Design Mediums and Other Phenomena of First Generation CAD Practice

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In the majority of architecture firms which use CAD tools, computer technology has been retrofitted to an existing traditional practice, with mixed results. I will address some of the more interesting phenomena which occur in first generation CAD practices of this type, taking as a case study one well-established firm in Barcelona which, after more than thirty years of a successful practice, has adopted computer technology to such an extent that it is now very difficult to find even an ink pen in their offices.

Less than three years after the introduction of its first computer workstation, the Barcelona office is fully computerized, from carrying out even basic design directly with computer technology, to developing in-house software and maintaining an internet node via modem. This rapid adoption of the technology, although a relatively smooth one, was not free from strange side-effects. Because of the continuing involvement of a large part of the existing staff, the transition to computer aided design required the appearance of hybrid methodologies which are neither the traditional ones, nor what one might expect to find in the newly established CAD practice.

Design Media and Design Mediums

One consequence of the radical introduction of new design media is the appearance of design mediums. These are junior architects who, in addition to their more natural functions, act as intermediaries between senior partners and the CAD workstation. The senior architect in this design triangle—composed of the computer, the medium and the designer—although unwilling or unable to use the new technology directly, becomes completely adapted (and sometimes even addicted) to it, losing interest in most manual drawing activities beyond the proverbial napkin sketch, and adopting the technical language of the CAD program.

Studying first generation CAD practices is a good strategy for highlighting the shortcomings of CAD tools in terms of common architectural practices, while at the same time illustrating an emerging methodology which gradually adapts itself to the available software and hardware. Such firms also provide an interesting cross-section of architects, from the older generation unable to adapt to the requirements of using the new technology first hand, to the architecture students young enough to have been using CAD since the beginning of their studies, and who enter into a process of architectural apprenticeship as mediums.

The process of apprenticeship is a familiar one in many architecture firms [Cuff, 1991]. Due to their constant exposure to the senior architects, apprentices who are mediums will soon learn all the characteristics of the designer's working method. They will also pick up some valuable tricks of the
trade which, in a more traditional setting, they may only be exposed to indirectly. Perhaps more significantly, mediums have an opportunity to bring their own skills and suggestions to the design effort in a direct and explicit manner. Taking advantage of a moment of hesitation, a medium willing to risk the annoyance of the senior architect can make suggestions with a direct bearing on the direction of the project. To a large extent, this role in the design cannot be compared to that given to junior architects when they have a chance to solve a design problem independently (Lewis, 1989). However, it is a much more significant role than that of the ‘drifter’ or ‘CAD operator.’

The role of medium may seem to be a specialization within the office. In reality, the dynamics of the medium system is more varied. Typically, it is the regular junior architect who doubles as medium occasionally or on a part-time basis. More importantly, when a senior architect sits beside a CAD-literate collaborator to work jointly at a workstation, the collaborator takes on the additional role of medium. In this way, a more interactive collaboration takes place within the design triangle.

The fact that younger CAD-literate collaborators directly control the means of production helps compensate for the otherwise inferior authority they have with respect to the senior architect. In the final analysis, the design triangle created by the medium system is not a natural way of working with the emerging design technologies, but as a spontaneous reaction to their rapid advance, it seems to us far more positive than typical strategies such as dedicated groups of CAD operators copying paper-based drawings to digital media (Kalisperis and Croninger, 1992). The medium system is one of the products of a relatively smooth progression to the second generation CAD office and, as a transitional phenomenon, it can be a revealing subject for CAD research. One indication of the transient nature of the system is that at the Barcelona office, any temptation that CAD-literate architects may have of making use of mediums is frowned upon. It is like illegally parking one’s car in a zone reserved for wheelchair users.

Parallax

Experienced mediums will tell you that their task is a little more complex than it seems. An apparently innocent example which they might give is that when the designer points to an element on the screen using a pencil, a finger, or some specialized pointing device, the point being referred to will be at about one centimeter distance from the point of contact. This is due to the fact that the view point of the designer is slightly different from that of the medium, and with the thickness of the monitor’s glass and the protective filter added in front of it, a parallax effect is created. This difference between the two ways of seeing actually goes beyond the spatial, giving rise to what could be called a conceptual parallax. At a primitive level, conceptual parallax manifests itself as a difference of semantics. What the designer calls “the perimeter of the core” may or may not include, from the medium’s perspective, a circulation area surrounding the core of a building, for example. These kinds of ambiguities, however, are easily resolved, unlike ones resulting from more subtle issues of interpretation.

Figure 2: The discrepancy between pointer and reference as a window into conceptual parallax.

Consider the case of composing an arrangement of windows in the facades of two adjoining buildings of slightly different widths but with otherwise similar characteristics. Imagine that after composing the first facade with the assistance of the medium, the designer who trusts the medium’s fluency with CAD operations such as ‘copying’, ‘scaling’, ‘mirroring’, ‘trimming’ and so on, requests to make the second facade “symmetrical with the first.” Obviously, due
to the different dimensions of the facades, the possible implementations of this intended symmetry are numerous. The medium can copy and mirror the windows of the first facade, and then try to center them in the second. Another choice might be to scale the copied windows horizontally by a factor proportional to the two facade widths. A third option would be to reconstruct the designer’s logic in composing the first facade, by placing windows at the same distance from the facade perimeter, for example, and then determining their sizes such that they will be centered with respect to the rooms to which they correspond. If a first reaction is to suggest that the medium consult the designer in order to get more specific instructions, it will be discarded once one considers the number of times such decisions are made during a typical design session. A good medium, according to a consensus among the senior architects who work with them, is not simply a good CAD operator, but one who has developed the skill of replicating the designer’s way of working. In the case of the facade composition, if the designer is one who relies on a system of compositional grids, then the medium’s first reaction would be to introduce it in the second facade, possibly eliminating any ambiguity in the designer’s request. Effective mediums learn to compensate for both the spatial and the conceptual parallax between their point of view and that of the designer, and they eventually establish a seamless working relationship with the senior architects. Their role in the design, although usually limited to a specific level of implementation, becomes more important than it might seem at first glance.

The Other Mouse

Annoyed by the fingerprints left by a senior architect on CAD workstation monitors, and by way of a joke regarding the increasing normalization of the designer/medium/workstation triangle, some junior architects in the Barcelona office offered a senior architect a telescoping pointing device as a birthday gift. This conductor’s stick was immediately put to use and is now part of the standard CAD equipment of the office.

Recently, due to a recognition of the parallax problem described above, a more technological alternative to the conductor’s stick has been discovered at the office. This device simply consists of an additional digital pointer – a second mouse – which is manipulated by the designer while interacting with the medium. This second mouse can be limited to a purely graphical presence, in which case it would only be used for pointing, never for ‘clicking’. The buttons of this second mouse would then be used to turn the designer’s pointer on and off, to change its color or direction, or to toggle through its possible aspects.

![Figure 3: A new mouse on the screen](image)

A more ambitious version of the second mouse would give it some functionality at the level of the CAD application. Certain functions, such as viewing facilities, which might be convenient for the designer to use without the intervention of the medium could be made available to the second mouse. Going one step further, we could give to the second mouse a function similar to that of the second steering wheel in some driving school cars. In this scenario, the designer (in a fit of impatience, for example) would be able to intervene directly in the production process, overriding or complementing the medium’s actions. Would this disruption of an otherwise well-defined division of labor introduce an element of discord into the design triangle? Will it, on the other hand, have the positive effect of tricking the designer into CAD fluency? In any case, such a broad functionality would justify replacing the term ‘the second mouse’ with the more interchangeable one of ‘the other mouse’. It would not be surprising if the idea of two or more digital pointing devices is incorporated in the near future into commercial CAD applications since it would also represent an important feature for collaborative projects distributed over a large-scale network.
Doing Out Loud

First generation CAD practices which have adopted the new technology as spontaneously as the Barcelona office are rich environments for studying processes of production in computer aided architecture. The verbal interaction between senior architect and medium, for example, is a perfect record for a natural protocol analysis [Ericsson and Simon, 1984], where the artificial 'thinking out loud' 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. To complete the history of the session, a trace of the second mouse described above could be used to track any references to graphic elements found in the verbal record. 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' [Schon, 1992].

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 (or mockup) of a possible interaction between the architect and the proposed machine.

A Digital Analog to Model Making

One special feature of the Barcelona practice used as a case study is the existence of a dedicated model maker. Juan, a former carpenter, is such a master at his trade that photographs of his models, formerly mistaken for real buildings are now often mistaken for state of the art computer renderings. In fact, technology minded staff members have had to resign themselves to incorporating a scanned photograph of Juan’s model into a computer-generated context model, instead of the usual practice of incorporating a computer model in a scanned photograph of the context. This kind of collage complements the usual practice of pasting a photograph of a model taken from a pedestrian’s view point into a photograph of the site from the same view point. Interestingly, the base plans used to build the cardboard model are themselves computer generated, and at least on one occasion Juan was given three-dimensional plots of

Figure 4: The mixed-media model: one of many combinations of digital and analog resources.
a computer model in order to quickly visualize what he is being asked to build. In this mixed-media way, analog models evolve from digital documents which are cut, pasted, and used as templates. For some presentations, color printouts of roads, infrastructures or vegetation are used to enhance site model representations, and it is usual to see plots of facades pasted on the facades of cardboard buildings. 

In a documentary on New York City's infrastructures, the Head of a municipal Sewage Treatment Plant boasts "We do it just like nature does it, only better and more efficient." This attitude, adopted by many technology advocates, of using machines to recreate natural processes with more efficiency may be appropriate for sewage treatment, but it is not always a good idea in computer aided design. Many architecture firms which currently make a marginal use of computers will find it difficult or undesirable to introduce CAD at the early stages of projects. Researchers in the field point out with good reason the inadequacy of current computer applications for the early phases of design [Flemming, Coyne and Woodbury, 1993]. The Barcelona case study, by demonstrating a successful (although unusual) use of existing technology in basic design seems to suggest a complementary problem, namely the inadequacy of current architectural practices to the current computer technology. It is likely that the first generation of software which succeeds in making inroads into design practice at its most basic levels will be as innovative in meeting designers' needs as in suggesting new ways of working.

In one of his essays on software engineering Frederick Brooks, a former project manager at IBM, explains how a small group of designers can follow Mills's surgical team pattern proposed in the early seventies [Mills, 1971] in order to increase its effectiveness in software development [Brooks, 1982]. The idea is to replace the several competent designers who cooperate in a team and who divide the work among themselves with one chief designer responsible for all the important aspects of the design.

This approach is familiar to many architecture firms, but may be implemented in a more ad-hoc way, with design responsibilities shared informally with collaborators. But the main characteristics of Mills's surgical team structure which can have a positive impact on the way CAD is introduced in an architecture firm has to do with the production task of the chief designer. Brooks writes that, in addition to defining the functional and performance

Figure 5: Traces of automation in the model shop

One of the special features of presentation models produced by the Barcelona office is that they can be taken apart building by building, floor by floor, or layer by layer. Very often, the way the digital database of a building is organized in order to be able to work on a plan layout, a section or computer-generated perspective is analogous to the way Juan cuts and assembles the pieces of the model. In smaller scale detail models (i.e., a building lobby) Juan solves the problem of having to show alternative textures or materials by pasting them on pieces of cardboard which can be interchanged, just as the texture mapping module of the high-end rendering software used at the office is organized according to a naming convention based on design alternatives.

Just Like Nature Does It

An important factor effecting the ease with which a computational environment is adopted by a group of architects is the kind of architecture they practice. In the Barcelona office, the technique of the firm and the stylistic characteristics of their work is such that the process of introducing computer technology at the early stages of design projects is a smooth one. This argues, on the one hand, against the appropriateness of presently available CAD tools for design practice in general but, on the other hand, it indicates that a successful use of the tools can play an important role in the architecture produced.
specifications of the computer program, the chief programmer "personally designs the program, codes it, tests it, and writes its documentation." The whole structure of the 'surgical team' (which includes a 'copilot', an administrator, an editor, secretaries, a syntax specialist, and others) is designed to counteract the effect of overloading the chief designer with work. The disadvantage of such a structure is the lack of true cooperative work within the design team, while its advantage is to bring the designer closer to the media and the tools of production. In the design triangle, senior designers, with their conductor's stick and through the medium, communicate with the computer drawing. The danger is that the increased productivity of senior designers may tempt them to become one-man orchestras, stifling collaborators' initiatives and disrupting the overall production of the firm.

Introducing computer-aided design in a well-established firm is, in general, a painful process. After several years of working with CAD the Barcelona firm is well under way to a healthy methodological integration of computer technology. Anomalies such as design mediums and mixed-media models are bound to disappear along with other phenomena like computer superstitions, tangles of cables and memory abuse. The smooth operation of the ideal CAD office is not a very useful prototype when one is dealing with the realities of established practices. A more eclectic and tolerant model is needed which will have to account for strange phenomena such as the ones described here.

Notes

1 Although the medium phenomenon is not a natural method of using CAD, we would hesitate to qualify it as 'unnatural' because of its spontaneity and its effectiveness. Perhaps 'supernatural' is a more appropriate qualifier.

2 A second mouse with purely graphical functionality is relatively easy to implement at the operating system level. It would operate as a parasite (or rodent?) occupying the CAD application window without necessarily having the application's consent. In order to implement another mouse with more ambitious functions may require careful coordination with the CAD application or the mouse driver. Note, however, that it would be relatively easy to switch the CAD application's control entirely to the second mouse and back again by simply tricking the application into recognizing one mouse or another at any given time.

3 Distributed collaborative design is another mode of designing where the revealing explicit interactions can be recorded non-intrusively.

4 Faced with difficult to explain technical problems, some architects in the office have developed a kind of computer superstition. Strange malfunctions of the plotter have been correlated with subtle factors such as the time of day; the disposition of staff members in the local area network or patterns made by cables on the floor. This phenomenon is affectionately referred to as the 'plottergeist effect.'
References


