Interaction Design for Large Vertical vs. Horizontal Displays: Open Issues

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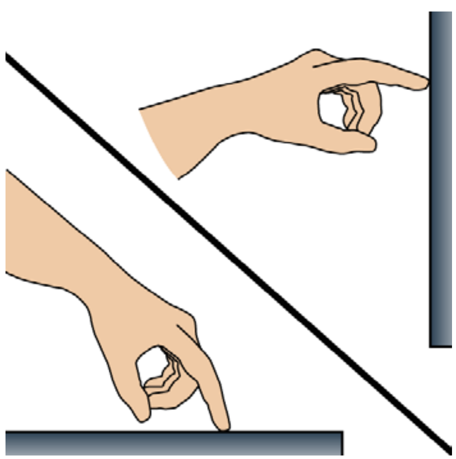

Abstract

With the proliferation of large horizontal and vertical displays in people's work environments as well as in public spaces, designing interactions that are adapted to the size and orientation of those screens becomes increasingly important. Past work comparing horizontal and vertical displays have mostly focused on studying social responses in collaborative work situations, but basic interaction design issues have received comparatively little attention. In this workshop contribution we raise a number of open research questions about how the orientation of large displays may –or should– influence critical input, interaction and interface design considerations. We review aspects covering typical input methods, gestural interaction, space usage and territoriality, each of which, we believe, potentially constitutes an interesting research avenue to explore.

Author Keywords

Interaction design; Large vertical displays, wall displays; digital tabletops.

ACM Classification Keywords

H.5.2. User Interfaces.

Introduction

Large displays are becoming increasingly widespread and their interactive capabilities more sophisticated,

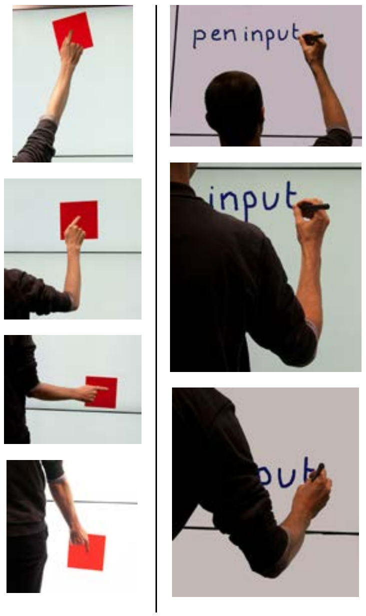

Figure 1: For direct input on VS, the location and particularly the height of target objects greatly affect body, hand and arm poses (illustrated above for touch (left) and pen (right) input). This potentially leads to differences in interaction performance and comfort. For touch in particular, a hand/wrist rotation is necessary to drag elements from the top to the bottom of the display (or vice versa). Is this a problem? Are touches with downward hand orientations (i.e. fingers pointing down) less accurate? Should fine-grained interactions in lower areas of VS be entirely avoided?

thanks to the progress of technology and dedicated software designed for those platforms. From digital tabletops to wall screens and tiltable displays, a wide range of interactive surfaces with different sizes and orientations are available to developers and users today. While a number of studies looking at social aspects in collaborative work have been performed (among other things, to determine collaboration patterns and user preferences for particular display orientations) [4, 7, 12], there is currently little documented research about the extent to which typical interaction models and UI designs can be transferred from horizontal to vertical displays and vice versa. Our experience with whiteboards and tabletops informs our intuition that text on the former should preferably be written with a pen, whereas a (virtual) keyboard is also appropriate for text entry on the latter, but formal performance evaluations have never been conducted to validate those instincts. Similarly, there is a dearth of empirical results showing which types of pen interactions are more efficient or comfortable on each surface (if there is any difference at all), if and how far particular gestures or postures are more suitable for horizontal or vertical surfaces etc.

In the following sections, we elaborate on those questions and a number of other interaction design issues that we think merit particular study in order to determine what orientation-dependent factors actually exist and how they might influence the design of interactions and applications on large displays.

For the sake of conciseness, we hereafter refer to large vertical and horizontal surfaces using the abbreviations VS and HS respectively.

Input

- Touch: In [6], Holz and Baudisch find that users' mental model of finger touch for target acquisition differs from how devices typically resolve point coordinates from raw input (top vs. centre of fingertip). This study was however performed with participants sitting at a table. Does this offset vary with surface orientation and standing users? If yes, how?
- Pen: For targeting on HS, a rested arm affords stability on pen approach [10]. On VS, the arm typically does not fully rest on the surface, so targeting is possibly less accurate. In general, pen hold and writing comfort seem to vary with input location to a much greater extent on VS (see Figure 1) than on HS. For palm rejection [5], does or should the different contact shape of the palm/arm when writing on HS vs. VS affect palm-rejection strategies?
- Tangibles: Gravity is not in favour of VS. Thus, unless they have special magnetic or sticky bases, tangibles used with VS are usually held by users and contact with the surface is temporary. Does this make tangible interaction less attractive an option for VS? Which tangible UI paradigms are practical for such types of displays?
- Contactless interaction: VS afford more contactless interaction possibilities because users are facing the screen and hence can easily point at elements on it or interact with their body [8] (Figure 2). HS, on the other hand, are facing upwards, therefore contactless interaction is mostly limited to above the surface and less based on precise input. Coarser interactions, such as detecting user proximity around the display, however, have been considered for both types of displays (e.g. [1] for HS and [2] for VS).

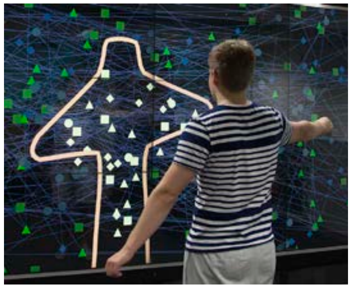

Figure 2: BodyLenses, body-controlled magic lenses and territories on wall displays [8].

Figure 3: Eyes-free assistive touch support using a handheld device for pen-based whiteboard activities [9].

Figure 4: Tools offloaded to an arm-worn device in SleeD [14].

Gestural Interaction

- Stroke gestures: With the pen, there are probably no significant differences in terms of gesture-recognition accuracy. For touch, Pedersen and Hornbæk found that dragging is slower on VS than on HS [11], which suggests that large drag-based stroke gestures might be less suitable on such devices. Furthermore, vertical displays currently tend to be TV screens or monitors with friction-prone glass panes, whereas tabletops and tablets more often have smoother, more drag-friendly coatings.
- Text entry. There is to date no empirical study that has thoroughly compared text entry methods on HS and VS, therefore it is unknown what techniques are most efficient and convenient on each platform and if there are any significant differences. Furthermore, it is unclear how far we can transfer our experiences of writing on non-digital VS and HS to the digital domain.
- Hand postures on surface: Hand postures can be used to trigger special commands or mode switches on HS [10, 13]. On VS, finger chords are presumably suitable on the entire surface because they can be performed with relaxed wrist and arm poses regardless of the height. This is not the case for postures based on larger contact shapes such as palms, hand edges, fists etc., however, and therefore such type of postures might not be adequate choices for VS.
- Bimanual interaction: According to [11], users show no desire to switch hands for single-touch tasks on VS or HS, regardless of object location on the screen. There is however prior work showing that simultaneous two-handed interactions, especially pen + touch, yield powerful possibilities for applications on tabletops [5]. Would such kinds of designs also make sense on VS? If yes, should they be adapted in any way?

Space Perception and Territoriality

- Angle at which items are viewed: On VS, viewing angles are relatively orthogonal when standing at a distance. Perspective-related issues appear when close to the VS, causing change blindness and restricting interaction to the area directly in front of the user [3]. Conversely, on HS, angles can be very acute for elements displayed at the far end of the surface. How do these issues influence UI design?
- Widget positioning and calling: We assume very large surfaces so in most cases, permanent widgets at fixed locations are not viable. Calling techniques such as finger/pen dwell or gestures are appropriate both for VS and HS. For tabletops additionally, areas close to the edges are easily reachable, so items can be dragged off bezels [5]. On VS, tools can be offloaded to handheld devices carried by the user [9, 14] (Figures 3 and 4).
- Space usage on VS vs. HS: How is interaction space used on HS vs. VS? Given sufficiently large displays in both cases, what is the typical spatial coverage of a user's workspace in static and mobile conditions? On HS, the workspace reasonably needs to be within arm's reach of the display's edge. On VS, it will probably be located at eye-level both for reasons of perception and because this is the area easiest to interact with.
- Vertical ranges for input on VS: As touched upon in Figure 1, viable vertical ranges for different input methods are an issue. Human motor skills and perception limit interactions to certain heights on VS, which suggests that different input methods might

be required depending on the target interaction areas. For instance, virtual keyboards may be usable only from chest height upwards, while touch in general is feasible at much lower heights. What heights are acceptable for which input methods? How does input precision vary across the vertical range? Furthermore, how do we handle regions that are out of reach (e.g. too high to touch)? Should far areas be dedicated to data-display only or should other interaction modalities be used?

Conclusion

When designing applications for vertical or horizontal surfaces, it is important to know which interaction models can be transferred from one platform to the other and how. Knowledge of critical orientation-related perception and performance issues is also valuable. We have raised a number of such issues that we think should be examined in greater depth, but there are of course many more.

References

1. Annett, M., Grossman, T., Wigdor, D. and Fitzmaurice, G. Medusa: a proximity-aware multi-touch tabletop. In *Proc. UIST 2011*.
2. Ballendat, T., Marquardt, N. and Greenberg, S. Proxemic interaction: designing for a proximity and orientation-aware environment. In *Proc. ITS 2010*.
3. Bezerianos, A. and Isenberg, P. Perception of Visual Variables on Tiled Wall-Sized Displays for Information Visualization Applications. *TVCG*, *18*, 12 (2012).
4. Everitt, K., Chia, S., Ryall, K. and Forlines, C. MultiSpace: enabling electronic document micro-mobility in table-centric, multi-device environments. In *Proc. TABLETOP 2006*.
5. Hinckley, K., Yatani, K., Pahud, M., Coddington, N., Rodenhouse, J., Wilson, A., Benko, H. and Buxton, B. Pen + touch = new tools. In *Proc. UIST 2010*.
6. Holz, C. and Baudisch, P. Understanding touch. In *Proc. CHI 2011*.
7. Inkpen, K., Hawkey, K., Kellar, M., Mandryk, R., Parker, K., Reilly, D., Scott, S. and Whalen, T. Exploring display factors that influence co-located collaboration: angle, size, number, and user arrangement. In *Proc. HCII 2005*.
8. Kister, U., Reipschläger, P., Matulic, F. and Dachselt, R. BodyLenses - Embodied Magic Lenses and Personal Territories for Wall Displays. In *Proc. ITS 2015*.
9. Matulic, F., Husmann, M., Walter, S. and Norrie, M. Eyes-Free Touch Command Support for Pen-Based Digital Whiteboards via Handheld Devices. In *Proc. ITS 2015*.
10. Matulic, F. and Norrie, M. Empirical evaluation of uni- and bimodal pen and touch interaction properties on digital tabletops. In *Proc. ITS 2012*.
11. Pedersen, E. W. and Hornbæk, K. An experimental comparison of touch interaction on vertical and horizontal surfaces. In *Proc. NordiCHI 2012*.
12. Rogers, Y. and Lindley, S. Collaborating around vertical and horizontal large interactive displays: which way is best? *Interacting with Computers*, *16*, 6 (12/ 2004).
13. Wigdor, D., Benko, H., Pella, J., Lombardo, J. and Williams, S. Rock & rails: extending multi-touch interactions with shape gestures to enable precise spatial manipulations. In *Proc. CHI 2011*.
14. Zadow, U. v., Büschel, W., Langner, R. and Dachselt, R. SleeD: Using a Sleeve Display to Interact with Touch-sensitive Display Walls. In *Proc. ITS 2014*.