WaveWindow: Public, Performative Gestural Interaction

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ABSTRACT
Retail products are often experienced through transparent barriers such as shop windows, vending machines or display cabinets. Such surfaces offer opportunities for digital augmentation to enhance the experience at this point of contact. To explore this domain and its challenges, we have developed and evaluated the WaveWindow. This is an interactive see-through display that allows users to interact with digital content that overlays physical items behind a semi-transparent screen. Navigating and selecting content is achieved by waving and knocking on the display. We performed a user study and the resulting user interactions were recorded and analysed, and a number of design recommendations are made for gestural interaction in public settings and their application in a retail setting.

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INTRODUCTION
See-through displays that offer the possibility of locating physical objects behind a transparent display are useful in retail, library and museum settings to protect delicate or valuable objects while allowing their inspection. In the case of shopping windows or vending machines where there may be some transaction required to gain access to the physical object they also offer a means of finding out more about the item prior to purchase. Retailers have already developed simple systems to support this activity. For e.g., Polo Ralph Lauren unveiled an interactive shopping window (engadget, Aug. 10, 2006), in which shoppers could view clothing and make purchases via an interactive touch screen, demonstrating retailers' interest in, as well as the practical feasibility of such see-through displays.

To date, most research on use of see-through displays has been point-based designs. An early example of this was DigiScope [1], utilising a transparent see-through display that allowed users to see information and physical objects through a transparent screen. Image-processing solutions have been proposed to allow users to point at the screen or at the physical object behind the screen [2,3]. Notably, Olwal [4] combined see-through displays with depth cameras to examine user's preference of touch vs. touchless interaction, showing that users prefer touch interactions.

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Waving gestures have previously been used to control applications (e.g. Sony's EyeToy), but given its commercial potential, there have been few formal evaluations of such display systems in real-world settings.

Public retail environments provide constraints that are quite different to the use of displays in other settings. Even non-interactive shop windows are explicitly intended to encourage multi-participant bystander viewing, and shop window real-estate cannot easily be designed for single users. Indeed, there is likely to be value in encouraging bystanders to become active participants in an interaction. The use of external windows as interactive displays is also problematic; touch-based interaction will smear the glass, making the items on displays less inviting, but also and at the same time, a dirty surface will make interaction unhygienic and potentially less inviting. Shop windows are also usually very large and interacting across an entire shop window by touch may be physically demanding. Finally, the external view of a shop is valuable retail space, and making

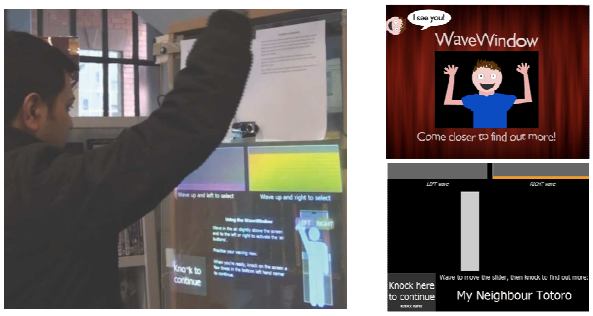

Figure 1: Left: WaveWindow in use, Right: user interface

it an enjoyable and attractive location is important, while bland forms of interaction are likely to lessen their impact as retail spaces.

As a step towards understanding user interactions in a public setting with see-through displays, we designed and deployed the WaveWindow, an interactive DVD display, in a retail setting at theatre/restaurant complex in the UK (see Fig. 1, left). In this paper we report the results of a user study, in which we highlight the nature of user interactions with the system and the forms of social interaction that arose from its context of use. The main *contribution* of this paper is in understanding how systems requiring 'expressive' gestural interactions are used in public places. Our interest is less on its commercial value or application, but more in how the form of interactivity and context of its use conspires to shape individual and social interaction.

This paper follows Peltonen *et al.* [9] who describe a week-long evaluation of CityWall, a large public display that bears similarities to WaveWindow. This was placed in a

shop window (although not displaying shopping-related content), and the paper describes its impact on group dynamics, social learning, playfulness, turn negotiation, and public space reconfiguration as a stage for multiple users. As with our paper, the evaluation also highlights performative aspects of interaction, although Citywall's touch-based interaction lends itself to somewhat different findings given its very different form of input.

WAVEWINDOW DESIGN

Users interact with the WaveWindow through a see-through display to watch trailers and reviews. Input methods were selected to make the interactive experience public and allow multiple-user interaction. WaveWindow was designed to attract passers by and to encourage expressive interaction through performance and spectatorship [4,8]. The WaveWindow's screen presents appropriate visuals depending on which interaction zone the users are currently in: it appears constantly active to attract the attention of potential users of the system and actively encourages their transition from an ambient bystander into a more involved 'explicit' interaction zone.

When nobody interacts with the system, the screen alternates between showing a cartoon-style animated waving man (fig. 1, top right, though not showing the see-though display) and a random DVD trailer with sound. This ensures that the screen content is constantly changing and attention grabbing. The animation also gives new users an insight in to the interaction technique before they actively participate. The words "Come closer to find out more" are also displayed on the screen whilst it is not being used, encouraging users to approach the device and become more involved. Once a user approaches the device (detected using simple face-recognition algorithms), an animation of a raising curtain is displayed, revealing the user interface beneath, further demonstrating the system's interactivity and responsiveness to the user's presence. In this explicit interaction zone, the users are closest to the shelf and can interact with the WaveWindow by *waving* in specific regions in the air and by *knocking* on the screen. By interpreting these inputs, the WaveWindow will present reviews, descriptions and trailers for each of the 10 films in the DVD display cabinet.

Public interaction by waving*:* Our intention was to create an interaction technique for explicit interaction that was touchless, expressive (i.e. both interaction *manipulations* and *effects* are visible) and easily understandable. Waving was chosen as the primary interaction method; in practice, waving with the left or right hand allowed users to move the 'active' screen projection left or right over a DVD inside the cabinet. In the case, of multiple users, the WaveWindow takes the highly activated input, i.e. where the most vigorous waving occurred. Feedback is provided by animated bars showing the level of activation for the wave 'zones', which ensures that even if a user has not 'fired' a wave action, they know how close they are to doing so. It also allows users to map the 'wave zones' in their physical space using trial and error. This can be seen in fig. 1 showing an orange activation bar on the right side to indicate that the user's right hand has been detected waving. When selecting a DVD, waving moves an information bar superimposed over a real DVD underneath the display and presents controls to select via knocking.

Public interaction by knocking: Knocking was used for control item selection, for e.g., to confirm a final DVD selection or to go 'Back' at previous stages in an interaction sequence. The action of knocking lends itself well to a public interaction paradigm as it adds an acoustic element to the system: by knocking, users perform an acoustically public action. Knocking was only active at a specific region on the bottom left of the display (see fig. 1, bottom right).

Hardware configuration: this consisted of a short-throw projector, webcamera and microphone to detect knocks. The inside of the plastic door was covered with an optical rear projection 'dnp Holo Screen' (www.dnp.dk) allowing images to be projected onto it whilst remaining translucent.

USER STUDY

The aims of the system deployment were to understand the use of highly visible 'performative' interactions in public spaces within a retail setting. These findings reported here therefore focus on the interaction of individuals and groups with the WaveWindow in public, how groups collaborated in their use of the system, and the interactions between passers-by and active users of the system.

The WaveWindow was placed in the entrance to a popular restaurant, movie theatre, conference and media centre in Bristol, where there is a 'front of house' shop selling DVDs and postcards. Its DVD store was immediately to the left of the WaveWindow by the movie theatre and stairs leading to the restaurant. Peoples' interactions with the device were observed and filmed continuously from 11.30am to 7.00pm over two contiguous Easter weekend days in 2010. This weekend was chosen to ensure maximum footfall, and a broad demographic across age, gender, group type and size.

During the study people were free to interact with the device at their own discretion and without interference. All interactions with the device were observed and filmed. The WaveWindow internal web camera was able to film users and close passers-by and ambient events. An HD video camera ~5 metres away and opposite the WaveWindow display filmed a wide overview of the interaction space. Logged data of system events were also recorded and matched to the video. The video and logs were coded and analysed, paying particular attention to the nature and types of interaction performed. A detailed video analysis of key interactions was also conducted from which several qualitative themes emerged: these form the primary focus of the data presentation and discussion in this paper.

FINDINGS

User demographics and interaction types: In total there were 455 distinct users (257 interaction instances) resulting in over 5hrs of system use over two days. Average group

size (with at least one user directly interacting with the system) was 1.77 individuals (median 2). The largest single sector was individuals, representing 48% (124 logged instances) of device interactions. However, overall there was a roughly even split (52%) between individuals and groups of two or more (133 instances). Of all groups, pairs were the most substantial sector after individuals, with 37% (94) of interactions, and groups of three or more people represented the final 15% (39) of interactions. This reflects the high proportion of couples and families in attendance.

Performance anxiety and social inhibition

Observations suggest that some users, after watching the initial training video, were too embarrassed to participate and perform the overt waving action. One observed episode involved a mother and teenage daughter entering the implicit zone of the device and watching the training video. After the completion of the video, clearly neither felt comfortable emulating the required action. Each then tried to encourage the other to perform: "Go on mum, you try it..." When neither was willing to interact, they exited the location. These episodes highlight social inhibition as a preventative factor to interaction, in line with a number of other studies in public interaction [4,6,7,9]. Our analysis showed that in 60 instances (n=257) the interaction ended in this state, although not all of these may be attributed to performance anxiety or social inhibition.

Conversely, the visibility of the interaction manipulations also helped overcome some of the social barriers to interaction. Watching others use the system was often a precursor to use [cf. 4,6,9]. This was also observed to a lesser degree in people watching unrelated persons. In one instance, a young woman was watching the WaveWindow and moved towards it, initiating an invitation from the WaveWindow to interact with it; however, she did not engage with it and instead began browsing the DVD shelf. As she did this, a man interacted with the WaveWindow, which the woman covertly observed. After he left, the woman then moved up to the display and interacted with it.

Collaborative interaction

Observations suggest that group members encouraged each other to interact. For e.g., when a user could not locate the correct wave region, another group member suggested: "*I think you're meant to wave up here*". Without the additional group input, the individual might have given up on the interaction, and this was observed on several occasions, however in this case collaboration enhanced and prolonged the interaction. In several cases observed, groups that were drawn in by one member interacted to a higher level due to the initial curiosity and enthusiasm of the interaction initiator. This was particularly evident in the case of children and teenagers that initiated interactions, in which parents were seen to prolong and encourage the interaction for the benefit of the younger group members.

In several instances, users did not directly interact with the WaveWindow, but were involved by making suggestions to the person directly using it on how to interact, as well as suggesting content selections. Typical situations of such use involve suggestions such as "*select that*" or "*watch the trailer*". In one example, the active user was attempting to knock at an incorrect location on the screen to select a DVD, when the other member of the pair who had been reading the on-screen information instructed the active user on the correct location to knock.

A competitive aspect was also observed in transitions of the active WaveWindow user between group members. In this respect, users waited their turn to interact, rather than interacting simultaneously. We observed this in a number of episodes, as bystanders would observe a person in their group interact relatively unsuccessfully, and who would then attempt to better their efforts by interacting themselves. Although this might be seen as an attempt to simply help their fellow interactors, these conversations were often explicitly framed in competitive language, with interactors often keen to show off their skills.

Sequential operations

Some group interactions were prolonged by each group member taking turns at interacting. This was particularly noticeable in groups with young children, in which each of the children would want their own distinct turn at the display. This behaviour was also observed in larger groups where, for example, one user from the group would interact, lose interest, and another user that was previously observing would continue the interaction from that point. We would characterise this activity as sequential rather then queuing (i.e. waiting their turn for interaction) in that these subsequent users were explicitly attempting to access the same DVD-related content as the previous users, rather than starting anew. We also observed some users alternated rapidly between interacting and observing, as one user would perform an action, then move out of the way to allow another user in their group to move in front of the display and perform a subsequent action.

This 'turn-based' system was notably observed on two instances where parents facilitated their children with the interaction by lifting them up to camera height to allow them to better interact with the system because their faces and gestures were too low to be recognised by the sensors. Because of the weight of the children and the difficulty of vigorously waving whilst lifting them, these parents would pick the children up to interact, put them down and carry out a waving interaction, occasionally repeating this lift/drop sequence multiple times.

Proxy and 'warranted' interactions

Groups with young children were often drawn into interaction with the WaveWindow initially by the children. The parents would then interact with the system on the behalf of their children, or in some cases, as described above, physically facilitate their children by lifting them up. It could be argued that in these instances, children are reducing the parents' sense of social inhibition by providing an 'excuse' for their overt behaviour, thereby 'warranting' them to perform in ways that they might otherwise have felt

uncomfortable with. Thus parents may feel more comfortable 'performing' to their children than to strangers. Certainly some of these instances were more drawn out and 'florid' than individual interactors or groups of adults using the system, with more movement around the space, more vigorous waving and louder verbalisations.

DESIGNING FOR PERFORMANCE

Although there are some similarities with Peltonen *et al.'s* study there are notable interactional and social differences, for e.g. in our use of touchless interaction and knocking, and in CityWall's context-independent content and independent multi-person use. Thus, the ways that multiple users have working spaces in CityWall means that territoriality issues arose that we did not see. Strikingly, the vigour of interaction was greater in the WaveWindow; we also saw more sequential turn-taking. WaveWindow's highly expressive performances drew more child-based interactions and consequently prolonged more intensive group use. Clearly, the very visible performative character of gestural interaction in front of the WaveWindow is an important aspect of public interaction, and this is likely to be the case for many such systems used in shop-front settings. Whilst this may be an inhibitor for engaging users in interaction, it also offers opportunities for design. We make some suggestions on these below:

Expressive gestures: making actions highly visible may discourage use, but at the same time, it turns the interaction into a public performance that ensures that interaction becomes an explicitly social event, building shoppers' curiosity and interest. Similarly, making actions and their outcomes observable supports vicarious learning, the ability to undertake collaborative sequential interactions, and allowing bystanders to offer suggestions on interaction.

Collaborative achievement: Allowing users to interact together may offer value in displaying and accessing digital content by offering turn-based systems, perhaps spread over distant parts of a window, or simply by providing onscreen content that can be seen by multiple people, rather than physically obscured by a single user.

Competitiveness: Building on user's competitiveness may offer greater interaction with the system and engagement with content. This may go against typical usability guidelines that expect (particularly walk-up) systems to be easy to use and allow quick and simple achievement of users goals. Paradoxically, making users work harder to achieve their goals may have benefits in these settings.

Engaging children: This is not just important in instances of selling children's products. Children's involvement in interactions appears to warrant more, longer and more engaged interactions than would otherwise be the case, because of their role in encouraging and stimulating interaction by adults.

Translucence: The see-through display adds context to the public nature of interactions. This makes the performance meaningful, rather than just odd. Users and bystanders can also see items behind the interaction space, and this especially important in shop windows in which display real estate is a valuable resource.

Knocking: audible interactions offer opportunities for making interactions publicly visible, but it may also be annoying and disruptive, in this case, to shoppers. Although such disruption was not observed in our study, this might be more of a problem for shop windows displays. Limiting knock areas to specific locations may offer a solution (as in this study), as these can be muffled more easily.

In sum, we have explored some factors affecting interaction with see-through displays in public environments. Interactions within this context are inherently social in a number of ways, being performed within the context of an audience or as part of a group. The visibility and audibility of these interactions makes them available to audience and collaborators alike with both inhibitory and facilitatory consequences. These are important considerations for the design of surface experiences in public domains likes retail. What appears particularly interesting in the interactions that we have observed is that it is the performance around the interaction that appears to drive important social behaviours. Making use of these performances through structuring the form of the interaction offers real value in shaping the kinds of social behaviour that take place around the display, and by tying this to the constraints of a retail context we can build see-though displays that fit with the practical and commercial demands of this context.

REFERENCES

1. Ferscha, A. & Keller, M., DigiScope: an invisible worlds window, adjunct Proc. Ubicomp'03, 261-264.
2. Wilson, A. D., TouchLight: an imaging touch screen and display for gesture-based interaction, Proc. ICMI'04.
3. Hirakawa, M., Kojima, Y. & Yoshitaka, A.,. Transparent interface: a seamless media space integrating the real and virtual worlds, Proc. IEEE Human Centric Computing Languages and Environments, 2003, 120-122
4. Hornecker, E., Marshall, P. & Rogers, Y., From entry to access-how shareability comes about. Proc DPPI '07.
5. Olwal, A., Unencumbered 3D interaction with see-through displays. Proc. NordCHI'08, 527-530.
6. O'Hara, K. Glancy, M. & Robertshaw, S., Understanding collective play in an urban screen game. Proc. CSCW'08, ACM, NY, 67-76.
7. Finke, M. Tang, A., Leung, R. & Blackstock, M., Lessons learned: game design for large public displays. In Proc. DIMEA'08, 26-33.
8. Reeves, S., Benford, S., O'Malley, C. & Fraser, M. Designing the spectator experience. Proc. ACM CHI'05, ACM, NY, 741-750.
9. Peltonen, P., Kurvinen, E., Salovaara, A., Jacucci, G., Ilmonen, T., Evans, J., Oulasvirta, A. & Saarikko, P., It's mine, don't touch! interactions at a large multitouch display in a city centre. Proc. ACM CHI'08, 1285-1294.