Distributed Collaborative Design Studio : a sketch-based environment to support rich distant collaboration

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An increasing number of large scale projects requires that distant teams collaborate together remotely. At the same time, the current CAD tools only offer minimal support for partial and asynchronous interactions. The application we propose enables full synchronous and remote sketch-based collaborative design. This setup is a combination of a virtual desktop (a remote meeting table), a standard videoconference system, a gesture recognition module and a networked, real-time, collaborative drawing software (SketSha). The solution as a whole is multimodal in essence (gestures, speech, drawing…) supporting immersive remote collaborative design.

Context

In a wide range of activities sectors, collaboration has been intensified, notably in the design domains. Collective work is increasingly organized simultaneously (rather than sequentially as it used to be in the past). Moreover, design teams are often spatially distributed, and the need for distant real-time interaction is consequently emerging. A lot of effective systems are available for the sharing of information, but most of them are asynchronous (e.g. databases, email…) or allow only partial interaction (e.g. phone) .

Virtual reality is a promising way to respond to the challenges of such changes in organizations and processes. The Lucid-ULg proposes a system for sketch-based multimodal interaction based on the paradigm of the *in-*

visible computer [1] . Instead of requiring the designers to change their way of conceiving, we propose to support one of the most usual way of collaborating : the free-hand sketching, which plays an important role, especially in the initial phases of conception. Even in domains where design constitutes only a part of the whole process (as for instance building or naval engineering, architecture, industrial design or town planning), there are great ideas that emerge from quick drawings made on the corner of a napkin! Many authors grant to the upstream sketching phase the biggest magnitude : it eases the cognitive charge, makes the designer explore more solutions, enhances creativity, and on top of that eases the artifact communication [2].

Our prototype, named Distributed Collaborative Design Studio (DCDS) is composed of a hardware part – the Design Virtual Desktop – and a software part –SketSha (sketch sharing), completed by external modules. Initially thought specifically for architecture, our system revealed itself to be useful for several other design domains.

Goals and Specifications

The system aims to respond to the following goals :

- Provide a natural pen-based environment, without wires, mouse or keyboard to support usual drawing. Moreover, working together on a shared space induces the need of a wide space, to express various and different points of view on a same subject. This environment must therefore have a large size (comparable to a drawing table), a high resolution and a high degree of precision.
- Support free-hand sketches, drawn from distant locations on a shared work space in real-time. The way of sketching must be as close as possible to the “classic” face-to-face drawing session, with a shared sheet of paper. Designers thus can express more ideas, concepts and alternatives than in long distant asynchronous collaborations, that inevitably and obviously provoke delays, misunderstanding, hazardous interpretations, loss of documents and coordination problems [3].
- Provide the awareness of the situation (who is around and what is happening) by supporting, in real-time, an global and multimodal overview of the context.
- Support the integration of additional reference material (notes, plans, manuals etc.) generally required for a collaborative work.

Description of the system

The Design Virtual Desktop (fig 1) consists on an electronic A0 table (ActivBoard) with a suspended ceiling equipped with a double projection system offering a large working surface (approximately 150x60 cm). The electronic stylus allows the drawing of virtual sketches on this surface. The central unit is placed in the ceiling. This leaves the stylus as the only interaction tool, so that the computer can disappears from designers' mind.

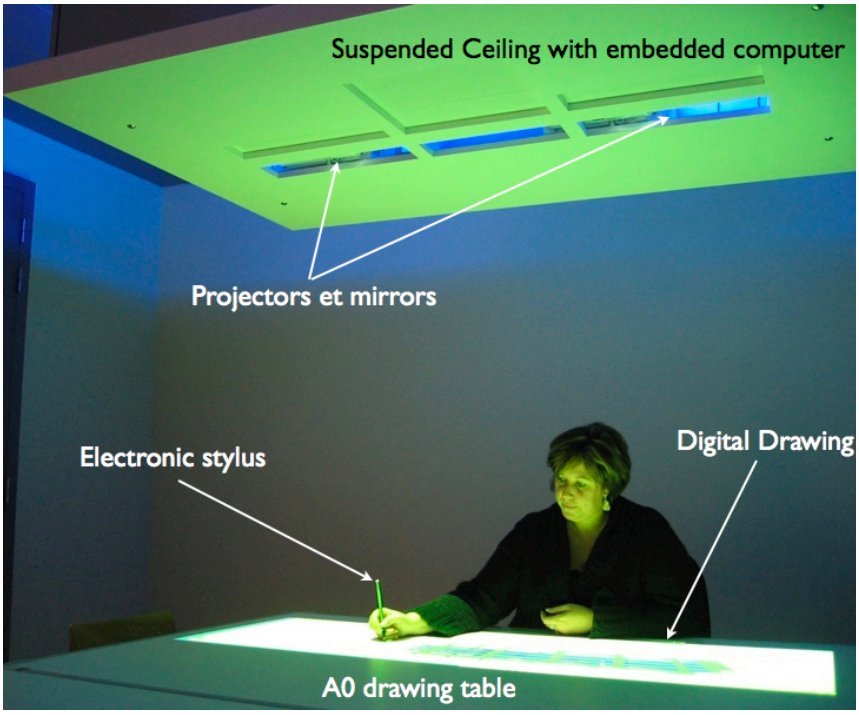

Fig 1 : Virtual Desktop

The SkeSha software (fig. 2) is a shared drawing environment allowing several workstations to be connected to the same drawing space. The functionalities, such as a panel of colored pens (and an eraser) and a navigation widget (zoom, translate, rotate), are proposed through intuitive graphical widgets. This software captures the strokes that compose the sketch, share them between the different distant locations (through a classic internet connection) and transmits the whole information in real-time on the active boards through video-data projectors.

Some of the CAD facilities have also been introduced in the prototype, such as the possibility to draw and to manage different layers and sheets of virtual paper, to delete or reproduce them, and to manage their transparency. The software also allows the importation of plans and images.

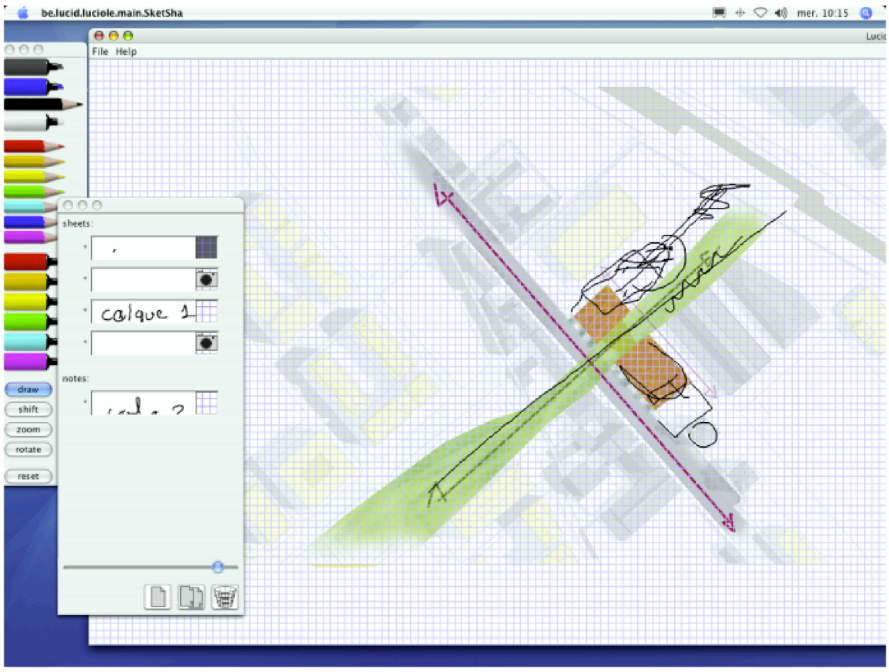

Fig. 2 : SketSha Interface

Pointing, annotating and drawing are possible thanks to the electronic pen that activates the virtual desktop drawing recognition. The other modes are transmitted through other modules in order to support the vocal, the visual and the gestural aspects of the collaboration. The system is completed by a 24 inches display and an integrated camera, that allow the participants to see and talk to each other in an almost 1/1 scale during a real-time conference. This integrated camera is in fact a very simple way to avoid the deviation of the look when talked to the interlocutor(s) (see fig 3 for the whole environment). Moreover, a gesture recognition module based on computer vision is currently being developed. In a near future, this system will be able to catch gestures and finger-pointing on a Virtual Desk, and send the information to other connected desks, which then will display a “hand avatar” of the distant partner.

Distributed Collaborative Design Studio

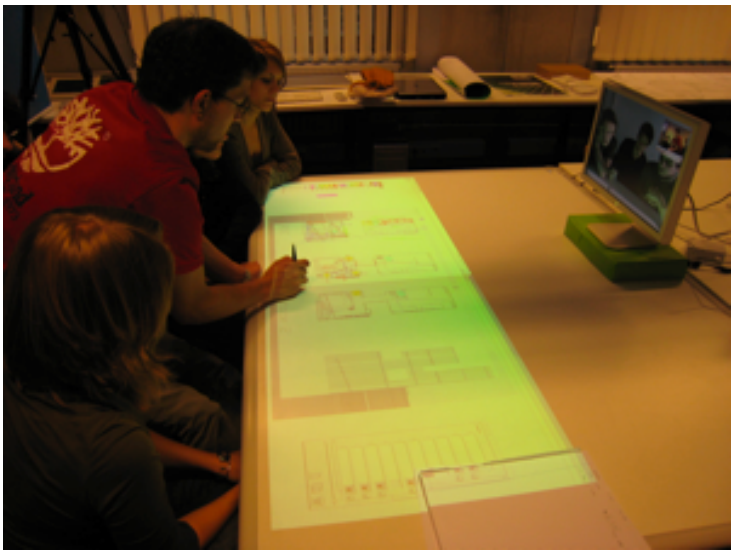

Fig. 3 : Distributed Collaboration Design Studio

Testings

The system has been tested in different sessions :

- in indivudual uses [4,5] ;
- in distant collaborative sessions [6] ;
- in a pedagogical long-term distant collaborative work setting [7].

All these testings have been videotaped (fig 4) and analyzed by ergonomists. They demonstrate the simplicity of the system, that is quickly mastered by all the participants. They also show the richness of the interactions in the environment, and the ability of the system to support collaboration close to copresent situations. The long term session has also shown its utility as an efficient cooperation tools for concrete projects

Furthermore, some industrial partners (design offices and architectural offices) have shown to be very interested by this environment for their professional practice and foresee many real advantages in adopting such a system.

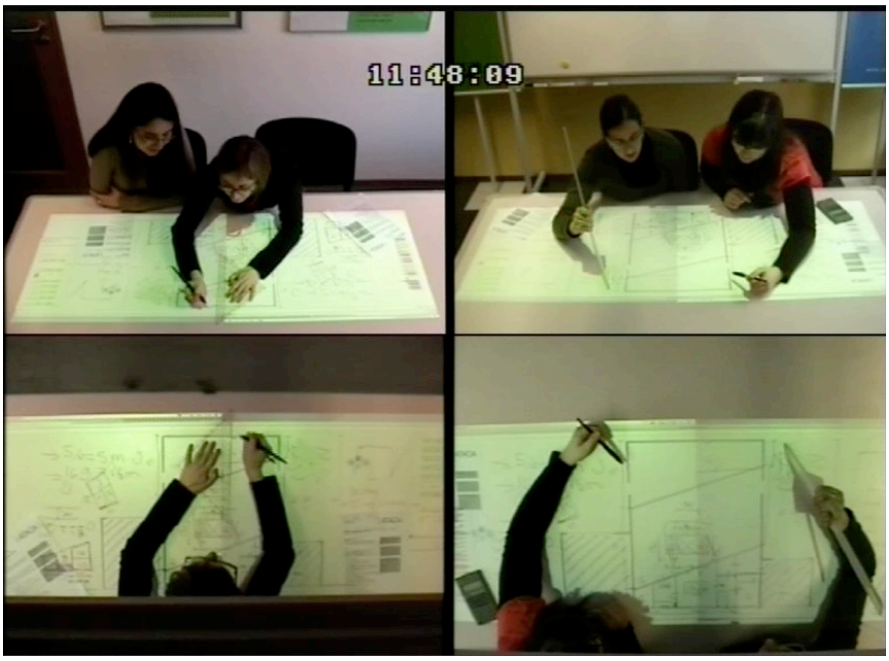

Fig 4 : Video recordings of collaborative design sessions

Issues

The system and its use raise number of interesting issues, for example:

- Design of work space. In order to enhance collaboration, a reflection on the workspace has to be driven. In particular, we shall investigate the usefulness of implementing private design workspaces in addition to the shared space. The orientation of the drawings may also be an issue : the distant tables could share the same orientation, or the drawing can be inverted to simulate a face-to-face arrangement.
- Integration in industrial practice. As the system seems to be really useful in experimental settings or for pedagogical purposes, how can it impact professional industrial practices ? The first comments of our industrial partners tell that the system won't replace real meeting, but can really support day-to-day collaboration, and indeed enhance trust between distant pertners and organizational communication.
- Property of information. In a design project, the different partners may have different responsibilities. If the whole information is shared, it may cause trouble for keeping track of the decisions, and thus for keeping

track of responsibilities. Modalities of information tracking and labeling should be designed.

- Ways of collaborating. Will the system change radically the way designers collaborate? Or will it need the definition of particular roles? Future long-term studies will inform us on the way people organize their work according to the possibilities of the system.
- Nature of sketches. We have already shown that the very nature of architectural sketches is slightly modified by the introduction of our virtual sketch environment for an individual use [5, 8, 9]. Does it impact collaboration? Can the nature of the digital sketch enhance mutual understanding? Or, on the contrary, will its digital nature reduce its expressive capabilities for collaboration? Our first studies show that the drawing is modified (size, type of lines…) but the informational richness of the sketches is not reduced, compared to paper-pencil drawings.
- Additional modules. SketSha is designed so that external modules can easily be plugged in. We foresee many possible developments : automated collaboration analysis, or domain-specific helpers, for instance. The integration of such additional tools, and their impacts on the collaboration has still to be studied.

References

1. Norman, D.A. (1998). *The invisible computer*, MIT Press, Cambridge University Press, MA
2. Cross N. : Strategies for Product Design, Third Edition. The open University, Milton Keynes, UK, Wiley (Eds) (2000).
3. Gül, L. and Maher, M.L. : The impact of Virtual Environments on Design Collaboration. In : 24th eCAADe Conference on Communicating Space(s), pp. 74-80 (2006).
4. Safin, S., Boulanger, C. & Leclercq, P (2005). A Virtual Desktop's First evaluation for an Augmented Design Process. *Proceedings of Virtual Concept 2005*. Biarritz, France, November
5. Safin, S., Leclercq, P. & Decortis, F. (2007) Impact d'un environnement d'esquisses virtuelles et d'un modèle 3D précoce sur l'activité de conception architecturale. *Revue d'Interaction Homme-Machine*. Vol 8, N°2, pp. 65-98
6. Burkhardt, J-M., Détienne, F., Moutsingua-Mpaga, L., Perron, L. , Safin, S. Leclercq, P. (in press) Conception architecturale collaborative avec un « bureau augmenté » : une étude exploratoire de l'effet de la distance et de la co-localisation. *Actes de SELF 2008 : 43ème congrès de la Société d'Ergonomie de Langue Française*. 17-19 septembre 2008 - Ajaccio

7. Elsen, C. & Leclercq, P. (in press) SketSha" or the sketch power to support collaborative design Proceedings of CDVE : 21-25 September, Majorque
8. Safin, S., Juchmes, R. & Leclercq, P. (under review) Du crayon au stylo digital : influences des interprétations numériques sur l'activité graphique en tâches de conception. Submitted to IHM 08 : 20ème conference francophone sur l'interaction homme-machine. Metz, France, November 2008.
9. Leclercq, P., Elsen, C., Le croquis synthé-numérique. *Proceedings of SCAN 07 : Séminaire de conception architecturale numérique*, Liège, Belgique, 2007.