Object and Arm Shadows: Visual Feedback for Cross Device Transfer

Guillaume Besacier[1,2]
[1] Systems Design Engineering
[2] Games Institute
University of Waterloo
Waterloo, Ontario, Canada
guillaume.besacier@uwaterloo.ca

Julie Tournet[1,2,3]
[1] Systems Design Engineering
[2] Games Institute
University of Waterloo
Waterloo, Ontario, Canada
[3] Telecom Bretagne
Brest, France
julie.tournet@uwaterloo.ca

Nippun Goyal
Systems Design Engineering
University of Waterloo
Waterloo, Ontario, Canada
n4goyal@uwaterloo.ca

Frank Cento
Systems Design Engineering
University of Waterloo
Waterloo, Ontario, Canada
foscento@uwaterloo.ca

Stacey D. Scott[1,2]
[1] Systems Design Engineering
[2] Games Institute
University of Waterloo
Waterloo, Ontario, Canada
s9scott@uwaterloo.ca

CHI'14, April 26–May 1, 2014, Toronto, Ontario, Canada.
ACM 978-1-4503-2474-8/14/04.
http://dx.doi.org/10.1145/2559206.2574832

Abstract
Rekimoto's *Pick-and-Drop* (PND) cross-device transfer technique is commonly used to support multi-surface object transfer, for instance, between a multi-touch tabletop and tablet, due to its easily understood metaphor that emulates object movement in the physical world. Current multi-surface implementations of PND provide little to no feedback during the transfer process, creating confusion during transfer. This paper investigates two visual feedback techniques, *Object Shadow* (OS) and *Object-plus-Arm Shadow* (O+AS), designed to address this issue by visually representing the transferred object and its "owning" user during the transfer process.

Author Keywords
Cross device transfer; digital tabletops; tablets; multi-surface interaction; private and shared surface

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User interfaces: Graphical User Interfaces

Introduction and Related Works
Large interactive surfaces, such as multi-touch walls and tabletops, are being increasingly used to support different collaborative endeavours. Their large display surface and ability to support simultaneous multi-user interaction facilitates shared viewing and manipulation

of data, fostering communication, collaborative analysis and decision-making, as well as overall social engagement.

A limitation of these devices, however, is that all data are inherently "public," that is, they are visible to anyone at or nearby the display. Yet, someone may desire (or require) access to private (or secret) information, such as their email inbox or classified documents while at a surface. To address this situation, researchers have begun exploring the use of mobile personal devices, such as multi-touch tablets or smartphones, in conjunction with large surfaces, to provide a multi-surface ecology comprises both shared and private workspaces for group members to use

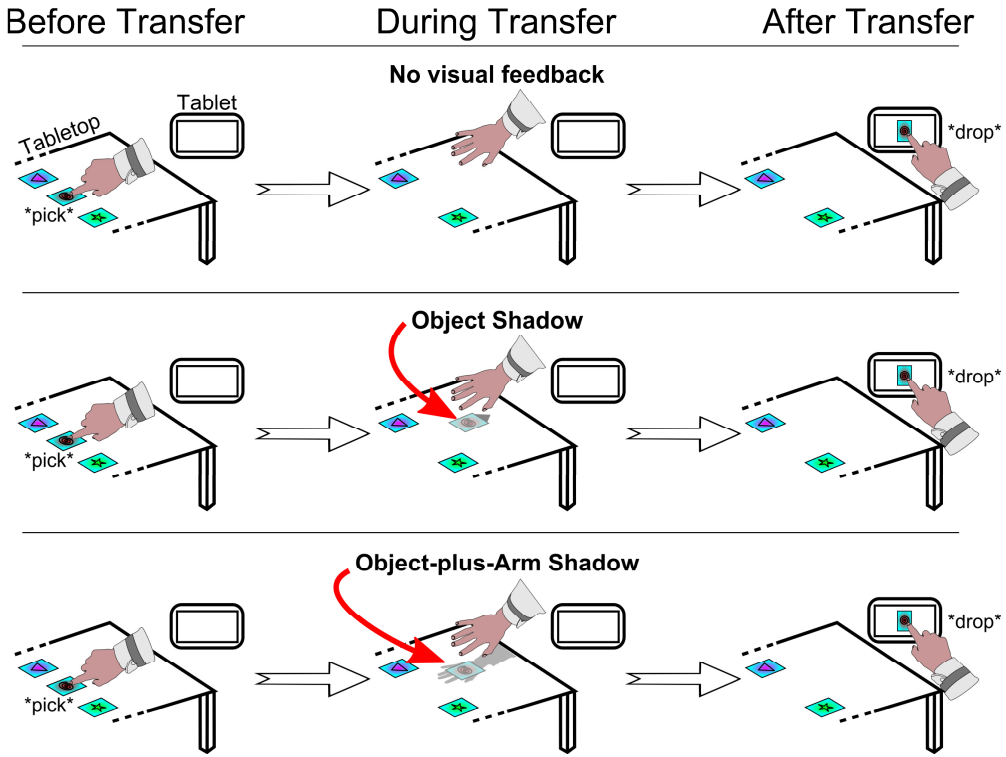

Figure 1. Conceptual design of Object and Arm Shadow feedback during a Pick-and-Drop cross-device transfer. Before transfer (left column) the object is on the table. During transfer (middle column), the object would normally be invisible (top row). With Object Shadow (middle row) and Object-plus-Arm Shadow (bottom row) the eponymous visual feedback appears on the table beneath the users arm. After transfer (right column) the object is on the tablet.

Utilizing personal and shared surfaces during the same collaborative activity introduces a need to be able to move digital content from one surface to another. For instance, if someone wishes to share a particular email message with the entire group, they should be able to easily move it from their personal device onto the shared surface with minimal interference to the ongoing conversation or task activities. Several cross-device transfer techniques have been proposed to enable transfer across multiple displays [3]. Rekimoto's [4] Pick-and-Drop (PND) technique, which enables a user to "pick" up a virtual object from one device and "drop" it onto another device, has been widely adopted by researchers of large surfaces and multi-surface environments due to its easily understood metaphor [2, 5].

A shortcoming of the PND technique is that objects are often invisible during transfer, once they leave the originating display and before they arrive on the destination display. In previous work comparing transfer techniques in a multi-surface environment, we found users often became confused during PND transfer, especially during complex or problematic transfers [6]. To address these usability issues of Pick-and-Drop, we propose two visual feedback techniques, *Object Shadow* (OS) and *Object-plus-Arm Shadow* (O+AS), cf. Figure 1, which draw from virtual embodiment concepts used in distributed surface

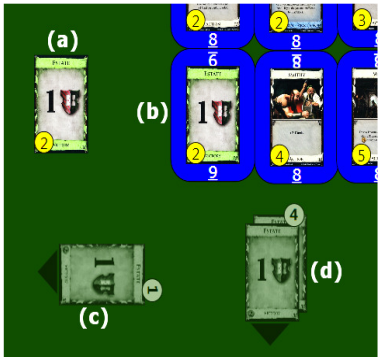

Figure 2. Object Shadow visual design in the context of a tabletop card game application: (a) a normal card, (b) decks of cards, (c) an Object Shadow of one card being transferred by the Left Player, and (d) an Object Shadow of multiple cards being transferred by the Bottom Player.

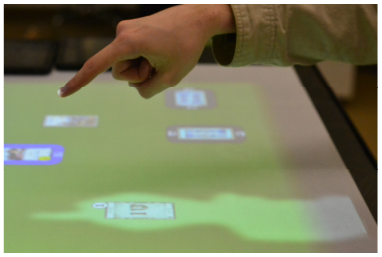

Figure 3. Object-plus-Arm Shadow visual design in a tabletop card game context: the player is transferring a card between his tablet and the tabletop.

environments [7]. These techniques provide dynamic visual feedback on a tabletop surface during PND transfers between a tabletop and a personal surface. In the OS technique, a shadowed representation of the transferred object is displayed on the tabletop below the user's hand. In the O+AS technique the OS is displayed along with a shadow of the user's arm below their physical arm, which extends back to the user's position at the table to provide more explicit feedback on who is transferring what in a multi-user environment.

Design and Implementation

Touch-based multi-surface environments present several challenges for implementing PND transfer. First, no digital pen is available to serve as the proxy. Second, it is unclear how to bind/unbind the transferred object to/from the proxy, which was originally done via a button on the digital pen. Our previous *Adapted Pick-and-Drop* technique [6] addressed these issues by, metaphorically, using the user's hand as the physical proxy between personal and shared surfaces, and gestures or context menus (depending on the device) to trigger object binding/unbinding. Dedicated "personal areas" were provided on the shared surface (a digital table) for each user, where any picks or drops would be associated to that user, ensuring the right picks corresponded to the right drops during multi-user transfers. A study comparing this technique with a the virtual portals approach found it to be more efficient, but that it introduced usability issues, such as confusion and errors, due to the lack of visibility of objects during transfer [6].

Based on this study, we identified the need to provide users with more persistent feedback during object transfer, in order to convey information about:

- the type and number of objects in transit, and
- which user is transferring the object(s).

To address these design goals, we developed two visual feedback designs for a multi-surface environment: Object Shadow (OS) and Object-plus-Arm Shadow (O+AS). These designs utilize above-the-table tracking to enable user identification and real-time feedback during transfer.

The Object Shadow visual feedback provides a shadowed version of the transfer object under the user's hand on the digital table during the transfer process. That is, OS projects the object being transferred as a semi-transparent image on the table. If multiple objects are transferred at once they are stacked and a counter displays the total number of objects. The OS is displayed under the user's hand as it moves over the digital table. Figure 2 illustrates the OS visual designs for single-object (1(c)) and multi-object (1(d)) transfers in a digital card game context. The OS image is rotated toward the associated user during the transfer process, with a small black arrow attached to its bottom to indicate who is transferring the object(s).

The Object-plus-Arm Shadow visual feedback extends OS feedback by adding a more explicit visual link between the OS and the user currently "holding" the object, in the form of a virtual arm shadow embodiment. That is, the OS is displayed along with a shadow of the user's arm below their physical arm, which extends back to the user's position at the table (Figure 3). The purpose of providing the Arm Shadow in addition to the Object Shadow is to more explicitly communicate who is transferring which objects, which can become particularly confusing in a shared environment where several people are interacting in the same area.

Both OS and O+AS are only visible during transfer. A fading animation is used during "picks" and "drops" to minimize disruption to the transfer process, and a short animation moves (and rotates if necessary) the card from its original position to the center of the user's hand (which is more robustly tracked than the fingers).

In order to realize the OS and O+AS feedback designs, persistent tracking of the user's hand and arm position above the table surface is needed. To accomplish this, we utilized Genest et al.'s [1] KinectArms toolkit that enables persistent tracking of multiple users' hand and arm interaction above a table by mounting a Microsoft Kinect[1] three-dimensional depth sensor above the digital table. We customized this toolkit to further identify the "owning" user of each detected arm, based on the user's known location[2] at the table. The OS and O+AS visual feedback mechanisms both rely on the user identification and above-the-table tracking information in order to correctly bind transfer objects to the appropriate user's hand and provide persistent feedback of the transfer object, respectively, during simultaneous transfers at the digital table. In addition, O+AS visual feedback uses the KinectArm's arm tracking data to project the shadow of the user's arm on the digital table during the transfer process.

Conclusion

This paper presented two visual feedback techniques, Object Shadow and Object-plus-Shadow, designed to improve the usability of Pick-and-Drop transfers between a shared tabletop and personal tablets. We used a Microsoft Kinect mounted above the table to track the users' hands and arms in real time.

[1] http://www.microsoft.com/en-us/kinectforwindows/

[2] User identification is currently limited to four users, one per table side.

Acknowledgments

We gratefully acknowledge the following funding sources for supporting this project: NSERC SurfNet Research Network, SSHRC IMMERSe Research Network, and the LEIF Canada-EU Exchange Program. We thank members of the Surface Research Group at the University of Waterloo for their feedback on this project. We also graciously acknowledge Phil McClelland, whose original concepts and earlier work sparked the project.

References

1. Genest, A.M., Gutwin, C., Tang, A., Kalyn, M., Ivkovic, Z. KinectArms: a toolkit for capturing and displaying arm embodiments in distributed tabletop groupware. *Proc. CSCW'13*, 157–166.
2. Haller, M., Leitner, J., Seifried, T., Wallace, J.R., Scott, S.D., Richter, C., Brandl, P., Gokcezade, A., Hunter, S. The NiCE discussion room: Integrating paper and digital media to support co-located group meetings. *Proc. CHI'10*, 609–618.
3. Martinez Maldonado, R., Dimitriadis, Y., Kay, J., Yacef, K., Edbauer, M.-T. Orchestrating a multi-tabletop classroom: from activity design to enactment and reflection. *Proc. ITS'12*, 119–128.
4. Rekimoto, J. Pick-and-drop: a direct manipulation technique for multiple computer environments. *Proc. UIST'97*, 31–39.
5. Rekimoto, J. A multiple device approach for supporting whiteboard-based interactions. *Proc. CHI'98*, 344–351.
6. Scott, S.D., McClelland, P.J., Besacier, G. Bridging Private and Shared Interaction Surfaces in Co-located Group Settings. *Proc. IST'12*, 403–406.
7. Tang, A., Boyle, M., Greenberg, S. Display and presence disparity in Mixed Presence Groupware. *Proc. AUIC'04*, 73–82.