Curve: Blending Horizontal and Vertical Interactive Surfaces

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ABSTRACT
Desktops are the most prevalent environment for productive use of computers. However, there is still a gap between physical and virtual desktops. Previous approaches merged both worlds into one interactive horizontal surface. We argue that horizontal and vertical surfaces serve different purposes and offer different advantages. Therefore, we propose the combination of both surfaces by a soft curve forming one large, L-shaped surface. This setup preserves the unique properties of horizontal and vertical surfaces while allowing interaction across boundaries without disruption.

Author Keywords
multi-touch interaction, interactive surfaces, non-planar

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces

MOTIVATION

In today's computer use at desks a dividing line exists between the physical work environment on the (horizontal) desktop and the virtual work environment on the (vertical) computer screen. Most human-computer interaction is done by means of keyboard and mouse combined with a vertical screen. For interacting with the physical world on our desktop hands, fingers and pens are the primary tools. Various research prototypes have tried to merge physical and virtual work environments [1, 2, 7] on digital, horizontal screens. As horizontal and vertical surfaces have complementary advantages and disadvantages they are not interchangeable. On the one hand, vertical surfaces are well suited for displaying information but less practical for manual (touch-)interaction. On the other hand, horizontal surfaces facilitate direct manual interaction with virtual and physical objects while making it difficult to work with different documents at the same time. In the following we describe the design of an interactive surface supporting those properties and our findings of its ideal size based on an initial exploratory study.

Figure 1. The *Curve* concept combines a horizontal and a vertical interactive surface, merging physical and virtual desktop.

BLENDING HORIZONTAL AND VERTICAL SURFACE

Our approach seeks to combine a horizontal and a vertical surface into one large interactive surface while preserving the unique properties of each. While others have presented combinations of horizontal and vertical displays previously [6], no system offers a seamless interactive surface. Screen bezels or a right angle between surfaces disrupt drags and make it necessary to implement special interaction techniques [4]. *Curve* (Figure 1) is a desktop-sized interactive surface with a horizontal and a slightly tilted vertical surface connected by a smooth curve. The curve creates a continuous display and interaction surface and allows for effortless dragging of physical and virtual objects across the whole surface without special techniques.

SCENARIOS

A curved display may offer several benefits to users in different situations. The horizontal surface most likely is covered with physical objects like keyboard, mouse or papers, while still leaving the vertical surface for display. This allows legacy WIMP applications to co-exist with novel multi-touch applications. The *Curve* concept makes it possible to virtually augment physical objects lying on the desktop while users still can work with their documents just the way they prefer – editing on the vertical and reading on the horizontal screen for example. Users might also take advantage of the individual traits of both surfaces, e.g., in sorting tasks. Bi-manual sorting within the horizontal area might be more efficient than sorting objects with the mouse on the vertical part of the display. Furthermore, touch on vertical surfaces would lead to the so-called gorilla-arm-effect. One might think of many more scenarios where tasks in the vertical and horizontal

layers may benefit from a direct connection between them like collaboration on such an interactive surface. However, in order to actually replace a conventional desktop, a *Curve* desktop needs to be at least as ergonomic. In the following section we will describe our approach to this requirement.

FINDING THE RIGHT DIMENSIONS

To address the ergonomic issue, we used a three-step approach: First we collected general ergonomic requirements for desktops, based on German[1] ergonomics standards [3]. In discussions with designers and cognitive psychologists we determined additional constraints. Open factors were the display's height, its inclination and the radius of the curve.

Study Setup

We conducted a user study to gain information about these open factors. One factor to be tested was whether the top edge of the vertical surface should be above (54 cm above desktop) or below (44 cm) a seated user's eyes, concerning the trade-off between a larger display and the possibility for users to avert their eyes. This means +/- 5 cm compared to the average user's eye height (DIN 33402-2). Furthermore, we tested three different inclinations of the vertical surface (5, 10, and 15 degrees) and three different radii (5, 10, 15 cm) for the curve. In total, we used *2 Heights* (*44 cm*, and *54 cm*), *3 Inclinations* (*5 degrees*, *10 degrees*, and *15 degrees*) and *3 Radii* (*5 cm*, *10 cm*, and *15 cm*) resulting in a total of 18 prototypes. The distance between desk edge and vertical area (45 - 50 cm) and a fixed width (120 cm) were chosen due to characteristics of an average user [3]. The table height (72 cm) was chosen based on guideline values for occupational health (DIN EN 527-1). Nine students, aged 22 to 27, participated in the study and were asked to draw several paths on the paper with one or two fingers of their own choice. Each participant had to test all 18 surfaces in a counter-balanced order. After each task they had to fill out a questionnaire about the prototype. Finally, participants had to re-test the three surfaces they liked best and rank those.

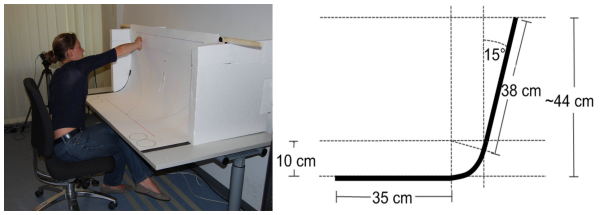

Figure 2. left: A study participant trying to reach the upper left corner of the prototype. right: Suggested measures of *Curve*.

Findings

Three different methods were used to determine the attributes which characterize the most popular prototype. Surfaces were ordered by the average results according to the questionnaires' answers, by their occurrence in the top three ranking of each participant and by a condorcet vote [5]. Based on this order we can define the most popular parameters for a *Curve* desktop. The users' answers to the questionnaires suggest that the interactive display need not be wider than 120 cm but might be rather less wide. Body height seems not to have an impact on the answer. On average the low prototypes with greatest inclination were preferred. This seems to be because of an easier and smoother direct manipulation in the upper corners compared to the high prototypes with small inclination. Three out of four most popular prototypes had an inclination of 15 degrees to the back. It also seems that inclination and height are more important than the curve radius because there was not a definite preference between a radius of 10 or 15 cm. Therefore we suggest to use a radius of 10 cm in order to maximize the size of horizontal and vertical surfaces. Based on these findings we propose that a *Curve* desktop should have a width of 120 cm, a height of about 44 cm, and a curve radius of 10 or 15 cm. The vertical surface should have a backward inclination of 15 degrees (Figure 2).

[1]Study participants were and will be German citizens. The mean values for size and arm length we used should work for most Caucasians. Depending on target group, height and depth of the surface might have to be adjusted.

CONCLUSION

An interactive surface that encompasses a horizontal and a vertical area may be able to blend virtual and physical desktops and help users in completing everyday tasks more effectively compared to common desktop-computers. Within our study we identified some of the general requirements for novel curved displays. Based on these findings, we are currently building a *Curve* setup. We will investigate the effects of *Curve* on various everyday tasks in the future.

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