Augmenting Remote Presence For Interactive Dashboard Collaborations

Conference Paper · November 2015

DOI: 10.1145/2817721.2823486

Pablo Bermell-Garcia

Airbus

Augmenting Remote Presence For Interactive Dashboard Collaborations

Rodrigo Pizarro
EVENT Lab
Universitat de Barcelona
Barcelona 08035, Spain
rodrigo.pizarro@ub.edu

Mar Gonzalez-Franco
Airbus Group Innovations
Newport NP10 8FZ, UK
mar.gonzalez@airbus.com

Mark Hall
Airbus Group Innovations
Newport NP10 8FZ, UK
mark.hall@eads.com

Pablo Bermell-Garcia
Airbus Group Innovations
Newport NP10 8FZ, UK
pablo.bermell-garcia@airbus.com

ITS '15, November 15-18, 2015, Funchal, Portugal
ACM 978-1-4503-3899-8/15/11.
http://dx.doi.org/10.1145/2817721.2823486

Abstract
We implement the use of silhouette representation for collaboration using interactive dashboards. In order to test its effectiveness against other modalities of interaction we ran a guided data exploration task in a Visual Analytics tool using a tactile dashboard in three modes: face-to-face, teleconference, and enhanced teleconference with silhouette representation. Even though no performance differences were found across the conditions, results show increased coordination abilities of the participants when the remote person is represented by a silhouette, furthermore important behavioral changes related to the presence illusion are also found only in the silhouette condition.

Author Keywords
Dashboard collaboration; Presence; CSCW; Silhouette shadowing

ACM Classification Keywords
H.5. Information interfaces and presentation; H.4.3: Computer conferencing, teleconferencing, and videoconferencing; I.3.7. Color, shading, shadowing and texture

Introduction
Computer Supported Co-operative Working (CSCW) systems enable distributed individuals to work together on tasks which improves their level of productivity [1] and enhances collaboration [4]. This collaboration may be broadly divided into three categories, namely (i)

communication (ii) information sharing, and (iii) co-ordination [9]. Inevitably, face-to-face encounters will provide a richer form of collaboration due to eye contact, body gestures and proxemics, and there is a benefit to achieving similar experiences during remote collaboration [6,7,11]. In that line, Mixed Presence Groupware aims to support remote participants working over a shared workspaces [8] by combining video conferencing with synchronized devices [10]. These systems include: distributed tabletops [15], large interactive displays [3], immersive telepresence [11], robots [12] and tangible interfaces [2].

To provide richer presence on an interactive dashboard we implement a real-time silhouette shadow (Figure 1) that can provide body gestures and offer an improved means of collaboration [5]. Although presence is sometimes understood as the illusion of being transported to a remote location [13,14], in this research we focus on the contrary effect of feeling somebody present in the local destination. We tested our silhouette approach following a user study that further evaluates the effectiveness of the CSCW system in providing communication, information sharing and co-ordination. Participants undertake a guided task using the interactive dashboard in three conditions of interaction, including both face-to-face and remote situations, with and without silhouette.

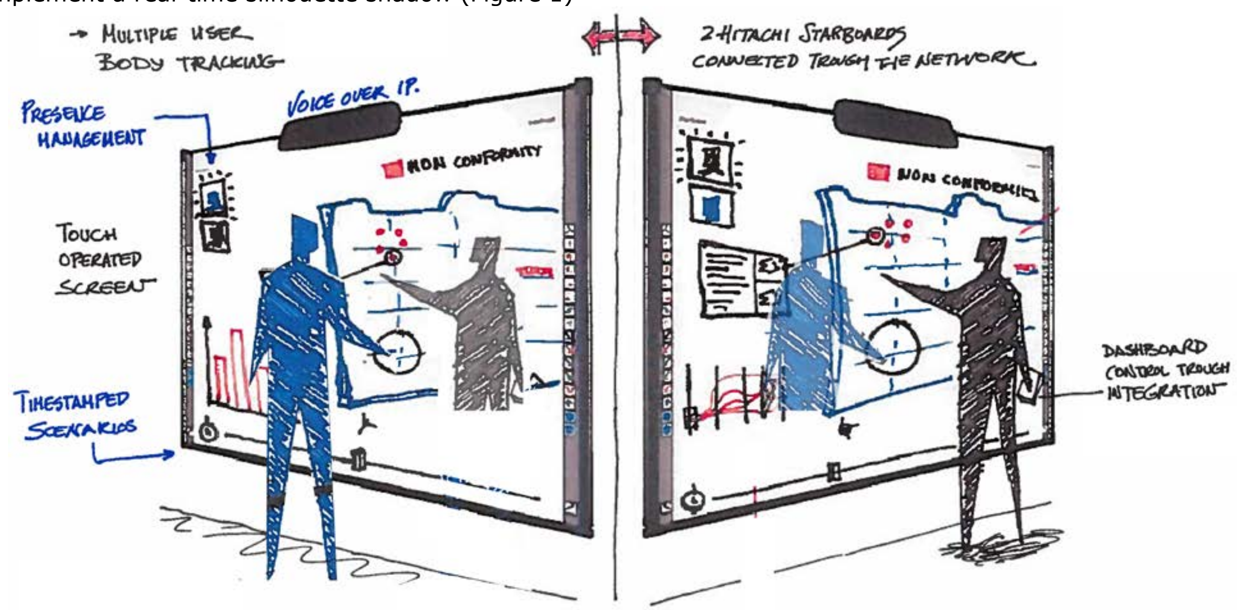

Figure 1: Concept with two tactile whiteboards with silhouettes to augment remote presence during interactive collaborations.

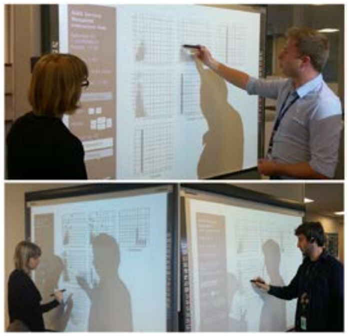

Figure 2: Top: Face-to-face interaction. Bottom: remote silhouette interaction.

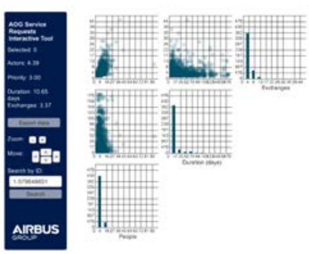

Figure 3: Dashboard containing a multidimensional data Scatterplot Matrix (SPLOM) with histograms. On the left side of the screen we show statistical information of the selected points.

Materials and Methods

We carried out an experiment to test different means of interactions with touch whiteboards. In particular we wanted to explore the use of this technology for Visual Analytics dashboards in remote collaboration (Figure 1). In order to do so we ran three different experimental conditions: real face-to-face interaction, teleconference interaction, and teleconference interaction with silhouette representation (Figure 2).

Participant recruitment

18 participants aged 32 ± 10.5 years old (1 female) volunteered for the experiment. Following the Declaration of Helsinki all participants were given an information sheet, signed informed consent and agreed to participate in the study. Participants were distributed across conditions balancing technological expertise using scatterplots, videoconferencing and tactile systems.

Apparatus

During the experiment, participants stood in front of an infrared based multi-touch whiteboard (Hitachi Starboard FX-DUO-77) combined with board pens, which emulate mouse movements and clicks. The display was presented through a ceiling-hung NEC VT695 projector at a 1024x768 resolution. The whiteboard was 1.57 x 1.18 meters and driven by an HP ZBook 17 laptop running the client application in Windows 7. In the multi-touch screen we implemented a dashboard with over 4,000 data points (Figure 3). The interaction with the data can be performed by clicking and dragging the board pen. The area contained in the selection while performing it is marked in a transparent gray rectangular shape. All selected points are highlighted in green (See Supplementary Video).

We used Photon Networking[1] engine to deal with the communication between computers and application. Additionally, with that engine, all the interaction with the data was synchronized, i.e. selection areas and selected points.

Silhouette

Using a Logitec C310 camera mounted to the ceiling projector we monitored the activity at the whiteboard. The video footage was used to calculate and later overlay the silhouette of the participants in a remote location. The images were streamed to the remote location at 5 fps, 160x120 resolution and PNG compression. In order to calculate the silhouette we capture an initial image of the whiteboard without the participant and then all subsequent frames calculate the pixel-by-pixel difference with respect to the original one using GPU fragment shading. The silhouette is then overlaid as semi-transparent. Choosing the right threshold we were able to filter the noise produced by echo, small changes in ambient lighting and sensor errors, thus distinguish the human silhouette.

To crop the camera capture to the area of the whiteboard we perform a four-point calibration where the experimenter manually selects the four edges of the board. With that information, we can calculate the distortion produced by the angle in which the camera is looking at the screen, and counter the linear distortion to generate an output image that looks aligned with the renders.

[1] http://www.photonengine.com

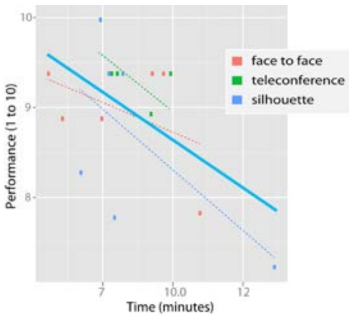

Figure 4: Correlation between time and performance (from 1 to 10) in solid blue.

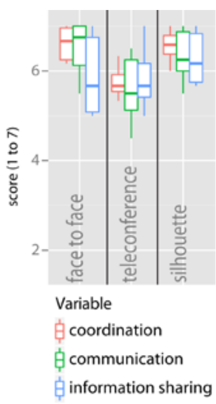

Figure 5: Collaborative Work scores (from 1 to 7).

Experiment procedure
We ran a between-groups study, i.e. each participant underwent only one of the three conditions. Participants were guided through a task that was identical in all conditions so we could measure performance effects. Participants completed a demographics questionnaire and familiarized themselves with the touchboard and the pen for a brief period before starting the actual experiment to ensure they knew how to operate the hardware. When they felt comfortable with it, the experiment was ready to begin.

In the face-to-face condition, the experimenter stood in front of participants, while in the teleconference and silhouette conditions, the experimenter was in a remote location and communicated remotely with participants through a phone call and through the dashboard, as both the experimenter and the participants could draw selections. The only difference between the two remote conditions is that in the Silhouette one we overlaid the shadow of each user in the remote location.

At the beginning of the guided task, the experimenter gave some context to the data, explaining its origin and meaning. Subsequently, we asked participants to perform some operations that involved selecting particular cases or sets of cases that followed specific criteria stated by the experimenter. A second experimenter silently monitored the actions of the participant and evaluated if they were performed correctly and kept track of the time spent.

Finally, participants filled a CSCW post-questionnaire to assess their Information Sharing, Communication and Coordination experience during the task. Those who were assigned to the remote conditions filled an additional questionnaire related to their feeling of presence [13] that included questions such as: "*While I was interacting I tried to avoid occupying the same side as the experimenter's shadow*", "*I felt as if the experimenter was just by my side, I could feel her presence*", "*I felt the experimenter was being transported to my location*". The last two questions were combined to create a presence score.

Results and Discussion

Performance
No Significant differences were found on the correctness of the task performance score (Kruskal-Wallis, $\chi^2(2)=1.2$, $p=0.5$) nor in the time spent to complete the task ($\chi^2(2)=0.33$, $p=0.8$). This is probably due to a ceiling effect, as we find all the participants completed the task notably well. However, a significant correlation between time and performance score was found (Pearson correlation, $r(16)=0.52$, $p=0.024$) (Figure 4). In general, participants that performed better also did it faster. Although this might seem contradictory, the reality is that the participants that had to interact more with the experimenter in order to understand the question or were not sure about their answers and took more time to finalize the task.

Collaborative Work
When looking at the collaborative work related questions the scores are also high for all conditions (Figure 5). However, a significant difference was found in the coordination capabilities of the different methods ($\chi^2(2)=9.1$, $p=0.01$). Furthermore, the multiple comparison post-hoc test shows significant differences between the face-to-face condition and the teleconference conditions ($p<0.05$) as well as between the teleconference and the silhouette conditions

($p<0.05$), but not between the face-to-face and the silhouette conditions ($p>0.5$). This result could be interpreted as if the silhouette condition was able to provide similar levels of coordination to the real face-to-face situation, which was not always possible using only teleconference.

The other two main variables related to collaborative work (communication and information sharing) did not show significant differences among the three conditions. This lack of difference in the communication score could be due to the high expertise of the participants in the use of videoconferences, as at least 66% of the participants reported using videoconferences at least on a monthly basis. Regarding the information sharing, the technology and methods for information and dashboards remained consistent across all conditions, all participants used the same tactile board to display and interact with the data, and therefore it is within our expectations to find no differences.

Presence

The presence questionnaire was provided only to the participants in the remote conditions (teleconference and silhouette). We find a significant differences ($\chi^2(1)=8.4$, $p=0.003$): participants in the shadow condition felt more as if they were in the same location as the experimenter (Figure 6). Furthermore, in the shadow condition, we found that most of the participants significantly preferred to look at the shadow than to actually follow only the audio instructions ($\chi^2(1)=8.3$, $p=0.004$).

Interestingly we also found a great amount of participants that would avoid occupying the space of the experimenter shadow (score 5.7, std=1.6 out of 7), which is in line with the stronger feeling of having the experimenter located by their side ($\chi^2(1)=3.6$, $p=0.05$).

Conclusions

In recent years, teams and companies have adopted workflows that involve working remotely. The current findings could prove useful for many situations in which those groups require remote collaborative work.

The present results indicate that when people see the remote person's shadow, they feel as if that person had been transported to their location to a greater extent that when there is no shadow. Even though participants were consciously aware that the other person was interacting with them remotely, they developed behaviors associated with face-to-face encounters, such as keeping an interpersonal space distance or paying attention to the body language and gestures rather than only focusing on the auditory clues. This presence illusion may explain the differences found in collaboration capabilities among the two remote conditions. Evidence suggests that those who experienced the silhouette condition were able to work collaboratively as they would do in a face-to-face encounter, while that was not achieved in the only teleconference condition. In traditional remote CSCW non-verbal communication is lost; our approach seems to provide at least a subset of that information that could enhance collaboration, being thus a Mixed Presence Groupware.

Additionally, unlike many screen sharing setups, e.g. Webex, our approach allowed bidirectional interaction and that might be also key to understanding the performance ceiling effect.

References

[1] Baecker, R.M., Grudin, J., Buxton, W. a S., and Greenberg, S.Readings in Human Computer Interaction: Toward the Year 2000. (1995), 950.

[2] Brave, S., Ishii, H., and Dahley, A.Tangible interfaces for remote collaboration and communication. *CSCW*, ACM Press (1998), 169–178.

[3] Elrod, S., Pier, K., Tang, J., et al.Liveboard: a large interactive display supporting group meetings, presentations, and remote collaboration. *CHI*, ACM Press (1992), 599–607.

[4] Eseryel, D. and Edmonds, G.S.Review of Computer-Supported Collaborative Work Systems. *Educational Technology & Society 5*, 2 (2002), 130–136.

[5] Everitt, K.M., Klemmer, S.R., Lee, R., and Landay, J. a.Two worlds apart: bridging the gap between physical and virtual media for distributed design collaboration. *CHI*, ACM Press (2003), 553–560.

[6] Gonzalez-Franco, M. and Chou, P.A.Non-linear modeling of eye gaze perception as a function of gaze and head direction. *QoMEX*, IEEE (2014).

[7] Gonzalez-Franco, M., Hall, M., Hansen, D., Jones, K., Hannah, P., and Bermell-Garcia, P.Framework for remote collaborative interaction in virtual environments based on proximity. *3DUI*, IEEE (2015), 153–154.

[8] Greenberg, S., Greenberg, S., Boyle, M., Boyle, M., Tang, A., and Tang, A.Display and presence disparity in Mixed Presence Groupware. *28*, 2003 (2004), 73–82.

[9] Grudin, J Poltrock, S.Computer Supported Cooperative Work. In *The Encyclopedia of Human-Computer Interaction, 2nd Ed.* Aarhus, Denmark: The Interaction Design Foundation., 2014.

[10] Gumienny, R., Meinel, C., Gericke, L., Quasthoff, M., LoBue, P., and Willems, C.Tele-Board: Enabling Efficient Collaboration In Digital Design Spaces Across Time and Distance. In *Design Thinking*. Springer Berlin Heidelberg, Berlin, Heidelberg, 2011, 147–164.

[11] Higuchi, K., Chen, Y., Chou, P.A., Zhang, Z., and Liu, Z.ImmerseBoard: Immersive Telepresence Experience using a Digital Whiteboard. *CHI*, ACM Press (2015), 2383–2392.

[12] Kishore, S., González-Franco, M., Hintermuller, C., et al.Comparison of SSVEP BCI and Eye Tracking for Controlling a Humanoid Robot in a Social Environment. *Presence: Teleoerators and Virtual Environments 23*, 3 (2014), 242–252.

[13] Slater, M., Usoh, M., and Steed, A.Depth of presence in virtual environments. *Presence 3*, 2 (1994), 1–33.

[14] Spanlang, B., Normand, J.-M., Borland, D., et al.How to Build an Embodiment Lab: Achieving Body Representation Illusions in Virtual Reality. *Frontiers in Robotics and AI 1*, November (2014), 1–22.

[15] Tuddenham, P. and Robinson, P.Distributed tabletops: Supporting remote and mixed-presence tabletop collaboration. *Tabletop*, IEEE (2007), 19–26.