between shared and independent work. Third, it could be used to support transitions between different device types.

To begin, we focus on Isenberg and colleagues' work on the visual analysis process (2008). Here, the authors outlined several processes that individuals in a group engage in when analyzing visual data together: Browse, Parse, Discussion Collaboration Style, Establish Task Strategy, Clarify, Select, Operate, and Validate. Several of these processes intuitively map to how interstitial space could be used. During the "Browse" process, for example, people look through the data, implicitly sorting it into several piles based on how they might expect to use the data. Interstitial space could be used here for groups of items that may not seem as important (i.e. saving valuable "interaction" space). In so doing, it can also support a faster "Select" process, as items can remain visible without having to be "piled" into groups.

Another common design requirement arising out of studies of collaboration is to support fluid transitions between shared and independent tasks (i.e. collaborative work and independent work). Interstitial space can support this transition by providing a visible storage or transport medium for different workspaces. Moving different workspaces across to different displays through the interstitial space supports collaborators' awareness of what is happening in the workspace, and how work and tasks are being divided among individuals and sub-groups. For example, if data is to be examined by a sub-group or an individual, the interstitial space can be used as temporary "ether", a "scratch-pad" or as a space where content is placed temporarily for these or other individuals to retrieve at a later time. We hypothesize that allowing users to off-load their internal "scratch-pads" onto interstitial space will facilitate analysis on only core components to the task.

Finally, because devices and displays in MDEs are physically (and visually) detached from one another, interstitial space can actually function as a visual bridge between the devices. It can be used for visualizing the movement of content or information across devices and displays in such an ecology.

DESIGN FACTORS FOR INTERSTITIAL SPACES IN MDES

In these early stages, we have considered several factors that influence the design of interstitial space—factors that influence how it is realized, how it is interacted with, and the affordances it provides.

Conceptual model: transient vs. ambient. Prior work that has considered this interstitial space (Xiao et al., 2011) has primarily viewed this space for transient interaction. That is, content in this space is only intended to be here for a short period of time. This relates to our concept of it as being a visual transport medium for content—something like a "clipboard" for the MDE. It can also be leveraged to support collaborator awareness of our interactions in the workspace (e.g. Shoemaker et al., 2006). Yet, we can also consider it as a low-resolution ambient space that either: (a) exposes functionality to manipulate the high-resolution interactive space (e.g. controls for visualizations could be placed in interstitial space to save room from the actual workspace), (b) provides low-resolutions visualizations that react to the interactions taking place on the shared displays.

Organization: semantic vs. spatial. One thing to consider is how content is to be organized in interstitial space: will it be organized semantically, or spatially. Recently, researchers have considered reinventing the interface to exploit users' spatial memory, through semantic association of interface components with spatial layout. Interstitial space provides a larger repository that can further enable more associations. However, separating the organization either semantically or spatially can be left to designers based on the affordances they wish to embed.

Objects: dynamic vs. static. How should content in interstitial space appear?

Content: artefacts that relate to work / artefacts that relate to the people in the MDE. To this point, we have mainly considered that artefacts in interstitial space would be data elements related to the analysis. An alternative conceptualization of this would be to place content as it relates to individuals in the interstitial space in such a way that it tracks or follows individuals. This content could relate to their independent tasks, or be tools that relate to those individuals. Having this information track and follow along with an individual would provide easy access to it.

BASIC TASKS WITH INTERSTITIAL SPACE

There are some basic tasks that people will need to accomplish with interstitial space: placing and retrieving content from interstitial space, querying data in this space and making the results visible, deciding how to eliminate or erase content from this space. While these problems have received less consideration, several basic mobile device interaction techniques could be used to facilitate these tasks. For example, a mobile device could act as a peephole for shared displays (as in Boring et al., 2010). Users can simply 'scan' interstitial space with their mobile device to make 'invisible' content appear on it. Other mechanisms might include displaying interstial content in a minimalistic ways, using methods of world-in-minature (e.g. Biehl & Bailey, 2006), or even with mechanisms that provide accurate cues to off-screen content (e.g. Gustafson et al., 2008).

Yet, we envision that designing appropriate interaction techniques will rely on an understanding of how these spaces will be used in domains such as collaborative analysis. One method for developing this understanding is to study how the interstitial space is organized (i.e. study how people organize content within the space); second, to develop methods to provide people representations of this organization and content, and then finally to use this understanding to iteratively design interaction techniques.

A CASE FOR IMPROVED ANALYSIS

Our primary argument infers that interstitial space will augment traditional methods of analysis and data inquiry. We elaborate on this aspect by walking through a simple case.

Let's consider a group of two analysts (for simplicity) inquiring into a recent case of a hit-and-run incident in a city. The police inform them that potential witnesses implied that a cab driver was involved and provide the analysts with GPS data from that cab's company, based on the time interval of the incident. The analysts now have to prod the provided data to assist the police in determining the suspect.

Effect of interstitial space on on-the-fly queries. As suggested earlier, instead of employing object piles, analysts can off-load immediately unnecessary content into interstitial space. For example, the analysts may 'store' multiple forms of space-time views of the data and instead of having it clutter the usable space can have it placed on the 'side lines.' A view showing all cab movements (from the GPS) can be placed into this space, while the analysts explore city wide camera recordings. On demand, the analysts may query the route data, which can then be presented onto the primary display for analysis. Based on our hypothesis that such space can better facilitate semantic-spatial associations, retrieving objects of interest on demand will be highly efficient. We plan on studying the effectiveness of such forms of object placement/retrieval methods in comparison to more traditional methods for analytic outcomes.

Attributing relevance. In the analysis process, some information is more relevant than other. To avoid completely erasing that knowledge (as it may have taken the analysts some time to produce it), organization in interstitial space can attribute relevance to the derived information. For example, if the analysts have now attributed the incident on a handful of cab drivers, the history information in how these were obtained and the relevance associated to each item in history can be organized in IS space for later presentation. Such forms of history tracking typically require large trees or lists, which can be avoided if properly partitioned in this additional space.

Linking between alternative forms of analysis. Another feature of interstitial space that we leverage for this analytic task could be for linking between various steps taken by the two analysts. Analysts may at times be working separately on the same source of data and such spaces can provide a common ground among their individual approaches. For example, both analysts may have refined their inquiry such that only one piece of the information may be left to solve the problem. Data from interstitial space could be fused, by auxiliary routines (metaphorically that run in the background) to suggest a refined solution. By removing the back-and-forth comparisons away from their primary displays, analysts may be able to find better solutions to their problem.

CONCLUSIONS

We are in the early days of exploring the design space of multi-display environments. Whereas most researchers have focused their efforts (rightfully so) on the main interactive shared displays in these spaces, our focus in this position paper is to consider how the low-resolution interstitial space can be used to support collaboration. We have discussed how an interstitial space might be used to support analysis, as well as described a set of design factors that can guide exploration into this space.

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