

Hybrid Design Environments

A Research Program on Creative Collaboration and Communication

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This paper gives an overview of a research program initiated in the Architectural Design Department of the Escola Tècnica Superior d'Arquitectura de Barcelona on issues of communication and collaboration in computer aided design [*]. The work is centered around emerging design situations which can be attributed directly to the incorporation of new technologies in education and practice. One of these is the "design triangle" composed of a traditional designer, a CAD workstation and a computer literate collaborator acting as the *design medium*. Another is the "virtual workshop" consisting of design collaboration involving large-scale distributed communications networks.

The research program stresses three common characteristics of these situations which it aims to study in parallel in the setting of an design workshop. The first of these is the characteristic of *distance*, both physical and conceptual, which separates, on the one hand, the traditional designer from the CAD document and, on the other, the participants of a distributed workshop from each other and each others' thinking. The second, is the typically hybrid nature of such situations where computer technology interacts with more traditional techniques and alternative media are combined both at the level of production and in channels and modes of communication. And finally, the third and most significant for the methodology of the research program, is the fact that both the design triangle and the virtual workshop make explicit aspects of design activity, interaction and intentions which remain hidden or are only implicit in traditional designing.

Distance

Drawings, and other means of abstraction in design production, distance the designer from the projected artifact. This distancing has a dual significance, simultaneously hindering and enhancing design activity. On the one hand, it diminishes the immediacy of a designer's response-and responsibility-with respect to holistic aspects of a design. On the other hand, while providing greater control over certain dimensions of an evolving artifact, the conceptual distance resulting from abstraction empowers the image-and imagination-as a basis for innovation.

[*] The program, initiated in collaboration with Enric Miralles, includes research in design theory as well as contributions to design studios at the Escola Tècnica Superior d'Arquitectura de Barcelona.

It would be appropriate here to borrow a hermeneutic conception of images as described by Richard Kearney in his treatment of their verbal, as opposed to visual, role in the philosophy of Paul Ricoeur [Kearney, 1989].

Insofar as hermeneutics is concerned with double or multiple levels of meaning, it is evident that images can no longer be adequately understood in terms of their immediate phenomenological *appearance* to consciousness. Replacing the visual role of the image with the verbal, Ricoeur affirms the more poetical role of imaging-that is, its ability to say one thing in terms of another, or to say several things at the same time, thereby creating something

This same phenomenon of distance takes on another dimension in the collaboration between designers, specially when one considers the role of media and means of representation or production as channels of communication. We would like to begin by considering now a special case, in fact a singularity, of the interaction between designers, media and means production, namely the design triangle.

The design triangle

For architects whose education and practice have involved the exclusive and intimate use of traditional media and techniques, the introduction of new design technologies can constitute a barrier to productive activity. The conceptual distance which they were expert at managing and exploiting takes on a predominantly negative aspect of remoteness. One spontaneous response to this problem in the case of the introduction of Computer Aided Design tools is the design triangle, where an architect actively cooperates with a CAD-literate collaborator who acts as a "medium", communicating with the CAD workstation.

Even within this closed environment of collaboration, the conceptual distance which exists between the "traditional" architect and the medium can be a relevant factor in the dynamics of design production. As a symbol of the discrepancy between the two different ways of seeing of the architect and the medium, let us site the effect of parallax produced when the architect points to an element on the display screen of the CAD workstation. Due to the thickness of the screen's glass, often accentuated by a protective filter placed in front of it, a point of reference on the surface of the screen, which seems to coincide with a graphic element from the architect's point of view, can be at a considerable distance from the element seen from the point of view of the medium who looks at the screen from a different, and typically opposite angle.

The conceptual counterpart of the parallax effect is, in fact, closely related to the divergence of interpretations of two or more designers observing a document. The multiplicity of interpretations can lead, at the same time, to difficulties and opportunities for innovation both in the case of a traditional design team and in the design triangle.

Virtual workshops

Perhaps a working environment which combines the characteristics of the mature design team and the more embryonic design triangle is that of a distributed group of collaborating architects working in different locations and potentially at different time intervals, but sharing a project through a communications network. If the optical parallax effect is an appropriate metaphor for the conceptual divergence in a design triangle, then the geographic distance which separates designers collaborating through an electronic communications network could be the corresponding metaphor for the differences of interpretation produced in a distributed workshop. An important challenge in collaboration in a virtual workshop environment is that of converging on a unique and coherent project, continuously harnessing the design potentials of proposals whose natural tendency is to diverge [Wojtowicz et al., 1993]. This challenge is, of course, common to all settings where group dynamics plays an important role. But to the extent that the "virtual group" of electronic collaboration is not merely a more or less faithful emulation of the traditional group, it represents the promotion of secondary group dynamics issues to fundamental characteristics of collaboration.

This last point highlights a basic difference of outlook between two complementary approaches to computer supported collaborative work. The first, which we will call the "phenomenological approach", focuses on solving the difficulties associated with new aspects of collaboration introduced by the physical separation of participants. The variety of means of communication available during face to face contact among collaborators is reduced, in the case of the distributed workshop, to whatever audio-visual channels are provided by the network. This first approach aims at enhancing the dimensions, quality and performance of electronic channels of communication, trying to make them as rich in phenomenological content as interpersonal contact. A second approach, assumes the new constraints encountered in the virtual workshop as an incentive for developing novel ways of working adapted to them. While motivating and incorporating enhancements of collaboration technology, this perspective-let us call it the "methodological approach"-aims at having participants of the workshop actively design dynamic conventions for the packaging and interchange of information, adapted to the characteristics of the medium.

Seen under a particular perspective, the telephone answering machine represents a device which can create awkward social situations and which hinders personal interaction and dialog. A phenomenological response to such a problem would consist of reinventing the telephone, the video phone and finally face to face contact as more interactive and multi-dimensional ways of conveying messages. The methodological approach, on the other hand, would encourage a culture of use adapted to the possibilities and constraints of answering machines. It would aim at solving problems such a "phone tag," where successive messages requesting a telephone conversation are answered by similar messages. It would reinvent techniques such as call-forwarding, personalized messages, remote telephone access to a machine, or would conventionalize customs such as screening calls by listening to one's answering machine.

Hybrid environments

Typically advertised models of the computerized design studio tend either towards an excess of practicality, describing a non-intrusive addition of computer tools in terms of "computer rooms" and "CAD operators", or an excess of idealism, assuming the ability and willingness of the participants in all phases of a design process to make a mature use of the technology. As expertise in CAD becomes more wide-spread, less and less people intuitively consider it incompatible with design competence, and few design professionals-and even fewer students-are left unexposed to it. The design triangle is one consequence of this often uncomfortable transfer of technology. But there is a variety of other modes of collaboration between different ways of working, which together constitute a new hybrid design environment.

Hyper-mixed-media

Paper-based media are one of the mainstays of documentation technology. The computerization of information systems, which for some represented a step towards the paperless office, has so far resulted in an increase in the reliance on paper. De Sola Pool points out that for information handling the role of paper is increasing even as it is being restricted to specific uses [Sola Pool, 1983].

In costs for retrieval, electronic means are gaining the advantage... There is little doubt that searching for a record in computer memory and displaying it out again on screen, or even printing it out again on a sheet of paper that can then be thrown away because the permanent record is still in the computer, will become, even if it has not yet become, cheaper than getting it out manually. The main continuing use of paper in a mature electronic communication system is likely to be as a medium for active handling and short-run retention, and this use may grow enormously.

Even in some of the most computerized practices, design activity which is carried out exclusively on CAD workstations seems to occur in bursts between one paper-based episode and another. The consequence of this predominance of paper, combined with the ubiquity of computers is that the most common mixed-media combinations in design production involve digital and paper-based media. Plotting, scanning, digitizing are all operations related to this combination. Operations and technologies which mix slightly different kinds of media with the digital are computer plots used as templates for models, CAD-driven laser-cutters, three-dimensional plastic forms or holography produced directly from computer models, and so on. But a whole other level of mixed-media becomes possible when we consider combining with the traditional analog and digital media, the less tangible medium of the communications network.

Coincidence, coherence, cooperation

Collaboration can take one of several modalities, depending on the physical and temporal relationships of the participants. In traditional *face to face* collaboration, the work takes place in the same location, and at the same time for all participants. The most common incentive for working in a setting which does not bring participants into physical contact, is the fact that collaborators often tend to be in

different geographical locations. If they can at least agree to work at the same time intervals, and have the technology to do it, they can work in what is called a *synchronous distributed* mode [Maher et al., 1993]. On the other hand, if their problem is only one of temporal incompatibility, that is, they need to work at different times, then they can leave each other work in progress and messages at the common workplace, thereby participating in an *asynchronous non-distributed* setting. Finally, collaborators who can neither agree on a time nor on one given meeting place, but who are still determined to work together, will have to choose the *asynchronous distributed* virtual workshop, arguably the most interesting basic model of collaboration [Wojtowicz et al., 1992].

It is unlikely that any of the four modes of collaboration described above can be sustained in its pure form for more than a short period of time. Face to face collaborators will probably subdivide work among themselves to a certain extent, or will discuss work by telephone occasionally. Members of a group working asynchronously may also synchronize with each other just enough to use the telephone or to carry on a real-time electronic dialog, and may meet once in a while even if by chance. Similarly, synchronized collaborators may easily fail to overlap completely in their work schedules, or may give in to the temptation to carry on a line of development independently off line.

Given these considerations, we will argue that a hybrid model of collaborative work, combining the four basic models described above, is the most generalizable, and probably the most productive version of the virtual workshop. To make this model even more attractive, let us add that a hybrid design environment can exist at a local level at each node, where a mixed-media approach is combined with a setting such as the design triangle. In the design triangle, an architect could point to elements on the screen with a second mouse, in order to avoid the problem of parallax described above [Fargas, 1993]. But a second mouse can not only reduce the parallax but it can also act as the representative of a remote collaborator.

Non-intrusive observation

There are many ways of observing and analyzing design activity. Some take the design artifact as their basis, while others are more focused on the process which takes place during the evolution of a project. In the latter case, both the design triangle and the distributed group, are interesting subjects because they make evident aspects of design activity, interaction and intentions which remain hidden or are only implicit in traditional designing.

Doing out-loud

The verbal interaction which occurs in the design triangle is a perfect record for a natural protocol analysis, where the typical thinking out loud [Schön, 1988] is replaced with a spontaneous 'doing out loud'. A record of the verbal interaction within the designer/ medium/ workstation triangle makes evident much of the activity involved in designing, and represents a very significant part of all that is explicit in a given design effort. This verbal record can be synchronized with a log of the transformations of all the design documents used or produced during a session. Obviously, such a history, although potentially very revealing, should not be confused with an account of the design thinking behind a project. Rather it

should be thought of as a basic source document for the effort to construct a design assistant.

The information captured in the history of a design triangle represents a certain level of abstraction where all interactions are made explicit. Although the intentions of the designer may be inaccessible to a large extent in this record, it is interesting to compare it to a similar record which may be obtained by recording the history of a CAD-literate architect's silent interaction with an evolving design drawing. One obvious advantage of the design triangle record is that the designer must convey ideas and desires in a manner explicit enough to be understood by the medium. Asking CAD-literate designers to simultaneously talk about their actions as they are working presents the fundamental problem of reliability. In theory, they could give one of many possible accounts of their actions, any of which may or may not correspond to a revealing correspondence with the design effort being studied. Another important consideration in the 'thinking out loud' method is that it starts with an intent to study a 'typical design session', but actually generates an analysis of another kind of process which might not be the subject of research, namely the process of 'designing while thinking out loud'. This is the fundamental insight which highlights the advantage of studying the history of a design triangle session. Designing with the help of a medium is probably a significantly different activity from designing individually, however it is definitely one of the many possible modes of design activity. The advantage this particular mode has over many others, is that it can be studied non-intrusively. The act of recording the interactions in a design triangle, unlike the act of thinking out loud, is unlikely to alter the course of a design session. And finally, another reason why the analysis of design triangles can form an important part of the research into automated design assistants, is that it comes very close to being the prototype of a possible interaction between the architect and the proposed machine.

Publication as dialog

A special electronic communications network is not a prerequisite for working in a distributed workshop. Exchanging technical documents and information via the postal system, by fax, and using the telephone is an alternative which has been complementing traditional practice for some years now. In fact, the hybrid model of design collaboration proposed here includes the postal system, the fax, and the telephone as important channels of communication along with their more specialized counterparts such as large-scale computer networks. Regardless of the versatility of channels used, however, one characteristic distinguishes it in a fundamental way from the traditional practice of group work, namely the size of its typical unit of information. A message exchanged in the virtual workshop is less likely to be one sentence accompanied by a drawn line, than a relatively complete sketch accompanied by an explanatory paragraph. It may be more precise to state the inverse: It is unlikely that in a dynamic face to face group setting, a participant will be able to develop a relatively complete sketch and to explain it, without receiving intermittent inputs from other members of the group. In fact, as Tang points out, the information in a drawing produced in the face to face group is closely linked with much of the activity accompanying its

production [Tang, 1991], such that a self-contained unit of information is much smaller than the drawing.

The importance of experiencing the process of creating and using drawings, especially when expressing ideas, is indicated by the fact that the resulting drawings do not make sense by themselves. They can only be interpreted in the context of the accompanying dialog or interaction of the participants. This observation is especially apparent with hand gestures, which do not leave behind any persistent artifact, yet do communicate significant information.

On the one hand the design of a virtual workshop should aim at capturing much of the richness of traditional group work, evident in gestures, overlapping dialogs, tandem sketching, and so on. On the other hand, it should not ignore the potential of distributed collaboration to achieve an extended dialog similar to--but much more dynamic than--that of successive publications. For the researcher interested in studying a project in terms of the design activity behind it, one option is to think of the contributions of participants in the virtual workshop as black boxes, meaning that the design activity which led to them can be considered mysterious. Thus the model of designing implicit in such a study would be based on the log of transactions of the virtual workshop.

Programming the design workshop

Having given an overview of some concerns central to our research on communication and collaboration in design, let us now briefly touch upon the issue of organizing design activity in hybrid settings such as the virtual workshop. As mentioned above, one of the challenges of working in distributed and asynchronous settings is that of converging on coherent solutions. We will consider some of them below as a first approach to developing a repertoire of organizational techniques.

Faith in modularity

One basic principle which can be employed in designing the interaction protocol between collaborators is that of the abstraction barrier. While they are developing the design at hand, the participants in a virtual workshop would be expected to develop certain contractual relationships among themselves in order to channel the evolution of the project. Without necessarily limiting themselves to a strict division of labor, they would try to set certain interfaces among themselves, and among the components of the projects itself, thereby offering certain guarantees to each of the participants. These could be as simple as the adoption of a common module, or as complex as an design grammar. Mitchell generalizes some of the possible formal guarantees established by a design group-or by the very nature of a design medium-as axioms [Mitchell, 1990].

Sometimes axioms express arbitrary conventions, for example that all dimensions are modular or that rectangular cuboids can only be arranged orthogonally to each other. When designers work with conventional graphic and physical modeling media, much of the axiomatization is implicit in the physical properties of the materials

and instruments that are used. Similarly, in a computer-aided design system, the axiomatization is in the organization of the data structure and the definition of the procedures used to operate on the data structure. In principle though, the axioms of a design world may be stated formally and rigorously as a set of theoretical assertions.

Some projects are particularly appropriate for treatment in the virtual workshop, since they lend themselves to a natural strategy, which we will call "divide and confer" of establishing a hierarchy of interfaces. A project involving the design of a series of row houses offers the possibility of combining otherwise incompatible designs as adjacent alternative proposals [Wojtowicz, 1992]. Of course, simply adjoining different design leaves us with no guaranty of formal compatibility among them, and that issue brings us to a another organizational strategy, which relies on an analogy with urban regulations [Fargas and Papazian, 1992].

In some of his projects of the mid-1980's, the architect Lucien Kroll made use of computer technology in an almost apologetic manner, trying to avoid a perceived threat of "dumb repetitions" [Kroll, 1986]. Part of his strategy in projects of a relatively large scale, was to create a set of self-imposed abstract norms, similar to urban regulations, as a step previous to that of generating specific proposals. In one simple instance, the principal facades of a group of houses were not allowed to "see each-other". These kinds of abstract norms can obviously be developed and re-invented for any given project in order to facilitate the creation of interfaces among collaborators. Of course, the challenge in creating such systems is to avoid designing a restrictive set of rules which would discourage interaction among collaborator, while maximizing the utility of each contribution and its compatibility with other proposals.

Algorithms and games

Extending the regulations model to it's extreme can result in another set of typology-based techniques., which Gerhart Schmitt subdivides into "prototypes" and "cases" [Schmitt, 1993]. These are generalized formal representations of artifacts, in the form of parametrized objects, archetypes, and formalizations of knowledge about specific typologies. Applying these techniques to the organization of the virtual workshop can be a relatively ambitious task. It assumes that participants will first collaborate in the task of compiling a set of prototypes or establishing appropriate cases, thereby increasing the likelihood that specific proposals will be coherent, to the extent that they are based on common typological models.

Perhaps a more practical model of collaboration is captured by an analogy not with formal regulations, but with games [Habraken and Gross, 1988]. In this model, collaborators are seen to be making design moves as if they were making moves in a game. This has the advantage of turning the otherwise problematic confrontational side of competing design proposals into a creative endeavor, but might limit interaction to relatively small successive contributions, with a lesser control over the global evolution of the project.

Conclusion

The adoption of computer based design technologies has not been a smooth process in most academic and professional settings. On the other hand, attempts to come to terms with the new information and communications technology have often resulted in conceptual models of design environments which are neither sufficiently flexible to contemplate partial implementations nor tolerant of adaptations. We have proposed a more open and heterogeneous approach to understanding the interaction of different design technologies and the settings in which they are used. In particular, we have proposed hybrid environments which include the cooperation of more than one type of medium, varying levels of expertise with different aspects and tools of design production, and several modes of collaboration. Implicit in the adoption of a hybrid design environment model as the basis for a program of research is the hypothesis that such settings can be a prime source of motivating ideas, for ways of working and design technologies which are both novel and mutually compatible.

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