Toward a tool to evaluate visual behavior in multi-device environments

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Abstract
We are developing a novel method to analyze the visual behavior of multiple participants engaged in a collaborative task using a multi-device environment. Our algorithm generates descriptive labels of visual focus for each participant engaged in the group work. Preliminary data indicates that our algorithm is accurate, and that it will be usable by researchers with different backgrounds as they investigate collaborative use scenarios.

Author Keywords
Visual behavior; eye tracking; collaborative environment; multi-device environment.

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

Introduction
In his seminal paper Mark Weiser [7] described a vision of interconnected devices of different scales – from tabletops, to tablets, to handheld devices. We are interested in exploring this space to understand how different design decisions will impact the ability of users to collaborate, and to complete various tasks successfully, quickly, and with a high degree of enjoyment. In particular, we seek to understand the

effects of design decisions on the visual behavior of the users: where, when, and for how long do users cast their gaze, and how are these behaviors related between users?

To be able to answer such questions we are conducting studies in which each participant wears an eye tracker to track their gaze. We are also developing a tool that will allow researchers from different disciplines to use such eye tracker data to analyze and compare the different behaviors of individuals. Our aim is to be able to tackle multi-device environments, with tabletops, walls, and personal devices. We also aim to allow for different sizes in each of these devices.

Related work

Collaborative multi-device environments such as iRoom [2] and WeSpace [8] which integrate personal devices, large wall displays, and a multi-touch table offer additional benefits for data-driven discussion and information visualization. Several studies indicate that visual coordination and joint visual attention of users can reveal insights about their collaborative work [3, 5]. Visual attention could be tracked with the use of mobile eye trackers, that have developed rapidly in recent years [1], and they have been used extensively to assess the behavior of the user. However, most of the work in eye tracking (both mobile and stationary) has been done to explore the eye movements of a single participant. In contrast, we track the gaze of multiple users simultaneously. This direction of research is relatively novel, with few contributions in the literature [4]. Most of the work done on this area was also done with the help of markers that were placed in the view of the participants to determine gaze positions. In contrast, we introduce techniques to determine gaze positions using landmarks in the users' visual scene.

Tracking gaze in multi-device environments

Apparatus and setup

We are experimenting in a room with two large scale devices that consist of tiled 55'' Ultra-Thin Bezel MultiTaction (https://www.multitaction.com) cells. One device is a tabletop, the other a wall. Each participant also operates a small-scale device, which could be an iPad or an iPhone, and each of them is equipped with a head mounted eye tracker from Pupil Labs (https://pupil-labs.com). We modified these eye trackers by attaching a color LED to each device (red, green, or blue), so we could distinguish between users in the videos.

Algorithm

The algorithm is implemented using Matlab. The eye trackers provide videos of the world camera recordings, as well as log files which indicate the location of the estimated gaze position in world camera coordinates, as well as an indicator of the confidence level of the eye tracker estimate.

The algorithm identifies objects where a participant's gaze is turned, and does this for each video frame. The algorithm can label gazes as being directed at a personal device (iPad or iPhone), an area on a tiled tabletop display, an area on a tiled wall display, as well as on another person wearing an eye tracker tagged with a color LED.

Conclusion and future work

We have encouraging preliminary results, which indicate that our algorithm will be useful in assessing

the visual behavior of groups of users in collaborative situations, as they interact with a number of multi-touch devices of different sizes. We already shared results from using a preliminary version of this algorithm for understanding joint visual attention in a single device environment – with users collaborating around a large scale interactive tabletop [6].

We are currently processing data from a study in which five groups of four users (for a total of 20 users), completed two experimental tasks each. In the first task, each group completed a set of scripted tasks, in which they were instructed where to move their gaze at any given time. In the second experiment, they were asked to collaboratively review a set of nine academic paper abstracts and select by consensus a subset of three papers to be assigned as readings for a class discussion. The results of these experiments will be used to (a) validate our algorithm, and to (b) demonstrate the types of data that it can generate for researchers. We are also working on wrapping the entire process into a tool that can be used by other researchers with different backgrounds.

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References

1. Andreas Bulling and Hans Gellersen. 2010. Toward mobile eye-based human-computer interaction. *IEEE Pervasive Computing*, 9, 4 (2010), 8-12.

2. Brad Johanson, Armando Fox and Terry Winograd. 2002. The interactive workspaces project: Experiences with ubiquitous computing rooms. *IEEE Pervasive Computing*, 1, 2 (2002), 67-74.

3. Yan Liu, Pei-Yun Hsueh, Jennifer Lai, Mirweis Sangin, Marc-Antoine Nussli and Pierre Dillenbourg. 2009. Who is the expert? Analyzing gaze data to predict expertise level in collaborative applications. In *Proceedings of the Multimedia and Expo, 2009. ICME 2009. IEEE International Conference on*, 898-901.

4. Sami Pietinen, Roman Bednarik, Tatiana Glotova, Vesa Tenhunen and Markku Tukiainen. 2008. A method to study visual attention aspects of collaboration: eye-tracking pair programmers simultaneously. In *Proceedings of the 2008 symposium on Eye tracking research & applications*, 39-42.

5. Bertrand Schneider and Roy Pea. 2014. Toward collaboration sensing. *International Journal of Computer-Supported Collaborative Learning*, 9, 4 (2014), 371-395.

6. Hidde van der Meulen, Petra Varsanyi, Lauren Westendorf, Andrew L Kun and Orit Shaer. 2016. Towards understanding collaboration around interactive surfaces: Exploring joint visual attention. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*, 219-220.

7. Mark Weiser. 2002. The computer for the 21st century. *IEEE Pervasive Computing*, 1, 1 (2002), 19-25.

8. Daniel Wigdor, Hao Jiang, Clifton Forlines, Michelle Borkin and Chia Shen. 2009. WeSpace: the design development and deployment of a walk-up and share multi-surface visual collaboration system. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1237-1246.