The Escritoire: Remote Collaboration in a Task Space

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ABSTRACT
We argue that the reason videonconferencing has not become widely used despite being available for decades is that it provides a person space, whereas participants would often more usefully share a task space. That is, a graphical space where they they can view and manipulate the same visual representations. We have created a system called the Escritoire that has a large horizontal display and allows collaborating participants to share the contents of a full-sized desk with sheets of virtual paper. Participants found an audio channel and desk interaction much more useful than a video channel in a task involving a large amount of information, and they were aided by facilities for gesturing in the graphical space.

Categories and Subject Descriptors
H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces

General Terms
Design, Experimentation, Human Factors

Keywords
projected display, foveal display, person space, task space, videoconferencing, pen input

1. INTRODUCTION
The Picturephone from Bell Labs was introduced publicly at the 1964 World Fair and at the time it was predicted to replace the existing voice-only telephone by the early 1970s. The intuitive appeal of video communication fuelled forecasts of its wide-scale adoption [4] but, except for limited use in business settings, it has not become a substitute for face-to-face meetings.

Buxton uses the term *person space* for the sense of presence between group participants in a videoconference that can see each other's facial expressions and gaze directions, and

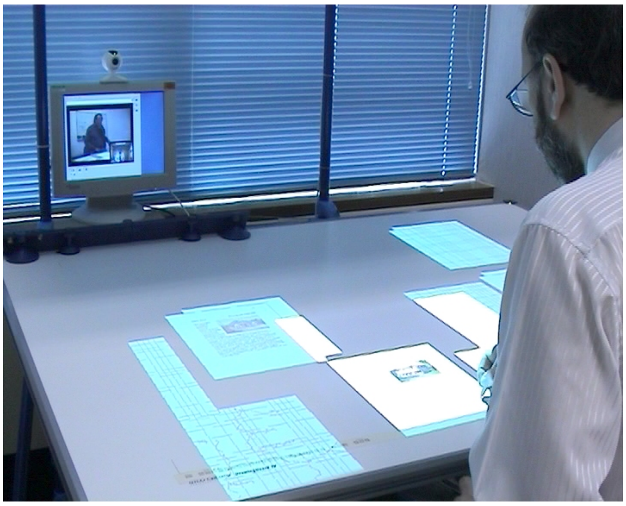

Figure 1: Two Escritoire desks allow the local and remote users to share a task space containing many documents. The users can also see and hear each other via a conventional videoconference. The remote user is visible on the LCD monitor at the top left.

the term *task space* for copresence in the domain of the task being undertaken [3]. Krueger's VIDEODESK [7], created around 1970, was an early example of a collaborative system that presented a task space to users at remote locations. More recently studies have shown [6] that, especially for for visually complex tasks in which things change frequently, a shared view of the task is very useful, and more useful than the person space provided by a traditional videoconference.

We have created a system called the Escritoire [1] that presents its user with a horizontal desk-sized display on which documents are displayed life-sized. Two or more Escritoire desks can be linked to allow users to collaborate around items such as documents and images. The display provides a large visual context that the users share and they can collaborate in this task space, easily working together in a complex visual environment.

2. DESK DISPLAY
To create a display that is as big as a desk but can also display a life-sized document at a legible resolution, we have combined two projectors to create a *foveal display.* A projector mounted above the desk creates the high-resolution

fovea, and another behind the desk creates the large *periphery*, as shown in Figure 2.

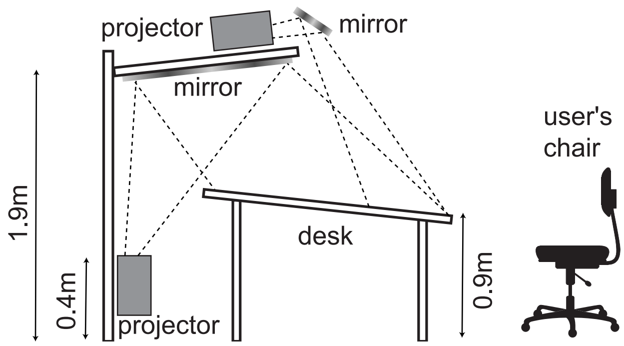

Figure 2: The arrangement of the projectors that create the two regions of the foveal display.

The display is visually similar to the focus plus context screen by Baudisch *et al.* [2] which combines an LCD panel and a projector, but our system uses projective warping to correct the distortions due to oblique projections and align the projectors, and commodity 3D hardware to perform the warping in real time, as described by Sukthankar *et al.* [8]. The desk fills much more of the user's visual field than a conventional monitor and allows her to arrange many items so that they can be quickly glanced at to identify them, and quickly grabbed and brought to the fovea if they are needed

3. USER INTERFACE

The desk onto which the graphics are projected is a large digitizer with a cordless pen. We have found no commercially available device that offers simultaneous two-handed input over such a large area so we have combined the accurate digitizer with a less accurate ultrasonic pen. The two hands can thus work simultaneously, with the more accurate pen in the dominant hand for detailed movements like writing, and the less accurate one in the non-dominant hand to move items around the desk.

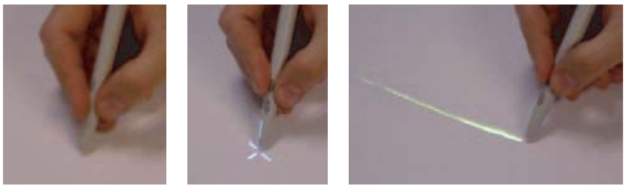

Figure 3: The three options for pen cursors: no cursor, cross hair, and trace.

We have implemented three options for cursors: no cursor, a cross hair, and an animated trace that follows the pen indicating its recent movement (Figure 3). When collaborating users work on visual material many of the actions they make will be ephemeral gestures rather than drawing or annotating actions. Gutwin has found that traces improve gestural communication for both the creator and the viewer of the gesture [5]. In our testing we have found that users working alone much prefer to have no cursor, presumably because, unlike an indirect pointing device like a mouse, the location at which the user is pointing with a pen is always obvious. In a collaborative setting, however, users preferred the trace, as explained below.

4. NETWORK

We have split the software for the Escritoire into a client and a server. Inspired by the thin-client model of VNC `<www.realvnc.com>`, the client does not store any state so it can be restarted at any time. Multiple clients can connect to a single server so mutliple users can collaborate on documents and images in a WYSIWIS (What You See Is What I See) manner. The server implements the sheets of virtual paper on the desk as Java classes that handle all the interaction. The client simply displays *tiles*, which are bitmaps that show the graphical representations of the sheets. Figure 4 shows the relationship between client and server.

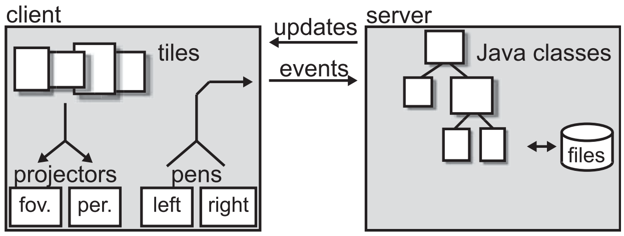

Figure 4: The Escritoire client handles the projectors and pen input devices, and leaves all of the event handling and storage of state to the server.

The Java code on the server can cause changes to the sheets on the desk at any time which suggests using a server-push scheme, in which a message about a change is sent as soon as it becomes available. However, the client has much graphics processing to do, and can be the bottleneck in the system, so we do not want to overload it. The approach we have taken is to switch automatically from server-push to client-pull. During quiet periods server-push is used, which gives a fast response to a change, and in busy periods a client-pull scheme allows new messages to be buffered at the server where redundant messages can be combined or discarded.

5. COLLABORATION

We added interaction between two Escritoire desks to the audio and video channels of a traditional video conference to study how the task space of the shared desk surface would complement the person space between the users. Figure 1 shows the system in use. The local user is annotating a sheet of virtual paper on the desk while the remote user, who is shown on the LCD monitor, is watching the annotation be made while listening to the comment from the local user.

5.1 Tests

To test the system we used three pairs of collaborating participants. One person in each pair was a member of the University of Cambridge and used a desk in Cambridge, and the other was an employee of Thales Research & Technology, who sponsored this work, and used a desk at their site in Reading about 100 miles away. Initially each participant worked on his own. He was shown 30 sheets, each with details a house on it, as shown in Figure 5, and was given a few sheets of virtual paper on which to make notes. Then the pair of remote participants was connected and they were given the task of finding the three best houses from groups of 10. This task was repeated three times, each time using a different cursor option from Figure 3.

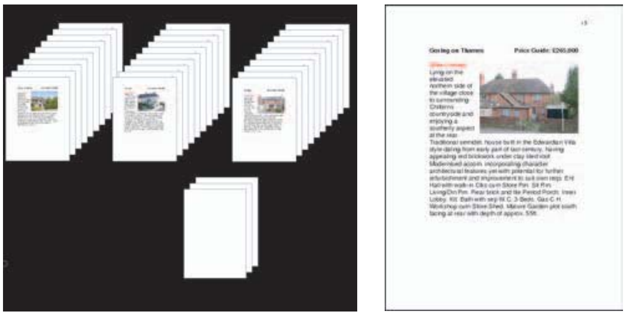

Figure 5: Collaborating participants were given sheets detailing 30 houses.

The Escritoire server was at Thales and the participant at Cambridge was connected to it via a DSL link delivering 256kbps which was shared between the audio, video, and desk. After the tasks each participant was asked which cursor type she preferred and for comments on the cursors, she indicated her agreement on a five-point scale to the statements 'the audio channel was useful for the task', 'the video channel was useful for the task', 'the desk interaction was useful for the task', and she was asked whether the difference in brightness and the difference in resolution between the fovea and periphery was a problem. She was also asked for general comments on the system. The whole process took around two hours for each participant.

5.2 Results

All of the participants immediately understood the concept of interacting through the desk while conversing over the videoconference link. After they had used the desk system on their own they did not need any extra training to use it for remote collaboration.

One participant was split between preference for the cross hair cursor and the trace which made the totals 0 for no cursor, 0.5 for the cross hair and 5.5 for the trace. This is almost the opposite of the single user case when the absence of a cursor was preferred. Traces proved to be useful in allowing a participant to direct the attention of the other, for example, when pointing out details in a photograph. One participant said that pointing to things, especially on the map he had drawn, was difficult when no cursors were present. Another said he would normally hate traces when working on his own, but they are useful to show someone else what you are doing.

Table 1: Responses from participants of the collaborative tests. 1–strongly agree, 5–strongly disagree.

	1	2	3	4	5
audio useful	6	0	0	0	0
video useful	0	2	2	0	2
desk useful	6	0	0	0	0

The responses to the three statements are shown in Table 1. Participants clearly considered the audio and desk interaction essential for undertaking the task, but deemed the video channel relatively unimportant. The difference in resolution between the fovea and periphery was only considered to be a mild inconvenience by half of the participants. The difference in brightness was not considered a problem, and was considered an advantage by one participant because it makes the boundary between the two regions apparent. Two participants would have liked a different assignment of functions to the two pens to enable them to browse a pile with one hand while making notes with the other. Two participants said they would have liked to have had a private workspace to make notes that could not be seen by their partners.

6. CONCLUSION

The desk of the Escritoire provides an interface that is more like manipulating papers on a physical desk than the conventional desktop metaphor. Users required minimal training to use the system, and no extra training to use it for collaborative work, which indicates the inherent usability of the interface. They found the pen traces distracting when working on their own, but found them very useful when working collaboratively—the traces allow users to gesture to each other in the task space that they share, and provide continual lightweight feedback that allows one user to stay aware of the actions of another. Further user testing could determine an optimal assignment of functions to pens that would allow the two-handed techniques that are most useful.

7. ACKNOWLEDGMENTS

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