Blended Interaction for Information Visualization

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Abstract
Thinking about interaction in information visualizations from the perspective of blended interaction may provide new freedoms that allow people to think about digital information in ways that fit more closely with their existing everyday thinking practises. We have performed two studies to gain a better understanding of everyday visual thinking practises and one study that investigates the use of multitouch-and-sketch-based interactions for creating basic visualizations. We highlight results from these studies that are particularly relevant to a discussion of blended interaction.

Author Keywords
Blended interaction; information visualization; externalization, sketching; qualitative studies

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. See:

Introduction
The ideas in blended interaction, which incorporate the integration of real and digital actions, offer many new opportunities to think beyond current information visualization (InfoVis) interaction paradigms. They may open up data exploration possibilities that are inspired by people's existing everyday thinking processes. For

example, exploring, analysing, and understanding large quantities of digital information remains a challenge. Blended interaction may augment InfoVis' mission to address this challenge by making interactive visual representations of data.

Our current research in interactive visualizations relates strongly to several of the concepts in blended interaction [3]. Consider, for instance, *externalization* [4], which encompasses the myriad of ways in which humans create and manipulate tangible, external representations of their thoughts as a process that aids their cognition. Externalization, according to Kirsh [4] occurs when we "reify an internal object of thought", in other words, when we turn a thought into something tangible and (usually) visible. Discussions of externalization often reference its usefulness as a memory aid, both for long-term storage and as a temporary holding place for things that don't fit into our working memory. However, Kirsh points out several other reasons why people externalize, among them creating a shareable representation of thought (useful for communication and for thinking together with others) and most importantly, to make our thought processes more efficient. Essentially, externalization is an ad-hoc *tool* that helps reduce the barriers to thinking about a given problem.

We aim to create information visualizations that blend the computational power of the underlying data with everyday externalization practises such as ad-hoc whiteboard sketching. This may enable people to think about digital information in ways more compatible with their own thinking practises.

Background

There is a series of discussions that relate closely to our recent research, including post-WIMP interaction [8]; natural user interfaces [12]; reality-based interaction [2]; and blended interaction [3]. Of these, we feel blended interaction captures most closely the spirit and long-term vision of our perspective.

Post-WIMP interactions include a variety of interactions that go beyond windows, mouse, menus, and pointing including instrumental, proxemic, and touch interactions [5]. Reality-based interaction as described by Jacob et al. suggests that "natural" interfaces benefit from mimicking reality [2]. More recently, Jetter et al.'s concept of blended interaction suggests taking elements from the real world (externalization practices in our applications) and integrating them in the computational domain, resulting in new interactions that have emergent possibilities [3]. For InfoVis, this concept of emergent interactions that can arise from integrating real-world activities with digital information is enticing. In our research we are exploring blending sketch-based practices with digital visual representations.

Recent research studies

To improve our understanding of how best to blend sketching practices with computational access to data, we have conducted three studies.

Visual Constructs on Whiteboards [9]:
In this study, we took snapshots of over 80 whiteboards in knowledge workers' offices at a large research institution. We analyzed these qualitatively from an information visualization perspective, focusing

on the visual constructs used and the usage of words vs. diagrammatic constructs.

Lifecycles of Sketches in Software Development [10]: To better understand the role of sketches in work practices, we interviewed eight people who develop software about the sketches that were important to their projects. From the interviews, we were able to extract and depict individual sketch lifecycles, detailing the transitions the sketches went through, the media they were created and re-created on (both digital and analog), and the contexts in which they were used.

Wizard of Oz: Pen and Touch for Data Exploration [11]: We performed a wizard of oz study on a prototype system for creating basic InfoVis charts on a pen-and-touch-enabled digital whiteboard. We were interested in seeing how people would approach interactively sketching information visualizations, so our system maximized participants' freedom to choose interactions and minimized used of menus and buttons.

Selected results

In combination, these studies illuminate several aspects that may be of interest to the developing theories of blended interactions. While a more complete synthesis of these results is in progress, in this paper we highlight a subset of the results with respect to the concept of blended interaction.

The importance of sketching

In our studies and in the literature there is ample evidence that, in everyday thinking situations, it is important that people are able to break free of the restrictions and inefficiencies of their digital tools and create freeform visual representations - sketches - of their thoughts. This sketching is a common type of externalization. Generally in a knowledge work environment, many kinds of ad-hoc sketches can be found on whiteboards, notebooks, and the proverbial napkins. Other studies of whiteboard usage in offices have also found that sketching is used to "ponder" or "work through concepts" [6] and that one of their advantages is that they can be used to "flexibly generate representations of knowledge" [7].

In our study of sketch lifecycles, several participants found sketching so important to their workflow that they had spent considerable effort considering how they could smooth the transition of their sketches between the various contexts in which they would be used, be it creating a sketch while riding public transit, refining the ideas behind a sketch, sharing one in a meeting, or archiving it for later retrieval.

Use of recognized visual constructs

Our study of visual constructs on whiteboards suggested that being able to create freeform representations of thought was not only important, but unsupported by commonly available digital tools. For example, one participant worked out a conceptual framework on a whiteboard and explained: *"Because I couldn't do that [in a word processor]. I could create the links, but I couldn't have kind of like a mental picture in my mind of how they relate"* [9]. Another participant preferred his whiteboard drawing to a cleaner, software reproduction of it, saying *"For me to replicate this [indicates whiteboard], [software] doesn't give me enough constructs. Kind of messes up my thought process. You start using artificial shapes and places just to fit it in [with the software]. Over here*

[whiteboard], I can do a lot more thinking. And this [whiteboard] is a lot less stressful" [9].

Combining sketching freedoms with data reality
We have come across some interest in combining the freedoms of sketching with the reality, or accuracy of data. While common usage of whiteboards tended towards "sketchy", inaccurate, conceptual, or abstracted information, it was clear that the inability to combine accuracy and freedom of sketching could be limiting. One participant, who worked with large volumes of data, was worried that any small sampling of data he could reasonably put on his whiteboard would be "*suggestive and possibly be completely misleading*" [9]. Another participant noted that creating accurate digital representations (of computer graphics-related forms) took time and in some cases the rapidity of sketching was more important than precision.

In considering blended interaction for InfoVis, one of the key challenges will be finding ways and places to allow people freedom of visual representation while balancing the inherent restrictions placed upon visual representations of data.

Preservation of sketches
Our sketch lifecycle study demonstrated that while some sketches are transient, others go through several

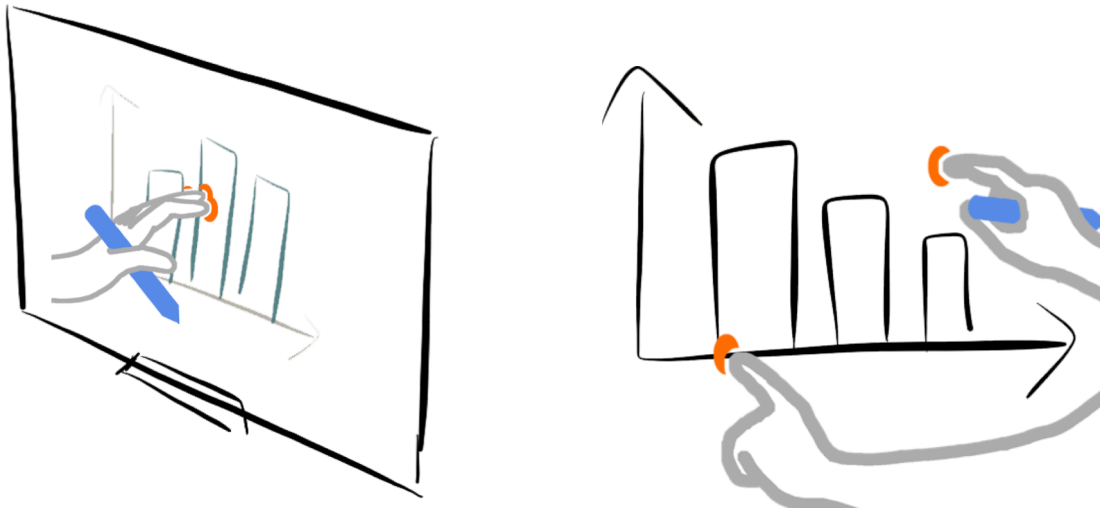

Figure 1. Illustration of selected hand positions used by participants in our wizard of oz study [11]. (Hand positions reproduced directly from video taken during the study).

iterations and contexts throughout the duration of a project. These sketches can go through several transitions after being created: they can be iterated upon, copied, archived, or discarded. They also may be used in several contexts including personal, group, and sharing with a wider audience. Importantly for blended interaction, we saw that in order for a single sketch to be used in these differing contexts, it was often necessary for people to switch between digital and analog media. For example, in one lifecycle, a sketch was drawn on paper, redrawn on a tablet PC, refined (redrawn and rearranged) on the tablet, shared on the tablet in a meeting, uploaded to several digital archives, and also printed for quick reference for the duration of the project [10].

Transferable learnability in interaction

One of the results of our wizard of oz study was evidence of *transferable learnability*, which is in agreement with research from psychology on *analogical transfer* [1], in which a principle learned in one case is applied to other cases. Our participants were allowed as much freedom as possible to choose the ways in which they interacted with our system. Some of the interactions we saw tended to be chosen on the basis of real-world experience, particularly when it came to deciding when to use a pen and when to use touch (transferability from the real world). Figure 1 shows a selection of hand positions we observed participants using when they chose to use touch interaction instead of pen interaction. Other interactions were chosen on the basis of previous experience with computers (transferability from previous experience). However, we also observed a set of interactions transferred from *within* the system. That is, in certain situations, participants figured out how to perform new tasks based on how they had previously completed similar, but not identical, tasks - even when the interaction for the previous task had not been based on the real world or typical computer interfaces [11]. This is evidence that blended interfaces do not need to mimic real-world or even previously learned interactions in order to be easily and rapidly used, though it does point to the importance of internal consistency and providing clear feedback for successful interactions.

Conclusion

In our research towards creating information visualization interfaces that integrate our everyday thinking processes with digital data representations we have conducted a series of studies. Through these studies we have gained a better understanding of sketch-based thinking practices such as how people create, use and re-create a given sketch in a project lifecycle, and how people create and make use of both well-known and entirely new visual representations. Through our wizard of oz study we watched people invent pen and touch based sketch interaction to achieve the tasks we set for them. In these interactions we saw how they pulled interaction ideas from reality, from other software and from previous experiences within the system. Together these results indicate that the idea of developing interactions from a blend of both digital and reality actions may resonate with people.

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