Comparing Visual Feedback Techniques for Object Transfer between Private and Shared Surfaces

Julie Tournet[1,2,3]
[1]Systems Design Engineering,
[2]Games Institute
University of Waterloo
Waterloo, ON, Canada
[3]Telecom Bretagne
Brest, France
julie.tournet@telecom-bretagne.eu

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

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

Phillip McClelland[1,2]
[1]Systems Design Engineering,
[2]Games Institute
University of Waterloo
Waterloo, ON, Canada
phil.mcclelland@uwaterloo.ca

Stacey Scott[1,2]
[1]Systems Design Engineering,
[2]Games Institute
University of Waterloo
Waterloo, ON, Canada
stacey.scott@uwaterloo.ca

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Abstract
The increasing trend toward multi-device ecologies that provide private and shared digital surfaces introduces a need for effective cross-device object transfer interaction mechanisms. This work-in-progress paper investigates visual feedback techniques for enhancing the usability of the Pick-and-Drop cross-device object transfer technique when used between a shared digital table and private tablets. We propose two visual feedback designs aimed to improve awareness of virtual objects during a Pick-and-Drop transfer. Initial results from a comparative user study are presented and discussed, along with directions for future work.

Author Keywords
Cross-device object transfer; multi-display; private and shared surfaces; digital table; tablets; visual feedback

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

Introduction
Increasing interest in using personal surfaces (e.g. tablets and smartphones) together with shared surfaces (e.g. interactive walls and tables) creates a need for

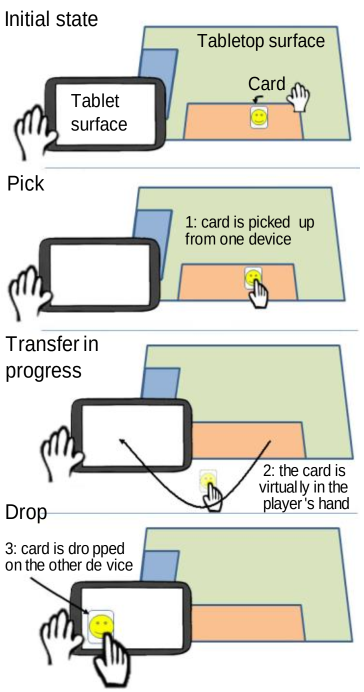

Figure 1. The Adapted Pick-and-Drop technique.

Figure 2. Game setup.

interaction techniques that enable digital content to be transferred between devices, ideally with minimal interference to the ongoing task activity. Rekimoto's Pick-and-Drop (PND) [4] object transfer technique has been widely adapted to this context [e.g. 2, 3]. PND is an extension of the drag-and-drop concept. A user "picks-up" an object with a stylus, and then "drops" it on a different computer display. A limitation of the PND technique is that objects are invisible during the transfer: they are no longer on the source display, but not yet on the target display. Thus, users can lose track of the transfers progress, both their own and other users' transfers, particularly during complex transfers (e.g. multiple object), when technical issues interfere with the transfer, or when distracted [2].

In this paper, we extend our Adapted Pick-and-Drop (A-PND) technique [2], a previous technique that used a user's bare finger rather a physical proxy (e.g. a stylus) for PND transfer (Figure 1). In particular, we explore the use of visual feedback during transfer to increase users' awareness of on-going A-PND object transfers between a shared digital table and personal tablets. Our visual feedback designs draw from embodiment concepts in distributed surface collaboration [1]. We evaluate our feedback designs using a digital implementation of *Dominion*[1], a commercial card game that provides a realistic task scenario that relies heavily on object transfer between devices (Figure 2).

In the next sections, we present our visual feedback designs, followed by preliminary results from a comparative user study evaluating these designs. Finally, we discuss some future directions for this work.

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Visual Feedback Design and Implementation

The original PND design [4] provided two types of feedback during object transfer. The design relied on users pressing and holding a button on a digital pen during object transfer, giving a tactile feedback that they were holding a digital object. When the stylus hovered over the target device (within a few millimeters), the digital object would appear with an attached shadow. When the object was dropped the shadow would disappear, completing the transfer.

In direct touch systems, similar tactile feedback is impossible. Similar visual feedback, though, can be provided, and extended beyond a few millimeters using above-the-surface tracking capabilities. This concept led to the first visual feedback design we explored, called ***Object Shadow*** feedback.

Object Shadow displays the objects being transferred as semi-transparent images on the table. If multiple objects are transferred at once, they are stacked and a counter displays the total number of objects (Figure 3). The shadow follows the position of the user's hand as it moves over the table.

Our second design, ***Object-plus-Arm Shadow*** feedback, extends the first by adding a visual link between the Object Shadow and the user holding the object. This link is inspired by embodiment concepts in distributed collaboration: the users' physical arms are projecting a virtual shadow on the table, while the objects they are holding are also projecting a shadow under the users' hands (Figure 4).

In both cases, the shadows are only visible during transfers. A fading animation is used on appearance

(a) (b) (c)

Figure 3. Card visualizations in the *Dominion* game: a) a normal card, b) an Object Shadow of a single card, and c) an Object Shadow for multiple cards.

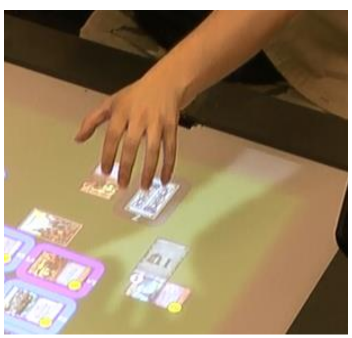

Figure 4. Object-plus-Arm Shadow feedback.

and disappearance, and a short animation moves the card from its original location to the center of the user's hand (which is more robustly tracked than the fingers).

Implementation

A Microsoft Kinect mounted above the table and the KinectArms toolkit [1] are used to track users' arms. KinectArms provides positional data for each user's hand, fingers, and shoulder, along with the shape (outline) of the user's arm. Custom calibration software is used to translate these data into the table coordinate space. As well as providing the system with above-the-table information, these data are also used to assign user identification information to tabletop touches, in order to associate the right "picks" with the right "drops" during concurrent multi-user interaction.

User study

A within-subjects user study was conducted. Six groups, recruited in groups of three friends, played three *Dominion* game sessions, each with different types of visual feedback: Object Shadow (OS), Object-plus-Arm Shadow (O+AS), and No Feedback (NF) as a control condition. Conditions were counter-balanced. All participants had experience with the *Dominion* game.

Game sessions were played on a custom Laser Light Plane (LLP) digital table (130x90cm and 1280x800 pixels), enhanced with a Microsoft Kinect mounted above the table. Players were provided with Samsung Galaxy Tab tablets for their private hands of cards.

Participants first completed an informed consent form and background questionnaire. They were then given instructions on the system interfaces. Next, they played three sessions of the *Dominion* game (28-45 minutes each). After each game, they completed a post-condition questionnaire eliciting feedback on the design they just experienced. After the final session, participants ranked the three conditions, and were thanked and paid for their participation. The study was reviewed and approved by our Ethics Review Board.

Preliminary results and discussion

Preliminary results from the study show that both Object Shadow and Object-plus-Arm Shadow feedback designs were effective in providing awareness during cross-device object transfer. Statistical analysis of the post-condition questionnaire responses found that participants reported both the OS and O+AS feedback conditions significantly better than the NF condition for providing awareness of *when they had a card in their hand* (tabletop to tablet: $F(2,32)=7.225$, $p=.003$), and of *how many cards they had in their hand* (tabletop to tablet: $F(2,32)=8.549$, $p<.001$; tablet to tabletop: $F(2,32)=4.359$, $p=.021$).

Participant comments confirmed the perceived utility of the OS and O+AS feedback, as illustrated by the comment, "The ghosted hand showing how many [cards] were in transit helped keep count" (P14, G5).

Beyond their utility during nominal game situations, both the OS and O+AS feedbacks were particularly useful when players experienced technical difficulties, such as inaccurate touch detection or inaccurate user identification. In such cases, players appeared to use the initial animation of the card towards its owner's hand to determine whether the card "went" to the correct player (Figure 5). However, this short animation was sometimes missed. In these cases, the persistent feedback provided in the O+AS condition of which

Figure 5. The animation of the Object Shadow flying towards its owner helps players realize that the card went to the wrong player.

player was currently “holding” the card was useful, as evidenced by the comment, ”The ghost hand was occasionally helpful when the software accidentally thought the wrong person picked up a card” (P5, G1). Moreover, several players who experienced the NF condition after O+AS expressed dismay over the lack of Arm Shadow feedback, as illustrated by the comment, ”Not having the hands displayed was very annoying. It resulted in many situations where too many cards were picked up or placed incorrectly…” (P6, G1).

Though the O+AS feedback appeared to be more effective in off-nominal situations, some players perceived it to be slower. Indeed, statistical analysis of the interaction log data revealed a significant difference in tabletop to tablet transfer time between conditions ($F(2,10)=7.029$, $p=.012$). Post-hoc analysis revealed that transfers with O+AS feedback were significantly slower (by an average of 800ms) than with OS feedback ($p=.010$). No differences were found between the other conditions, nor were any differences found between conditions for transfer times from tablet to tabletop. It may be possible that players were waiting for the arm shadow to fully appear (or were more distracted by its appearance) during the fade-in period. Further analysis of the logs and video data is needed to investigate this issue.

Finally, many participants expressed excitement upon discovery of the arm shadows in the O+AS condition, with comments such as “cool” and “fun” during the sessions. Thus, it appears that the O+AS feedback is both useful in off-nominal situations and adds a fun element to the gaming environment.

Conclusion and future work

Initial analyses from our comparative study revealed that Object Shadow and Object-plus-Arm Shadow both provide effective visual feedback that improves awareness of in-transit objects during Pick-and-Drop cross-device object transfer. The results also revealed that O+AS feedback provides additional benefits during off-nominal situations, such as inaccurate touch detection. However, further investigation is required to determine the cause of the observed time delay in tabletop to tablet transfers in this condition. Further analyses, and possibly further studies, are required to determine whether this time delay diminishes as people become accustomed to the O+AS feedback, or whether the perceived fun aspect of the arm shadows provides a benefit that offsets this time delay.

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