Sharing representations in distant synchronous collaborative design : framework, technological proposal and scientific issues.

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Abstract. This chapter addresses the issue of sharing in collaborative design by the use of an original system developed in the LUCID-ULg Lab. The Distributed Collaborative Design Studio (DCDS) is a remote workspace environment aiming to emulate, at a distance, the conditions of face-to-face meetings. It is designed to allow designers to interact collaboratively at distance on a shared workspace, thanks to «natural» pen-based interaction. This documents sharing and real-time collaborative annotations are supposed to enhance awareness and grounding during collaboration in design domains.

In this chapter, we explicit the theoretical rationale for sharing in collaborative design, briefly describe the DCDS, summarize the observations we made relative to resources sharing (plans, pictures, documents and so on), and conclude on the theoretical and methodological issues to be addressed to deepen our knowledge about sharing external representations in design, to enhance the system and to adapt it to other contexts.

Keywords: CSCL; architecture; multimodal collaboration; pen-based interaction

1. Introduction

In a wide range of activity sectors, and especially in the design domains, distant collaboration has become a critical issue. Indeed, collective work is increasingly organized simultaneously and design teams are often geographically distributed, and the need for distant real-time interaction is consequently emerging.

Moreover, design is recognized as a discipline requiring the use of external representations, known as "intermediary design artifacts" [19]. These representations support designers' individual thinking (especially ambiguous representations such as hand-drawn sketches [16]) and design team's communication.

We state that the main problem of communicating at distance, especially in complex domains as design, is linked to the lack of sharing common resources : real-time communication tools are not designed to convey representations of content but only comments on them, either by voice or video-conferencing. Thus, telephone, video-conferencing or web chatting do not allow for an evolving graphic representation to be shared. Yet, complex activities are characterized by the use of numerous documents, which are annotated or modified. In architecture, these documents are an integral part of the design process, translating existing perceptions and representations, then simulating and testing possible interventions: these documents include sketches, drafts, plans, specifications, etc. They are jointly produced by multi-disciplinary teams and are modified in real time (through annotation) to support the collective decision-making process.

In this paper, we address specifically the issue of sharing documents and representations in real time for designing. We first address the role of shared document in collaborative design, as stated in the scientific literature. We then briefly describe the Distributed Collaborative Design Studio, a technological environment allowing designers to share at distance the same graphical workspace in real time. Based on this description, we summarize the main issues, our previous studies and their main results, relative to sharing for collaborating.

We then conclude on our theoretical and methodological needs we hope to be addressed in the workshop.

2. Sharing in collaborative design

It is quite recognized that collaborative design requires three classes of activities: task-oriented activities, process-oriented activities and interaction management activities [6]. What are the requirements in terms of shared resources to those three kinds of activities? We propose in this section a synthesis of the framework we used for developing collaborative environments for design and to evaluate their effectiveness.

Task-oriented activities are directly related to the content of the design. Usually, one can distinguish problem framing, solutions generation and solutions evaluations. Design has been described as an ill-defined problem-solving process [15], a conversation between the designer and his representations [14], and more recently as an activity of construction of representations [19]. All those definitions insist on the core role of external representations (such as plans, sketches, texts, models and so on) for designing. They constitute intermediary objects of the activity [19] they acts as tools, but also as "results" of the design. Although some re-

searchers have shown that it is possible to design without drawing [1], all recognize that externalizing really helps the design process.

In collective task-oriented activities, a primary function of those representations is to communicate: an execution plan is a perfect unambiguous codified representation of a building to be built [7], and allows the different entrepreneurs to understand their mission clearly. Other plans and models allow communicating accurately between the different actors (structure engineers, acousticians, etc.) who need to work on the same content.

But external graphic representations are also used to communicate more high-level elements : concepts, knowledge, ideas, etc. To this end, the sketches are especially efficient, thanks to their low cognitive and resources costs. They allow to collectively make ideas emerge and evaluate those ideas.

Process-oriented activities are necessary to coordinate group actions. These activities are linked to the management of viewpoints, the synchronization and coordination, the conflict management, the building of a common knowledge [18]. Whatever the type of collaboration taking place (being integrated "co-design" or more divided "distributed design" [5]), shared documents seem to help the processes of coordination.

They support "situation awareness [3].This awareness of who is doing what, who is responsible for what, and what is the context of communication is a crucial factor of coordination in groups. Shared and interactive documents in the course of collaborative real-time meetings (such as interactive graphical annotation as proposed by the DCDS) allow to perceive the others actions and reflections, and are therefore supposed to be a strong factor of situation awareness. It is especially true for spatial references on objects (typical in design and architecture), which are facilitated by the presence of a common representation.

Another group process that helps the collaborative design is the sharing of a common view on the process (common ground [4] or joint problem space [8]). The negotiation of common ground is often a prerequisite for negotiating solutions. This common ground may really be helped by the sharing of representations

Interaction management activities. This third kind of interaction consist in managing and facilitating the process of communication : expressing messages but also verify they have been understood. Clarck & Brennan [4] state that the communication has a "cost" depending on the features and constraints of the media. A communication media can be characterized by several properties that can facilitate exchanges and the construction of a shared common referent. Amongst them, shared external represntations allows simultaneity of actions, sequentiality of the messages and reviewability.

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3. DCDS

In order to support remote synchronous collaboration, the LUCID-ULg lab has developed the Digital Collaborative Design Studio (DCDS), in which the resource sharing is a core element. This prototype is already synthetically described in this issue [11] and deeply in [10].

To summarize, the Distributed Collaborative Design Studio is a remote workspace environment aiming to emulate, at a distance, the conditions of face-to-face meetings. It comprises an original pen-based device, equipped with a real-time sketch sharing software (SketSha) and completed with a generic videoconferencing system. This environment allows the users to import documents (plans, pictures, sketches,..), to share them remotely and to annotate them in real time with the electronic pen, while conversing and being able to see each other (through the videoconference system).
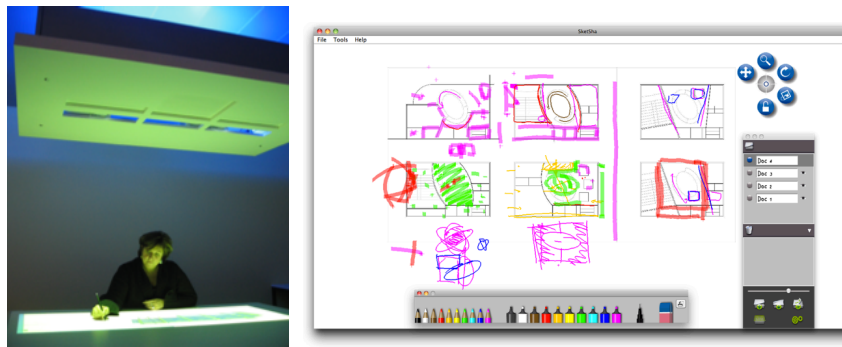
Figures : DCDS Material environment and interface

The DCDS is designed to allow designers to interact collaboratively at distance on a shared workspace, thanks to «natural» pen-based interaction. According to the theoretical framework described above, the sharing of documents and real-time collaborative annotations in DCDS are supposed to enhance awareness and grounding during collaboration in design domains, facilitate the regulation of communications, and support and enhance the design process.

4. Research questions and first answers

The system and the framework of references lead to several classes of issues, related to sharing for collaborating.

1 – Is it necessary to share to collaborate ?

This issue has not been the focus of our research, as sharing is the core rationale for the development of the DCDS. Although not specifically investigated, numerous testing in short and long collaborative work settings with students and professionals (see for example [2, 11, 12, 13]) have led to the implicit conclusion that the possibility to share and to interact on documents is a real interest for collaborative design. Nevertheless, activities best-supported by the system seem not to be related to creative design, as initially expected, but rather "project review". This kind of activity consist in reviewing all the individuals' contributions, resolving local problems, and planning the next work to do.

2 – What kind of documents must be used to collaborate effectively ?

This question is especially important in the framework of collaborative studios with students. In one of our study (related in [9]), we counted all the documents exchanged in the collaborative workspace by three groups of students during 10 one-hour per week session on the DCDS, in the framework of a distant collaborative studio of 3 months. Our observation showed that the most efficient group has several characteristics in terms of document sharing.

- They use significantly less documents in collaborative space than the two other groups.
- The type of document used change during the process. They adapt their modes of sharing depending on the advancement of the design.
- They interact a lot on all their document: they make significantly more collaborative annotation on the documents.
- They also share more "interactive representations", i.e. they draw more digital sketches on the shared workspace.
- Finally, they share no text at all during the synchronous sessions, but rather graphical documents (plans, sketches, 3D models screenshots, etc.).

Relative to the last comment, a previous study in the same setting [17] showed nevertheless that sharing texts in asynchronous collaboration (between synchronous sessions) is associated with a much better quality of collaboration during the synchronous sessions: sharing textual explanations on the documents previously to synchronous collaboration seems to help building a common understanding, enhancing collaboration quality.

3 – What is the role of interactivity, i.e collaborative annotations?

This is the main goal of our different studies. We investigated the role of collaborative sketching at distance in collaborative activities. Our main study on the subject, detailed in another chapter of this book [11], show the following main conclusions

- the digital sketch is used in a flexible way, allowing to support task-oriented, process-oriented and interaction management activities at the same time ;

- the shared workspace may be used as a tool for collaborative document edition, or as an interactive workspace allowing the expressions of ideas and the collective generation of solutions.

4 – What features of the system support or hamper group and task processes?

This issue is much more complicated, as it is difficult to observe situations which are sufficiently controlled and which have a strong ecological validity, i.e. structured comparisons (laboratory studies) with real design task (that are quite long-lasting). In all of our studies, we preferred to observe real design situation at distance, but without having strong reference situations, because the contexts and tasks may be very different between co-present and at distance collaborative design.

Nevertheless, we applied an analysis grid about the quality of collaboration on several corpuses of activities with students. This grid allows us to rate the collaborative processes on seven dimensions linked to the abovementioned model of a "good" collaboration (fluidity of collaboration, sustaining mutual understanding, information exchanges for problem solving, argumentation and reaching consensus, task and time management, cooperative orientation, and individual task orientation) (see [2, 11, 13]). Our results showed some constant scores, between and within groups, that may come from the features of the system. The most important regarding to the present issue is linked to the information exchanges for problem solving, which are each time quite high. It seems that working on a shared workspace supports and encourages the effective sharing of information, which is encouraging.

5. Conclusions and perspectives : what we expect from the workshop

In our previous R&D work, we never addressed specifically the question of the workshop ("Do we need to share to collaborate?"). Rather, we considered the necessity of sharing as a premise of our approaches.

In this contribution, we detailed our work on sharing for collaborating : at first, we described the theoretical framework, relative to collaborative design, which allows us to make this premise. Secondly, we briefly described the DCDS system the LUCID Lab developed, and its philosophy. Finally, we shortly described our main empirical studies and their results, relative to resources sharing.

Our future work will consist in investigating much deeper the role of digital sketching in collaborative design : we want to develop methods for specifically

addressing the role of the sketches for task and process activities, their characteristics and the way they may integrate collaborative environments.

We will also extend our work on other fields of design or other domains of complex activities. The idea is to understand more globally the role of graphical modality in distant collaboration and to develop tools adapted to these other contexts.

We expect from the workshop to define theoretical and methodological frameworks for deepening our reflections on the issue of sharing for collaborating. In particular, we are interested in the role of visual (and especially graphical) dynamic expressions as a mean to create or sustain a mutual understanding in complex situations.

Acknowledgements

References

[1] Bilda, Z., & Gero, J. (2008). Idea development can occur using imagery only. Paper presented at the Design Computing and Cognition'08.
[2] Burkhardt, J-M., Détienne, F., Hebert, A.-M.., Perron, L. , Safin, S. Leclercq, P. (2009) An approach to assess the quality of collaboration in technology-mediated design situations. Proceedings of ECCE 2009 : European Conference on Cognitive Ergonomics. Helsinki, Septembre
[3] Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness : synchronizing task-oriented collaborative activity. International Journal Of Human-Computer Studies, 58, 605-632.
[4] Clarck, H., & Brennan, S. (1991). Grounding in communication. In L. Resnick, J. Levine & S. Teasley (Eds.), Perspectives on Socially Shared Cognition. Washington: American Psychological Association.
[5] Darses, F., Falzon, P., & Béguin, P. (1996). Collective design processes. . Paper presented at the COOP 96, Second International Conference on the Design of Cooperative Systems, Juan-les- Pins.
[6] Détienne, F., Boujut, J.-F., & Hohmann, B. (2004). Characterization of collaborative design and interaction management activities in a distant engineering design situation. Paper presented at the COOP 2004 - Cooperative systems design: scenario-based design of collaborative systems.
[7] Leclercq, P., & Elsen, C. (2007). Le croquis synthé-numérique. Paper presented at the SCAN'05 : Séminaire de Conception Architecturale Numérique, Paris, France.
[8] Roschelle, J., & Teasley, S. (1994). The construction of shared knowledge in collaborative problem solving. In C. E. O'Malley (Ed.), Computer Supported Collaborative Learning (pp. 69-97). Heidelberg: Springer-Verlag.

[9] Safin, S. (2011). Processus d'externalisation graphique dans les activités cognitives complexes :le cas de l'esquisse numérique en conception architecturale individuelle et collective. PhD Thesis, University of Liège, Belgium.

[10] Safin, S., Delfosse, V., & Leclercq, P. (2010) Mixed-reality prototypes to support early creative design. In E. Dubois, P. Gray & L. Nigay (Eds). The Engineering of Mixed Reality Systems. London : Springer

[11] Safin, S., Juchmes, R. & Leclercq, P. (2012). Use of graphical modality in a collaborative design distant setting. Proceedings of COOP 2012, 10th International Conference on the Design of Cooperative Systems From research to practice: Results and open challenges

[12] Safin, S. & Leclercq, P. (2009). User studies of a sketch-based collaborative distant design solution in industrial context. Proceedings of CDVE 2009. The 6th International Conference on Cooperative Design, Visualization and Engineering. Luxembourg, Septembre.

[13] Safin, S., Verschuere, A., Defays, A., Burkhardt, J-M. & Détienne, F. (2010) Quality of collaboration in a distant collaborative architectural educational setting. Workshop W1: Analysing the quality of collaboration in task-oriented computer-mediated interactions, in COOP 2010 : 9th International Conference on the Design of Cooperative Systems. Aix-en-Provence, May 2010

[14] Schön, D. (1983). The reflexive practitioner : How professional think in action. New York: Basic Books.

[15] Simon, H.A. (1969). The Science of the Artificial. Cambridge, MA : MIT Press

[16] Suwa, M., Gero, J., & Purcell, A. (1998). The Roles of Sketches in Early Conceptual Design Processes. Paper presented at the Twentieth annual meeting of the cognitive sciences society, Hillsdale, NJ.

[17] Verschuere, A. (2010). Analyse du lien entre représentations externes et processus collaboratif à distance dans le cadre d'un projet de conception architecturale. Master Thesis of the University of Liège

[18] Visser, W. (2001). Conception individuelle et collective. Approche de l'ergonomie cognitive. Le Chesnay, France: INRIA - Institut national de la Recherche en Informatique et Automatique

[19] Visser, W. (2006). The cognitive artifacts of designing. Mahwha, NJ: Lauwrence Erlbaum Associates.