SKETCHPAD to 2000: from computer systems to digital environments

David Willey

It can be argued that over the last thirty five years computer aided architectural design (CAAD) has made little impact in terms of aiding design. The paper provides a broadbrush review of the last 35 years of CAAD research and suggests that the SKETCHPAD notion that has dominated CAAD since 1963 is now a flawed concept. Then the discipline was replete with Modernist concepts of optimal solutions, objective design criteria and universal design standards. Now CAD needs to proceed on the basis of the Post Modern ways of thinking and designing opened up by digital techniques - the Internet, multimedia, virtual reality, electronic games, distance learning.

Computers facilitate information flow and storage. In the late seventies and eighties the CAAD research community's response to the difficulties it had identified with the construction of integrated digital building models was to attempt to improve the intelligence of the computer systems to better match the understanding of designers. Now it is clear that the future could easily lie with CAAD systems that have almost no intelligence and make no attempt to aid the designer. Communication is much more central to designing than computing.

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Introduction

It can be argued that over the last thirty five years computer aided architectural design (CAAD), despite the arrival of the digital design office, has made little impact in terms of aiding design. This paper explores the conceptual issues underlying this critical position by revisiting ideas first published in 1976. It provides a broadbrush review of the last 35 years of CAAD research and suggests that the SKETCHPAD notion is now a flawed concept. That model has dominated CAAD since 1963 but what now seems to be emerging is a reconception of the role of the computer in the digital architectural design office.

The sixties and seventies

There were two main streams of CAAD work in the sixties, one based on the graphics systems invented by Coons, Ross & Rodriquez, Sutherland and Johnson (Coons et al, 1963) and the other the space allocation programs spawned by work study specialists. In Britain the graphics systems were represented by the Architect's Department of West Sussex County Council (Paterson, 1974) whilst the space planners were headed by Whitehead at Liverpool University's Department of Building Science. (Whitehead, 1964) Building modelling research was established in the late sixties at Liverpool with Arthur Britch, (Britch, 1970) at Edinburgh with Aart Bijl (Bijl, 1972)and at Strathclyde with Tom Maver. (Maver, 1972) They were joined in the seventies by groups at both Cambridge (Hoskins, 1972), Leeds (Beacon, 1978) and Bristol (Phillips, 1979). These teams employed the 'classic' CAAD conception that the computer would carry out the role of central record keeper for the design project, previously split between the designer's memory and the drawn record, and contain a complete description modelling the building's geometry and materials. This model would be available to a whole host of specialist design analysis programs that would access the model and produce accurate predictions of capital cost, daylight, heating costs and structural design as well as generate all the design drawings and the Bill of Quantities. The model could be simultaneously accessed by all the members of the building team thus greatly improving communication and efficiency.

> *'The fundamental concept of OXSYS is to replace the image on paper by an image in a computer memory. This image will be accessible to all members of the design team, and each member will be able to develop it.....this will shift considerably the workload from drawing to designing.'* (Hoskins, 1972, pp. 277-278)

The problems of representing building geometry and attaching materials to them within an integrated system supposed to be capable of modelling any building at all became the main research focus and soon led to attempts to reduce this complexity by restricting the building types or the building systems that would be modelled. By the late seventies it was clear that these modelling systems were not making the crucial breakthrough from research tools within restricted environments into the world of general architectural practice. That breakthrough was occurring with 'simple' graphic systems that allowed 2D drawings to be stored, amended and reproduced using (still expensive) mini computer systems linked to high quality graphics workstations. Aart Bijl wrote his pivotal critique of integrated CAAD systems in 1979. (Bijl, 1979) Thereafter the Edinburgh group began to search for ways in which to provide the computer system with more flexible and intelligent characteristics that better matched the professional orientation of the architect.

The eighties and nineties

The micro computer was well established in the early eighties but the entrance of IBM into the market created the personal computer. The combination of cheap hardware and well established software has transformed the architect's office during the late eighties and early nineties. Architectural practice is now digital.

In the early eighties CAAD research engaged with the complexities of Artificial Intelligence and Expert Systems. Gero's group at Sydney University emerged at this time focused on this new paradigm. (Gero 1987) Papers were published that demonstrated the potential of CAAD techniques developed from those already established in Artificial Intellegence. (Latombe, 1978; Toller, 1983) Development also continued of complex environmental programs that built their own models of the building under investigation but represented only the features that were relevant to them. (Maver, 1982) Such packages are an established part of engineering consultancy. However, despite architects now working within a digital drawing environment, the products of the CAAD research community have not been widely adopted.

The conceptual underpinning

In 1976 I was arguing against the conventional wisdom that a little more effort was all that was needed to resolve the problems of the man-machine interface. (Willey, 1976) I thought that the problems were so great that it made just as much sense to examine how design could be automated as try to create workable interfaces. The following quotations are lifted from the context of that discussion.

'The sketch design stage of the architectural design process is plainly critical to the development of a satisfactory building. The important issues such as the building's siting, volume, shape and constructional system are all decided upon during this period, thus largely dictating the construction and running costs, the completion date and the environmental impact of the project. If c.a.a.d. systems are to provide the architect with real help in controlling design then they must operate during the sketch design process.' (Willey, 1976, p. 181)

The real paradox of this idea that CAAD should operate at sketch design stage, where the ideas are fluid, half-formed and only partially described, is that computers are very poor at operating with partial information. If they have to guess they have to embody techniques that people use for guessing. They generally cannot use thir 'advatages' of high speed computation or the sifting through of large volumes of information. This notion that computers are needed in sketch design carries with it the implication that existing manual sketch design techniques do not produce satisfactory results. Maybe not, but there has been almost no research carried out intended to understand why sketch design might be difficult, or to illusidate where exactly the mistakes occur so that design aids can be carefully targeted. There has always been an implication, sometimes made explicitly, that architecture suffered from 'idealogical pollution'. (Maver, 1972, p.39)

'Architectural design is normally regarded as being too complicated to be described and solved automatically by a computer program. There are too many steps which have to be retraced, the generation of ideas is a poorly understood and highly complex process, and the design problem is normally only fully revealed during the design process itself. The conventional wisdom is, therefore, to stress the aided *aspect of computer-aided design and to see it as a partnership between man and machine. Each partner concentrates upon those things which each does best; thus the machine computes and the man conceives.'* (Willey, 1976, p. 181)

This idea lies at the heart of CAD and whereas engineering design does contain a large element of computing and a relatively low level of three dimensional complexity, architectural design contains a low level of computation and a high level of three dimensional complexity. The conventional wisdom can and has applied to engineering design but it makes little sense within architectural design. The architect can legitimately ask 'compute what?' There is nothing, hardly, for the computer to do. In the late ninties we might now reply that the creation of the virtual building is what is computed. However, even here the virtual building needs a level of description which places it some distance down the design process and probably beyond the threshold of sketch designing. For architecture to become a calculation based discipline would require a siesmic cultural change going far beyond the profession and the Schools of Architecture. If the computer aided design paradigm is inadequate, what did CAAD replace it with?

'By their very nature computer systems remove from the designer the freedom of action which pencil and paper techniques provide.' (Willey, 1976, p. 185)

CAAD systems turn the role of drawing on its head. In a CAAD system drawing is a way for the designer to communicate to the machine what the buiding is like whereas for the architect drawing is for the architect to find out what the building is like. Thus for the architect's drawings are a collection of clues, hints and reminders; they are fragments, some resolved and some not. Some represent overall planning solutions while some involve the threshold detail. All are held simultaneously adjacent to one another on the sheets of paper. A CAAD system like that remains an ambition. Of course it is not easy for people to acquire the graphic, conceptual and intellectual capacities to operate in this way. In a CAAD system the designers almost always have to tell the machine what they are about to do so that it can interpret what was input. Improving the interface remains a serious resach issue thirtyfive years after the 'breakthrough' of SKETCHPAD.

> *'Since the drawing task has been removed from the designer what creative operation has replaced it? Indeed, what specific advantage acrues (sic) to the designer who uses a c.a.a.d. system? There does not appear to be any immediate benefit to be gained from using the computer system except its novelty and apparent sophistication. No studies have been carried out which clearly demonstrate the advantages of a c.a.d. system for architectural sketch design.'* (Willey, 1976, p. 185)

Twenty-three years on this comment may need to be softened at the edges (and spelt correctly) but in essense it remains fresh. Environments offerd by the web may now display an immediacy and an ability to bring the unexpected onto the display screen that we could regard as the onset of a new creative operation to replace drawing.

> 'All of these problems appear to stem from the relationship between the designer and the design tool. At its root is the mismatch between the architect's conception of the design problem with all its facets and the simplistic representations of that problem which can be achieved using the computer. It would appear that because of its particular nature that architectural sketch design will always remain outside the compass of a computer-aided design system, contravening as it does the dictate of Ross and Rodriquez (Ross,1963) that the computer's view of the problem must match exactly that of the human.' (Willey, 1976, p. 185)

Drafting systems benefit architects

The CAD drafting systems developed during the seventies had identified a clear market. The bulk of the costs of an architectural practice were tied into the production of the working drawings for projects. Practices managed this situation by hiring and firing staff in order to meet deadlines and to control costs. It was difficult to maintain continuity and quality control. CAD drafting systems offered the architect the possibility of reducing the number of assistants involved thus lowering costs and increasing profitability, reducing the production period and reducing the complexity of quality control. The micro computer reduced the cost of entry.

The advantages of computer aided architectural design (CAAD) have generally been seen in terms of the client as the beneficiary of an improved design system. CAAD has generally offered a more efficient and less error-prone design process, based on more reliable data and communicated more effectively between the partners involved in the project's procurement. The benefits accrued from the development of a comprehensive data model shared by and accessed by all participants in the design process. The design of buildings would improve, but there would be no clear benefits for the architects expected to make the investment in CAAD.

What's the problem?

It is interesting to note that many of the CAAD systems that were developed during the seventies were developed for client organisations, in, for example, health or housing. That the benefits claimed for CAAD systems were chimerical was partly concerned with the pragmatics of the effort involved both in creating an accurate digital building model and in determining the level of detail required in it. It was (and is?) also the case that few architects saw the design process as problematic. There was no problem to be solved. Where CAAD systems could be effective was in routine situations where the building form and organisation was predicable and the CAAD system could assume materials and geometries with confidence. However, in these familiar situations the engineering solutions, fire performance, construction details, materials, building process, lighting and heating solutions were also well known. There was no need for extensive analysis. That analysis was needed where the architect was breaking new ground. However, in that situation CAAD systems could not assume a known geometry or standard details or materials. Here the effort might as well go into a specialised one-off analysis dedicated to the case in hand.

The general digital building model

The failure of the general digital building model to establish itself as the industry standard after thirty years during which it has been advocated is a clear sign that it is an inappropriate paradigm for CAAD. It does not address a clearly defined problem within the architectural design office. It offers no clear cost benefits to the architect expected to invest in it.

Many CAAD researchers, myself included, believed that CAAD would allow the quality of architecture to be improved through the increased control of the design process and increased predictability of the building through visualisation and engineering analysis. The problem was simply one of ensuring that the costs of the digital model's construction could be contained through specifying the building type domain of the model or through supporting the model's creation through increased 'intelligence' on the part of the system. Digital building modelling requires transferring to the CAAD system a large quantity of information, both geometric and theoretical, that is carried implicitly by the architect and engineer when combined with 2D drawings. Finding an effect way to transfer this information has proved to be a far more intractable problem than most researchers imagined. It is interesting to note that many of the research groups who were focused on these problems in the seventies and early eighties are not now concerned with it.

The problem faced in making a digital building model was clearly expressed by Ross and Rodriquez.

> *'Whereas the computer's 'understanding' of a problem takes the form of a huge and complicated plex structure, the human's understanding of the same problem must be accumulated in his memory of the meaning of all the statements which have been made about the problem, and which have led to the growth of the plex structure in the computer. In actual fact, the computer's view of the problem must match exactly that of the human, so that the human need not be aware of the internal structuring which allows the computer to understand the problem, but need only be concerned with the linguistic interpretation which is natural to him. The modelling plex must match exactly the meaning of the statements.'* (Ross, 1963)

It is this exact match between the model and the meaning that has consistently escaped CAAD research efforts but it is still sought after in current work. Saad and Maher, for example, thirty-three years after SKETCHPAD argue for a computer-supported collaborative design environment that will support shared understanding. They recognise that

> *'in the design of buildings, designers use formal and informal drawings, verbal and text-based specifications, computer-based and physical models, photographs and video to document and communicate their ideas.'* (Saad, 1996, p. 181)

This is a description of a rich, complex and flexible environment that requires the human collaborators to employ their technical, visual, social and cultural understandings to the full. It is self-evident that it will be very difficult, if not impossible within foreseeable timescales, to construct a computer system with this kind of range and capacity that carries the 'meaning as well as the description of the physical/geometric features of the design objects.' (Saad, 1996, p. 185) The concern for meaning as well as geometry that was present in the SKETCHPAD system is described without any serious attempt to explain why the computer system needs to 'understand'.

Saad and Maher have identified design as a collaborative activity requiring the sharing of information. Since much of any designer's work is now computer based - drawing, calculating dimensions, writing, e-mailing - it is natural to expect that the information for a design project would be held and communicated in digital formats available to all members of the design team. But there is no need to consider that the computer system needs any design intelligence. It does not need to understand the meanings in the design. Indeed, whether the machine 'understands' or not is not the issue. It is the engineer, the architect and the client who need to understand and the machine's 'understanding' is simply irrelevent in this context.

When SKETCHPAD was invented computers were seen as active systems that did things, like calculations. CAAD systems were therefore expected to also do something: be the AID part of computer aided design. Thirty years on computer systems are now, paradoxically, much more passive. The computer's role in e-mail is in automatically managing the routing of the message to anywhere in the world. But it does nothing to the message. Who needs computer aided e-mail? The CAAD research community needs to stop trying to get the computer to do anything important. 'Computer facilitated architectural design' captures our current condition.

cFAD

Computers facilitate information flow and storage. In the late seventies and eighties the CAAD research community's response to the difficulties it had identified with the construction of digital building models was to attempt to improve the intelligence of the computer systems to better match the understanding of designers. Now it is clear that the future could easily lie with CAAD systems that have almost no intelligence and make no attempt to aid the designer. They simply need to store and communicate design information and allow the designers to do what they know how to do, that is to design.

Computer aided design was devised in a world with a few expensive isolated computers and assumed that computer modelling of the manual design process would form the basis of CAD. The discipline was replete with Modernist concepts of optimal solutions, objective design criteria and universal design standards. Now CAD needs to proceed on the basis of the Post Modern ways of thinking and designing opened up by digital techniques - the Internet, multimedia, virtual reality, electronic games, distance learning. There needs to be less emphasis on computer systems and more on digital environments that are open to change and modification, that allow multiple forms of representation and that are rich in manipulation tools. Communication is much more central to designing than computing.

Systems which simply facilitate storage and communication are, of course, not quite as simple as they seem. It is true that e-mail does nothing to the message but the new medium has transformed the way many people, especially academics now work. If we want to examine the way in which the architect's office of the future might operate we have only to look at the range of computer based work currently undertaken in Schools of Architecture. (EAAE, 1998) We might also look at more recent work by Maher which is a fascinating discussion of how computer tools can change tasks and how those tools can be designed. As for this new tool 'does it need to replace necessarily, or run simultaneously'? (Maher, 1999)

Once we recognise that we should not necessarily replace current practice with new practice but run them simultaneously then we can have paper and pencil, screen and mouse, the airbrush elevation and the digitally enhanced photograph, the real napkin as well as the electronic one, the incomplete pencil perspective and the photo-realistic flythrough. We also restore to centre stage the human , (much maligned designer), who was only ever implied by the phrase 'computer aided design'.

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David Willey
School of Architecture
University of Plymouth, UK
dwilley@plymouth.ac.uk