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ClearFace: Translucent Multiuser Interface for TeamWorkStation

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Abstract

Through the experimental use of TeamWorkStation, we found the most serious problem is the smallness of the shared screen space. In order to fully use the limited screen space, this paper proposed a new multiuser interface design technique "ClearFace". The face windows are *translucent* and *overlay* the shared workspace window.
We implemented a prototype of ClearFace system on a TeamWorkStation. Several types of face window layout strategies were tested: fixed location windows (right side, left side, top) and movable windows. Through experimental design sessions, we experienced little difficulty in switching our focus between the face images and drawing objects. The theory of selective looking accounts for this flexible perception mechanism. Although users can see draw objects behind a face with little difficulty, we found that users hesitate to draw figures or write texts over face images. Because of this behavior, we concluded that the movable strategy is the best.
TeamWorkStation demonstrated the power of two different usage of translucent overlay technique: *fused overlay* of drawing surface images for seamless shared workspace, and *selective overlay* to save screen space.

1 Introduction

In order to provide distributed users with an "open shared workspace" where every member can see, point to and draw on simultaneously using heterogeneous personal tools, we designed "**TeamWorkStation**" [Ishii90, Ishii91]. TeamWorkStation integrates two existing kinds of individual workspaces: computers and desktops. Because each coworker can continue to use his/her favorite application programs or manual tools simultaneously in the virtual shared workspace, the cognitive discontinuity (seam) between the individual and shared workspaces is greatly reduced.

TeamWorkStation (TWS) provides a "shared screen" in addition to an individual screen. The shared screen supports (1) a shared drawing window for concurrent pointing, writing, drawing, and (2) live face windows for face-to-face conversation.

Through the experimental use of TeamWorkStation (by 2 ~ 3 users at the same time), we found the most serious problem is the smallness of the shared screen space. Because of the limitation of screen size (current prototype uses a 14" screen), it is very hard to secure the space for a shared drawing window large enough for effective use on one screen together with all face windows of the group members. The use of a bigger display or multi-displays is one solution. However, normal desktops are too limited to support these space-consuming solutions. High land and office rental costs in Japan (especially around Tokyo) are the main reasons for this constraint.

This paper proposes a new solution to this problem. We devised the idea of "*translucent*, *movable* and *resizable* live face windows over shared drawing window". We call this new multiuser interface design technique "**ClearFace**". We implemented a prototype of ClearFace system on a TeamWorkStation.

This paper describes the idea of ClearFace, and some findings through experimental use in design sessions. Several types of face window layout strategies are compared: fixed location windows (right side, left side, top) and movable windows. The effectiveness of ClearFace is also discussed using the theory of "selective looking".

2 Multiuser Interface for a Shared Workspace

White board is the most typical shared workspace in an ordinary face-to-face meeting. Fig. 1 shows a snapshot of shared workspace in a design session. Participants are drawing, writing, pointing, speaking and gesturing concurrently.

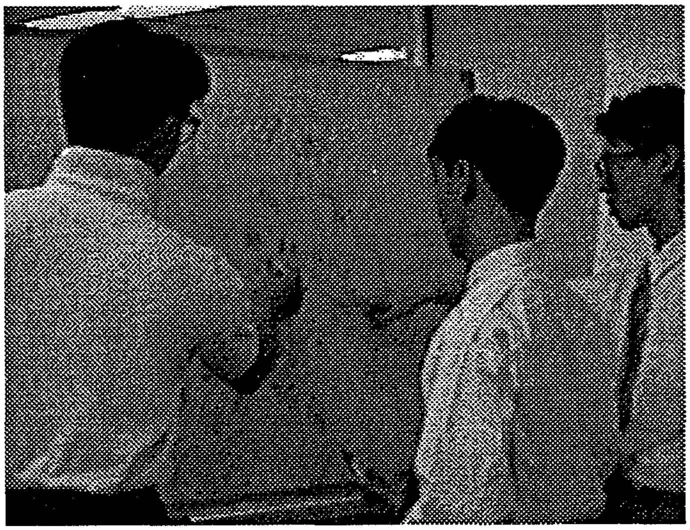


Fig. 1 An example of shared workspace in a design session

People use a white (or black) board as a *shared drawing space* that every member can see, point to and draw on *simultaneously*. Bly, Tang, Leifer and Minneman pointed out that the shared drawing surface plays a very crucial role not only to store information and convey ideas, but also to develop ideas and mediate interaction, especially in design sessions [Bly88, Tang88, Tang90].

At the same time, in the discussion, the participants are speaking to and seeing each other, and using facial expressions and gestures to communicate. In the conversations, it is essential to see the partners face and body. The facial expressions and gestures provide a variety of non-verbal cues that are essential in human communications.

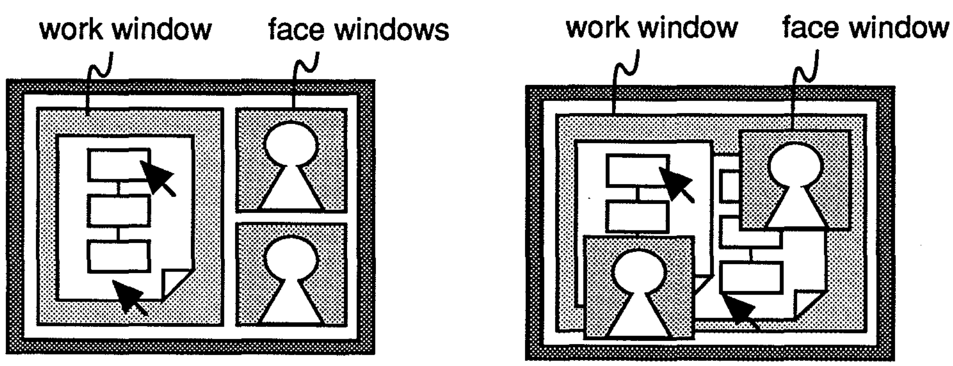
The focus of a design session changes dynamically. When we discuss abstract concepts or design philosophy, we often see each other's face. When we discuss concrete system architectures, we intensively use a white board by drawing diagrams on it. Through the use of TeamWorkStation in design of a video network architecture, we realized that the smooth transition between face-to-face conversation and shared drawing activity is essential for the seamless support of dynamic interaction in design sessions.

All of these dynamic and concurrent activities such as drawing, writing, pointing, speaking, gesturing by each participant form the *shared workspace*. Therefore, when we design the multiuser interface of CSCW environment to provide geographically distributed users with a shared workspace, it is not sufficient to simulate just only the white board function or to provide only a simple picture phone function. It is necessary to integrate a virtual white board with face-to-face communication channels, and users must be able to choose one of them or both channels according to the task contents.

In a face-to-face meeting, the room is perceived as a contiguous space, and there are no physical *seams* between the white board and the participants. By simply moving their eyes, participants can look both other participants and white board. However, in ordinary desktop tele-conference systems, the images of participants and shared document images are usually captured by different cameras, and dealt with separately (displayed in different windows on a screen). Therefore, users must often switch their focus between the face images and shared drawing space.

Previous Approaches: Tiling and Overlapping Windows

A variety of computer-controlled video conference environment, such as Media Space [Webe87, Stul88, Harr90], CRUISER [Root88], TeamWorkStation [Ishii90], MERMAID [Wata90], CAVECAT [Mant91], have been presented. Many of them are designed based on workstations with desktop video communication functions, and live face images are displayed in the windows on a screen. These workstation-based systems take one of the following face image layout strategies:
(1) tiling windows (Fig. 2 (1)), or
(2) overlapping windows (Fig. 2 (2)).



(1) Tiling windows (2) Overlapping face windows

Fig. 2 Two Existing Window Layout Strategies

TeamWorkStation took the tiling approach (1) to layout the windows in a shared screen. Figure 3 shows the appearance of the TeamWorkStation prototype. The individual screen and the shared screen are contiguous in video memory. Two CCD cameras to capture the face image, and the actual desktop image are provided.

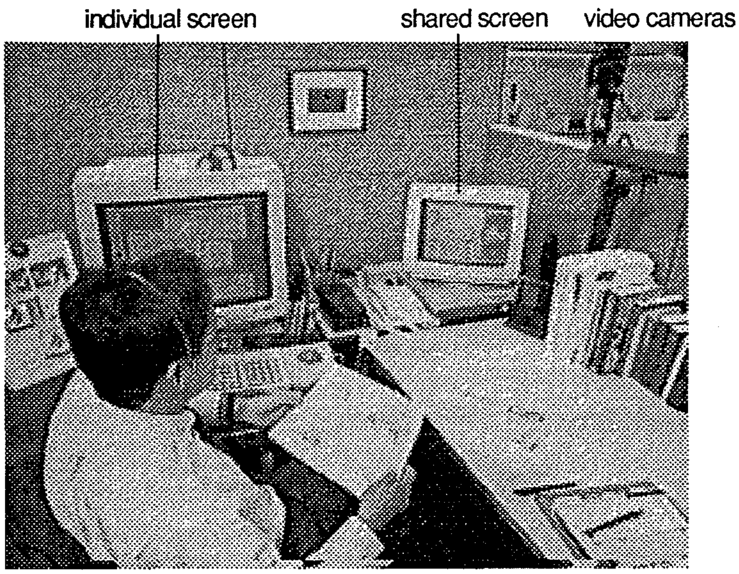


Fig. 3 Appearance of TeamWorkStation

Figure 4 shows an example of the original shared screen of TeamWorkStation in a design session. Two users are discussing the system architecture using a draw-editor, a hand-written diagram, pens, and hand gestures simultaneously.

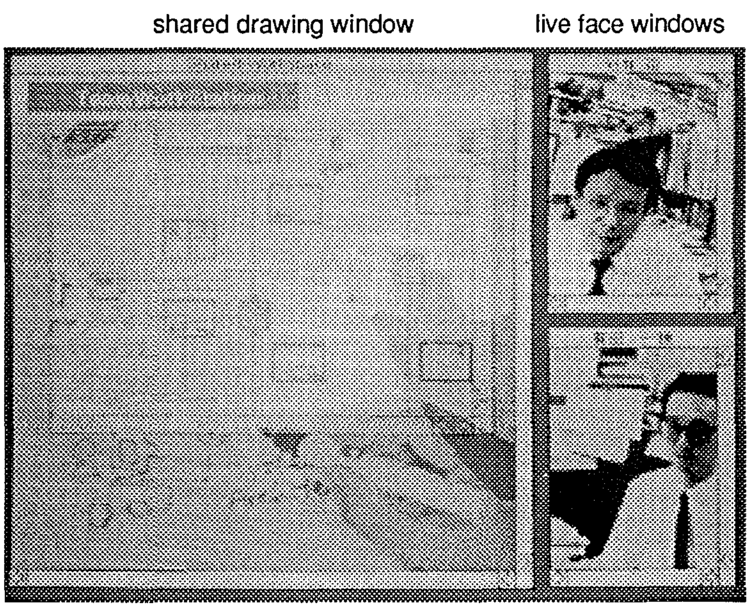


Fig. 4 An Example of Original Shared Screen of TeamWorkStation
(This layout is an example of the tiling window strategy.)

Both approaches, tiling and overlapping windows, must segregate the limited display area into the work window and face windows, and each window is strongly restricted. As a result, users must pay a lot of attention to keep their faces centered in the small face windows, and users must often "scroll" or "refresh" the work space window. Moreover, visually separated windows impose *seams* between faces and drawings to users. Since the goal of TeamWorkStation design is to provide a *seamless* shared workspace, the cognitive seams that exist between spatially separated face and drawing windows motivated us to develop ClearFace.

3 ClearFace: Translucent Face Windows

In order to solve the space problem and decrease the cognitive seams in the shared screen, we devised the idea of "*movable, resizable, and translucent* face windows over work window". The face images are translucent and overlay the shared drawing window. Users can move and change the size of these face windows with mouse operations. We call this new multiuser interface design technique "**ClearFace**".

The idea to superimpose face image over a computer screen image was originally demonstrated by Engelbart and English [Enge68]. However, in their system, the size of all superimposed images were the same. Therefore, it was difficult to show the face images of more than two people on one screen. We overcome this limitation by allowing users to *move* and *resize* the translucent face windows.

Figure 5 and 6 shows an example of ClearFace implemented on TeamWorkStation. These are the snapshots from experimental sessions on icon and screen layout design by the authors.

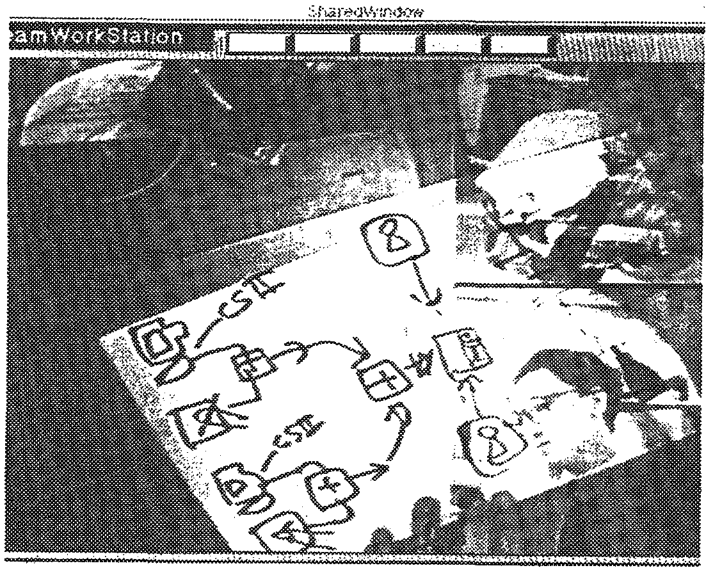


Fig. 5 An example of ClearFace (face images on right side)

Fig. 6 An example of ClearFace (face images at top)

Experimental Use of ClearFace

In order to investigate the usability of ClearFace, we implemented it based on several layout strategies: (1) fixed location windows (right side, left side, top) and (2) movable and resizable windows. Four subjects in our laboratories including the authors used these multiuser interfaces for the collaborative design of icons, prototype system architectures, and the diagrams for technical papers. Each layout was used for about 20 minutes, and the sessions were video-taped.

Until we conducted these experiments, we were unsure about the readability of the overlaid face and drawing surface images. However, the experiments of icon design and system configuration discussions confirmed that there is little difficulty in visually separating the overlaid video layers (face and drawing surface). When a subject looked at one layer, he/she found it is not difficult to ignore the other.

This ability of human perception is accounted for by the theory of "**selective looking**" [Neis75]. Fig. 7 illustrates the selective looking in the use of ClearFace.

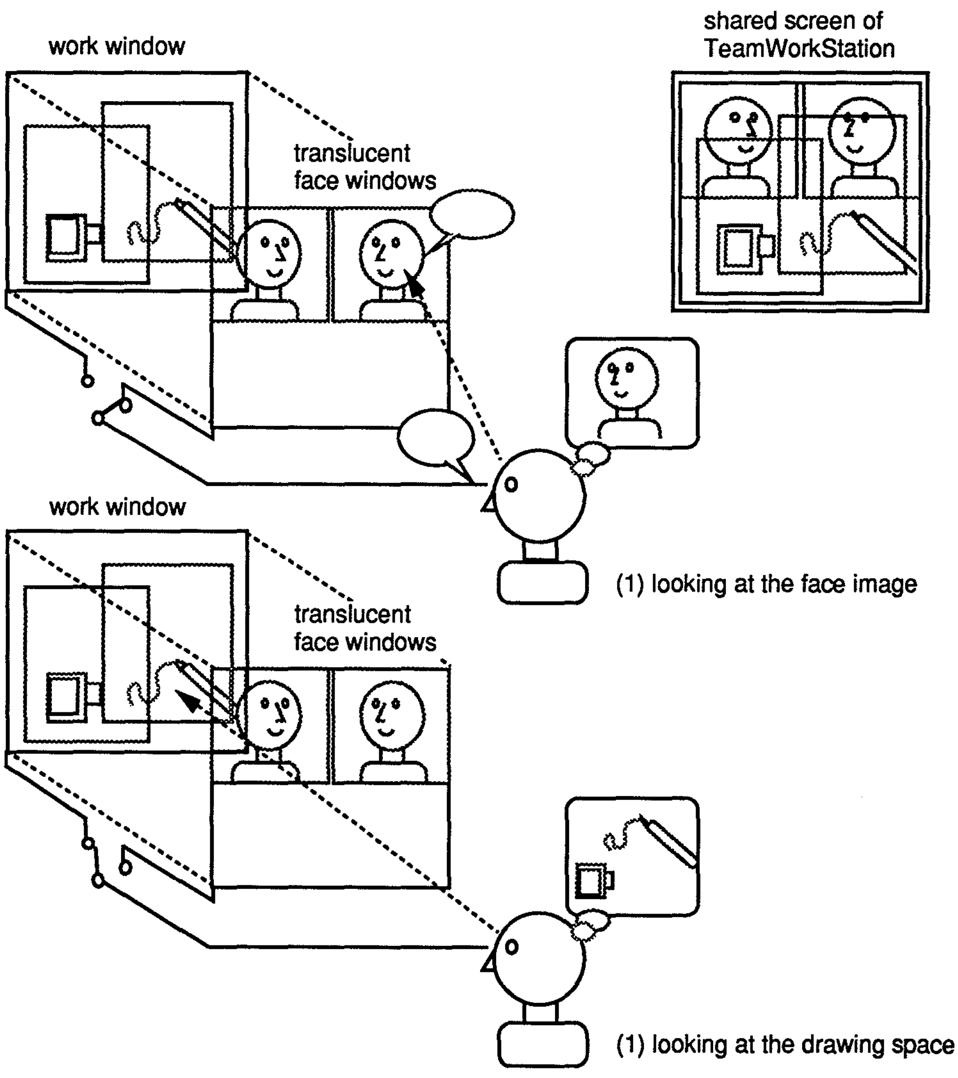


Fig. 7 Selective looking in the use of ClearFace

Neisser and Becklen conducted experiments that investigated the mechanism of "selective looking". In their experiments, the subjects looked at two optically superimposed video screens, on which two different kinds of things were happening. They were required to follow the action in one "screen" and ignore the other. They could do this without difficulty, although both were present in the same fully overlapped visual field. Events in the unwatched screen were rarely noticed. Through these experiments, they found that without any prior practice, it is easy to concentrate one image sequence and ignore another, even when they are overlapped.

ClearFace overlays face images on the drawing surface. Each face looks very different from the marks on desktop documents or hand gestures, and humans have a high sensitivity to recognize a human face. Therefore, because of this selective looking ability, ClearFace hardly confuse the participants.

Neisser and Becklen reported that it was very difficult to monitor *both* screens at once. In design sessions, however, we seldom look simultaneously at faces and drawing objects, but we do frequently switch our focus between them.

Another interesting observation is that all subjects hesitated drawing over the faces. Even though users knew that the entire screen was available for drawing, they tried to use the "free" space. Only when the subjects looked at the actual desktop without looking at the overlaid images on the shared screen, did they freely draw over face images.

When users *looked* at a drawn object behind a face, they did experience little perceptual confusion. However, when they *drew* figures or *wrote* texts on the shared drawing space, they avoided any collision with the face images. Because of this behavior, we concluded that the movable strategy is the best. In the design session, since the drawing on the work window dynamically expands, it is necessary to provide users with the functions needed to move the face images in order to avoid collision.

In the fixed location strategies, we found that "top" is better than right and left side strategies. The reason is because users often use their hands for pointing, drawing and gesturing, and the possibility of blocking the face images with hand images is the least in the "top" strategy. Next best was "left" strategy because all the subjects were right-handed. (Conversely, for left-handed subjects, the next best would be the "right" strategy.)

Another finding is that: to use ClearFace effectively, the background of a face image must be clean. When the face image is surrounded with a visually "messy" background, it makes difficult to distinguish draw objects from the background clutter.

Implementation of ClearFace

Figure 8 illustrates the system configuration for movable ClearFace. Prototype was implemented on TeamWorkStation that is based on Macintosh™ computers connected audio and video network. In order to implement a movable and resizable face windows, we utilized a desktop video board which inserts the live video image into a movable and resizable window. Therefore, users can simply move or resize the face images by dragging or resizing the window at any time in the design session. Special video effectors were also used to overlay video images translucently.

The quality of overlaid video images in this prototype is not sharp enough to support the sharing of drawings, because of the limitation of NTSC video quality. We expect HDTV technologies will overcome this problem in the near future.

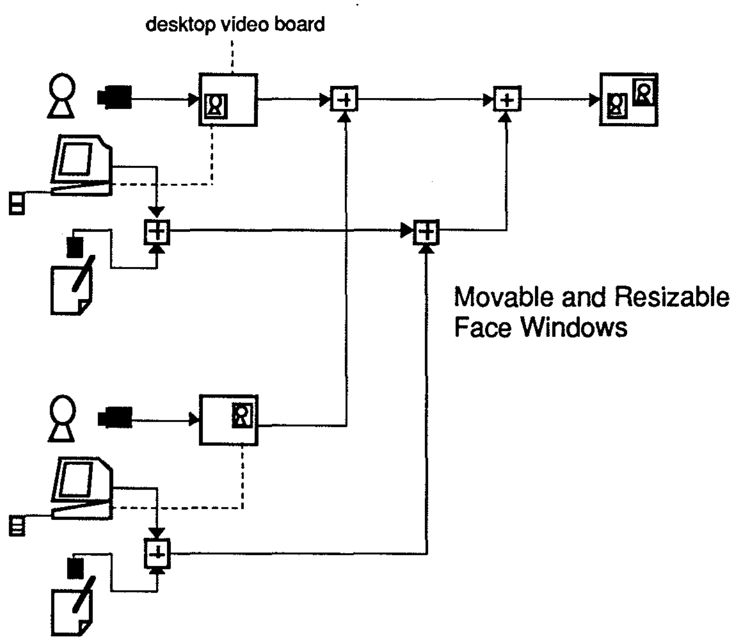


Fig. 8 System configuration of ClearFace prototype

4 Two Translucent Overlay Techniques: Fused and Selective

In contrast to ClearFace, the shared drawing window itself is created by overlaying translucent individual drawing surface images with a different intention. The goal of this overlay is the *fusion* of several images into one. Each video layer is originally physically separated. However, because of the spatial relationships among marks on each layer, the set of overlaid layers provides users with sufficient semantics, fuse them into one image. The usefulness of this *cognitive fusion* was demonstrated through the experiments of remote teaching of calligraphy [Ishii90] and remote instruction of machine operation [Ishii91]. We call this translucent overlay technique "**fused overlay**".

On the other hand, ClearFace demonstrated another technique "**selective overlay**" to use the limited screen space effectively.

TeamWorkStation with ClearFace is the first system that demonstrates two very different effects of translucent overlaid video images: *fused overlay* (for shared drawing window) and *selective overlay* (for face windows over the drawing surface) to create a multiuser interface for remote collaboration. Although the translucent overlay technique itself is very simple, we expect it will provide us with a variety of new research issues in human-human interface design.

5 Conclusion

This paper has proposed a new multiuser interface design technique "ClearFace". In order to fully use the limited screen space, we devised the idea of overlaying translucent, movable, and resizable live face video images over a shared drawing window. Through the informal observations of experimental use in design sessions, we found that we had little difficulty in switching our focus between the face images or drawing objects. The theory of selective looking accounts for this flexible perception mechanism. Although users can see draw objects behind a face without difficulty, we found that users hesitate to draw figures or write texts over face images. Because of this behavior, we devised the "movable" face strategy. However, further empirical evaluations are needed to clarify the usability and limitation of ClearFace approach.

TeamWorkStation demonstrated the power of two different uses of the translucent overlay technique: *fused overlay* of drawing surface images for seamless shared workspace, and *selective overlay* to save screen space. We are going to test ClearFace with a larger variety of tasks and users to investigate the most effective usage of the translucent video overlay technique.

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