Added Value

Of

Computer Aided Architectural Design

AVOCAAD

The Value when Cybernetics is added to CAAD

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In this paper it is argued that cybernetics gives added value to design in general and to CAAD in particular. Essential cybernetic concepts are introduced, and are then shown to reflect design. These reflections are shown to be potentially amplifiable by the use of computers through CAAD, if we will and dare it.

The Value when Cybernetics is Added to CAAD

Foreword

The theme of this conference is added value. In general, the idea is to explore how CAAD gives added value when it is applied. In contrast, in this paper (in some respects more of a tutorial) I explore how another subject (in this case, Cybernetics) adds to the value of CAAD.

In order to do this, I firstly talk about the relationship of theory to those subjects in which it is applied. It has become common for theory to be imported from one area into another, and it is interesting to consider why. What is theory about and why do we like to have it? This is a question of particular interest, I believe, in architecture. But it also leads to the need for examining aspects of theory, in itself.

There then follows what is, in effect, a tutorial section, in which I introduce a number of cybernetic concepts which I believe to be of great value to architecture, both from the point of view of the application of theory, and also in their own right. (I assume, as has been indicated by many including me, that architecture, or, more generally, design and Cybernetics have a great deal in common.) This forms the main section of this paper. I explain these Cybernetic concepts and their extensions, and I also introduce certain concepts concerning computation, some of which are clearly tied up in the Cybernetic concept-world.

Finally, I indicate how these concepts shed light on design and outline their particular relevance in CAAD, improving performance and, thus, adding value.

This is an ambitious undertaking. Inevitably, it is underexplained. There is much to be argued, and this is not possible within the scope of a single, short paper. Much of this I have argued elsewhere (see, eg, Glanville 1995, 1997). But not all. Much is also new.

Theory

Scientists have some clearly thought out concepts concerning theory.

For instance, theory is what is proposed to explain the phenomena that science concerns itself with. This approach to theory concerns itself with the notion of description, abstraction (pattern finding) and testing, for instance: it is looking to exactly describe patterns in the phenomena of observation such that the description is always in accordance with the patterns in the phenomena. Thus, this sort of theory is attempting to attain the unattainable: it is constituted of a number of concepts, several of which even seem to be in contradiction: for instance, that the description is made of observations, yet that there may be a “truth” waiting to be revealed. In its peculiar and sceptical approach it espouses falsification: the job of science is to test these descriptions to destruction.[1] (Popper 1963)

The benefits of this approach and of the development of this sort of theory (especially, I believe, the avowal of rigour and argument) are always with us as part of our everyday lives.

I would like to suggest that our use of, even need for, theory may be considered in another way. Theory lets us believe we are alright. If what we say is in accord with a theory, we have reason to believe it is strong and viable. (This assumes the theory is “right”. But for many, merely having a theory makes it right.) Thus, theory satisfies a psychological need, the need to feel that there is justification and that opinions are not alone. It provides security in an insecure, unmanageable world. It helps us . It gives cohesion and an overview: and it simplifies the world so that we do not have, personally, to take responsibility for everything we find. It is a prop. And it lends authority.[2]

This view is in accord with the general view of theory and, in particular, science. This view holds that humankind starts to face the complexity of the world it finds itself in (or it constructs for itself) by the construction of myth, the first theory. The role of myth is to explain the universe, to handle the incomprehensible, and to give rites and routines that allow both a belief in control and the ability to pass on some responsibilities. In this (constructed, historical) view, theory helps us believe there is sense and that we have a place. This belief remains behind all developments and applications of theory. My proposal of the psychological basis for the acquisition and application of theory is in broad accord with this view.

Cybernetics as the Theory of/for Design

It is my view that Cybernetics is the theory that matches the activity of design. It shares the form and preoccupations of design, and its way of working, unlike so many other theories that design has borrowed, pasting them on top of the practice of design. The connection is integral and natural.

I am not alone in this view. As early as 1969, my teacher Gordon Pask indicated he saw a relevance of Cybernetics for Architecture both inn providing a sensitive and appropriate theory and in his characterisation of design as a conversation with yourself via paper and pencil, about which more later (Pask 1969).

In order to demonstrate the viability of this assertion, we can look to the sort of appreciation of theory that the scientist has. We have to ask not only about the theory’s ability to support our insecurities, but also its ability to shed light on the subject. In particular, we look to see if the theory not only helps us understand a subject area better (with more

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1 I do not wish to debate the social correctness of the position assumed here, as many have done, although I do not believe scientists really behave in this manner: it is a (hopeless) ideal.

2 On another occasion I shall hope to argue this point more fully: I include it here because I believe it will have an immediate resonance with thinking architects.

clarity, greater coherence, etc), but also whether it can extend our understanding and appreciation of the area the theory operates on. Usually this is taken to be successful prediction. Good theories predict what we had not yet experienced/known. But they also account for more with less: this is Occam's Razor, the origin of Philip Johnson's Miesian aphorism "Less is More".

If Cybernetics does this for design, and particularly for Computer Aided Architectural Design, then my assertion can be taken to have more than psychological value (although I am certainly not belittling the importance of this). If it does not, we can dismiss the parallel, or pursue modification possibilities: but we will not need to do either of these!

Cybernetics

In its modern incarnation, Cybernetics can be said to stem from Norbert Wiener's book (Wiener, 1948) entitled "Cybernetics: or Control and Communication in the Animal and the Machine". However, it is Ross Ashby's 1956 book "An Introduction to Cybernetics" (Ashby 1956) that is the main source for (aspects of) the characterisation of Cybernetics given in the following sections, for it takes the work of Wiener and his colleagues and distils it into one, unified, coherent and highly abstracted body.[1] I use this book as a general reference for Cybernetics in general and for most of Ashby's concepts (except where otherwise referenced).

In this paper I briefly introduce certain aspects of Cybernetics that do, I believe, add value to CAAD.

Feedback

Cybernetic systems are often characterised through feedback. Feedback is necessary wherever there is (potential) error: Feedback lets the actor in a situation know whether the result of his action is what he desired (ie, did it achieve the goal). If not, it is possible to try again, having modified the action according to the error (the result), to compensate for (take account of) it.

Control

Feedback is, therefore, central to the working of control. If one system is to control another, it needs to know what that other is doing and, if it is not doing as required, to be able to control the other (use it to modify its behaviour) so that it performs more as required.

However, the controlling system must also modify its behaviour, itself, according to how the other system is doing. Ie, it is controlled by the other system. Thus control, through the action of the feedback loop, is circular. The controlling system is itself controlled by the controlled

1 Heinz von Foerster tells a lovely story about Ashby. When in the late 1960s he was visiting the Biological Computer Laboratory in Urbana Illinois, Heinz asked Ashby's students how he was getting on. The students said it was all rather simple. With some trepidation, Heinz told Ashby this. Ashby burst into enormous guffaws of laughter. He said "It's taken me 20 years to make it that simple".

system: which is controlling and which is controlled is a matter of a naming convention. Control exists within the circularity (between the systems), and not in one, the other, or even both of them.

Think of a thermostat. The wall switch turns the heating system on and off. What turns the switch on and off?

Communication

In order for control to be possible and to be effective, information must pass between the systems in the control loop indicating the states the systems are in. In this respect, communication is simple and trivial. But the moment communication is studied in its own right it is no longer trivial. For instance, just how are the (results of) actions encoded into information, and just how is that information transmitted and unencoded? And how do we know that this leads to the meaning being transmitted? What about the characteristics of the means of transmission (eg noise)? Communication is raised as a significant question.

The Observer

Until recently it has been customary to talk of that which we observe as if the observer[1] did not impinge upon it. Observations happened, and thus, not being the responsibility of anyone in particular, could be assumed to emanate from a postulated reality. This reality has the property of continuing immutable, and following some laws (of nature) which it was our task to discover, thus becoming revealed to us without our involvement.

In a circular system this is not a tenable position. The observer is in the system (or, as the Americans say, in the loop). In observing, the observer interacts with that which is observed and, so doing, changes it. The observer is not without effect, just as the controller in a (circular) control system interacts with that which was thought of as the controlled.

Cybernetics is concerned with systems in which the observer also makes judgements and initiates actions, and accepts that, in observing a system using the Cybernetic perspective, the observation of that system affects that system (ie, that "scientific" observation is not viable within the cybernetic model—except, perhaps, as a special case, according to Occam's Razor).

Second Order Cybernetics

The explicit inclusion of the observer in the system that changes the system so that it becomes a proper part of second order Cybernetics.[2] Second order Cybernetics is the Cybernetics that is aware of itself, that

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1 Observe is used here as an abstraction, not meaning "see", but meaning to sense in any manner.

2 I would prefer no longer to differentiate first from second order cybernetics. To me, one of the lessons of second order cybernetics is that the first order is properly part of the second order, and that when we treated it as first order it was because we didn't know how to move on!

examines itself as (part of) its subject area (the Cybernetics of Cybernetics). It is the Cybernetics of observing (as opposed to observed) systems (von Foerster 1974).

Second order systems are becoming well enough known nowadays, but they create problems in theory. Second order Cybernetics has set out to deal with these problems. It has examined the nature of systems in which the observer is an actor, and in which observing is seen as active, ie the observer's observations do not come about by magic but involve an active and participant connection with the system.

Difference

In including the observer in the system, the individual difference between the particular observer (you, me, the others) becomes very important. When the observer is not part of the system, and observations magically come to him, somehow preformed to be just what is required, the observer may be without impact. When the observer is part of the system the particularity of the observer counts. There are devices to minimise this difference (they are very useful, and they do allow us a "science": indeed, the conventional scientific observer is one such). But Cybernetics accepts that these differences are present, and does neither deny them nor attempt to dismiss them or rule them out, any more than it denies the existence of error, or attempts to dismiss that.

Thus, the significance of being you, or me, is recognised in Cybernetics.

The Black Box

A characterising cybernetic device is the Black Box.[1] This is a conceptual device that creates transformations between signals understood as entering and leaving the device. The observer observes both in and output. Indeed, the observer modifies the input (feedback). The arrangement is circular. The observer builds descriptions of the behaviour of the Black Box: these are used to predict outputs from the inputs the observer applies. The description is not what is in the Black Box (which we can never see inside). It is a proposal which we test. Because we have no idea what is in the Black Box, the description cannot have that sort of truth value (but what description can?): and this means that the Black Box embodies Wittgenstein's assertion that because something has gone on does not mean that it must continue to go on.

The Black Box is the device that embodies our ability to continue and to act in spite of not knowing what is there: the world as constructed

1 Ashby, who writes extensively about the Black Box, claims that the Black Box is a universal model for the mechanism of our ability to understand. He asserts that James Clerk Maxwell invented the concept, although I have never been able to trace this. There are many who state that the Black Box is a first order cybernetic device. I disagree. In the circularity of its description and in its accepted and inherent uncertainty, it is truly second order. I had a long and difficult disagreement with Geoffrey Vickers over this: he assumed the Black Box was entirely reductionist and mechanical; I assume it is non-reductionist and deeply human! In the end I persuaded him of my point.

hypothesis and description. It conquers the ignorance that is the basis of human existence. (Glanville 1979, 1982)

Conversation (not Code)

When you don't know what others are thinking (and who, in all honesty, ever knows this?), you might use the Black Box model to describe their behaviours.[1]

Conversation is the mechanism that allows us to communicate even when we don't know what it is we are talking about[2], and even when we cannot know what our conversational partner is thinking. In a conversation, each of us builds our own understandings and our own meanings.[3] We express what we wish through the medium of some "language", which our conversational partner hears as they will, and then re-iterates to us through the medium of language in their own words. If we can build an understanding from the partner's reiteration that matches our original intention, then we can assume we have communicated and that our partner has a meaning that, for them, works more or less as ours works for us. We own the development of this mechanism, and the concepts that go with it, to Pask (who worked extensively with architects).

Notice that there is no communication or meeting of meanings. And, since each of us makes our own meanings (different as we are), there is always "mismatch". This can lead to novelty: that you see things differently to me and communicate some of this can lead, should I keep an open mind, to new ideas that you, my conversational partner, give me.

This is in sharp contrast to the notion of coding, in which accuracy of communication is taken to be determinable and is all-important. In coding, there is no difference in understanding between the partners (whereas in conversation there is no alternative), and messages are transmitted from the source to the reception, whereas in conversation communication is between participants. Coding, in this sense, is a very limited version of conversation. (Glanville 1995)

Complexity and the Possible

1 In both senses. The Black Box might be the device chosen as the description type, and the working of the Black Box might be used to build the precise description.

2 In the sense of the Black Box, rather than in the sense of the being loudly ignorant and assertive!

3 I would argue that this is the general case. But not here. This takes a whole paper of its own! See Glanville (1996).

Another aspect of Cybernetics is its concern for complexity and for what is and is not, in principle, computable. Hans Bremmerman (1962) carried out a calculation on the theoretical computational capacity of matter (bits per gram per second). From this, Ashby (1964) calculated how much the earth, as computer, might have computed in its lifetime, as well as how much the universe might calculate. These rather arcane calculations should not be taken as accurate. They give a sense of scale and indicate that there are limits. Looking at the structure of these limits and combinatorics, one can very easily see that the possible answers to well-defined questions rapidly become beyond what could be computed even if the earth, or for that matter the universe, was a computer. Thus they are transcomputable.[1]

One example is in the choice of possible combinations of chemical elements. Apparently, according to Christopher Alexander (I cannot find the reference), there are 10^{20} possible combinations of chemical elements. Based on best estimates of the size of the universe and assuming the universe is a perfect computer, the universe, in its entire life, would not have been able to compute which combination of 5 elements would provide the ideal collection of materials for some purpose (eg, building a room: how many rooms only use 5 materials).

Variety (and the Law of Requisite Variety)

A measure of complexity is Variety. Variety is a measure of the number of states a system can have (repeated states are considered only to be one state). It is closely analogous to Shannon and Weaver's concept of information. There is a very important law that concerns the behaviour of systems that are to control other systems, the Law of Requisite Variety (due to Ashby). The Law of Requisite Variety is a law from first order Cybernetics . It states that the variety of the system that is controlling must at least equal the variety of the system to be controlled. If it is not, then it is not possible for the controlling system to "take into account" all the possibilities of the controlled system: in which case the so-called control would not be control but restriction.[2]

The second order corollary is that the variety in the controlling system must exactly equal that in the controlled system, since either could be named to the role controlled, and either the name controlling. Since both must have variety at least equal to the other, the only possibility is that both have variety exactly equal to eachother. This is, of course, an enormous difficulty even in the relatively undemanding situation where the controlled system goes transcomputable.

1 Of course, there are different ways of describing the contexts within which questions are formed. It is perfectly possible to answer a question by immediate association: the next thing that happens is taken to be the answer: this requires very little computational power.

2 The cybernetic concept of control is technical and devoid of the unpleasant notions that we often include with control, such as the type of so-called control Hitler exerted. Hitler, in the cybernetic sense, did not control: he destroyed variety and restricted the system. The cybernetic notion of control is closely allied to that of regulation.

Computing

I have argued at length concerning the nature of the computer and its application in design (eg Glanville 1994b, 1995).

I summarise here.

Computers make vast numbers of perfect copies almost instantly, and can send them virtually (!) anywhere in the world. This destroys uniqueness and hence that value of owning the original. Origination remains important. Owning the original does not.

Computers can carry out calculations that are vastly more complex that those we can manage, even working as a team for a long period. This was apparent right from the start, in Bletchley Park.[1] Thus, the scale of iteration that may be considered is changed (this makes slow acting genetic algorithms such as used by John Frazer (Frazer 1995) viable), and the shapes resulting from the intersection of complex shapes can be determined.

Computers can carry out transformations that are also beyond our powers. That is to say, computers can transform things in ways that are, at worst, only vaguely imaginable, and at best, completely beyond what we can imagine. Betweening and morphing are capable of suggesting new forms that we could not ourselves envisage.

Computer programs also have characteristics of their own. Often these go unnoticed. One way to reveal them is to encourage their abuse: ie, to use the software in ways beyond those intended. Inevitably, this way of using software in unexpected and unintended ways leads to surprises.

Finally, computers go wrong. What do we mean by "go wrong". One characterisation is that they behave in ways we did not anticipate. Sometimes this is thoroughly destructive (hard disc crash). In others, it can be enlightening. This is serendipity. Any machine is liable to go wrong: finding ways of benefiting from this is a constructive and potentially regarding challenge.

Cybernetics, CAAD and Architecture

From my point of view, the purpose of CAAD is to help us increase our creativity. Of course, creativity is a difficult area. It is in the nature of creativity that it cannot be either predicted or measured. When I talk of increasing creativity I talk in the manner of Ashby's (Cybernetic) amplification of intelligence (Ashby 1956). Ashby suggested that, to transcend the fixedness of the brain's variety, we could increase our effective intelligence through narrowing the areas we worked in. I believe we can enhance creativity in a manner similar in approach but the reverse in application: that is, we can increase the range of resources (ie

[1] The home of the original computers built under the direction of Alan Turing during the Second World War and used to check possible combinations in decoding the German Enigma Code.

the variety) available to us. And I am interested in the use of computers to aid this, in the belief that this enhances at least our potential creativity.

This is not without problems. Increasing range can, for instance, lead to overload. Nor is this the only way computers can aid architectural design: improved visualisation, clash checking and other co-ordinative activities and rule based form generation are all areas in which computers are taken to aid architectural design. I do not, here, wish to question this. But neither do I want to discuss these ways of helping or their effectiveness. I shall stick to the potential enhancement of creativity.

Design as Reflected in Cybernetic Theory

As early as 1968, and in sharp contrast to the prevailing approach in design research and methods, the cybernetician Gordon Pask had seen the connection between design (and specifically architecture) and Cybernetics. Pask spent much of his working life associating with architects (for instance, he worked with Cedric Price on Joan Littlewood's Fun Palace), and, to the end of his life, taught at the Architectural Association School in London (where his memorial was celebrated). He argued (although for different reasons than those I give here) that Cybernetics was able to provide the theory that was appropriate to architecture. And he argued that design was akin to holding a conversation with yourself via paper and pencil. On the base line, design is a circular process, and so is Cybernetics.

Thus, one would expect Cybernetics to be able to inform design at all levels and as practised through whatever form, including the use of computation. And perhaps one would expect even more since cybernetics is so often identified with computation and the future.

The Observer is a Designer

Many studies of designers at work are made by (pseudo) classical observers who like not to participate. And many accounts of how designers do their work make designers look like classical observers.

This is rather like the peculiar trick that biologists have traditionally played: killing what is alive in order to study life.

Cybernetics offers a paradigm in which the observer is within the system, that is, the observer behaves in the same manner as the designer. In effect, in Cybernetics we are concerned with activities as verbs, not nouns. The involvement of the observer parallels the involvement of the designer. It is circular, and it partakes in forming the outcome.

In addition, since each observer is different, each point of view is different, too. Thus, individual difference is preserved (and, with it, personality, individuality and style).

Design, Surprise and the Unknowable

Any theory that is to account for design, at least in the sense in which I mean it, must integrally support the notion of surprise. The experience of design is, I believe, rich in surprise, in finding the unknown and the unpredictable. The process of design typically involves finding that the design act itself leads the designer: you start with one idea and this develops to another, often while you are quite unaware of it. Equally, you make some doodle or sketch and, looking at it, are surprised to find in it ideas and images you have no awareness of having put there (hence Pask's styling of design as a conversation with yourself via paper and pencil). Designers handle the unknown and the unpredictable. This property is not one that comes about from poverty of description, but is structural.

For example, this is not a matter of emergence. I have argued (Glanville 1994a) that emergence is a property that derives from the description after the event. In contrast, this is a matter of being surprised and of not quite knowing what will happen, ie involving novelty: which, after the event, may appear describable as emergence.

The Black Box model is a model in which the unknown is accepted and welcomed. Indeed it is the raison-d'etre. It is integral. Of all models, this is the simplest to permit the unknown. And it involves interaction with the observer to make whatever will become known known. (In this it is radically different from such models as chaos, etc, which develop in and of them selves, autogenetically.) The Black Box models the development of some believed in description or statement of what is, through interaction with the observer. Substitute designer and medium (eg paper and pencil), and you have a description of designing which recognises and develops the element of surprise and dealing with the unknown.

This raises a challenge for the computer. Can CAAD act in the manner of paper and pencil, ie as a Black Box, to participate in and encourage the creation of novelty and surprise that so characterise design? (I believe it can, and cover this briefly below.) The cybernetic model of the Black Box not only describes the activity of design, it also challenges us in using CAAD in designing.

Variety, Sharing and Copying

The Law of Requisite Variety tells us, for instance, that the so-called controlling system must have at least as much variety as the controlled system. Very often, this seems not to be possible. For instance, the variety in a teacher's brain is very unlikely to be able to even begin to approach the variety available in a classroom full of scholars (see Robinson 1979).

There are three ways to deal with this (retaining the classroom example). The first, the traditional (military/fascist) way, is to reduce the variety in the classroom. This is familiar from the conventions of the old-fashioned classroom.

The second is to allow some form of mutual control, such as has been practised quite generally in more recent educational strategies in which students form groups and the teacher is a facilitator, observer, friend.

The third is to increase the variety in the teacher's brain.

This latter is the strategy of interest here.

How can this be done?

The architectural studio is an example. You can increase the variety in your brain if you can borrow the brains of others. And this is precisely what happen, at least to some extent, in the architectural studio.[1] The studio is a place where theft is legalised, or, rather, where the notion of ownership of ideas is rejected—as it should be—and replaced with the notions of respect for origination and free access. It is an arrangement where we borrow eachother's creativity. The question is how, with computers, we might arrange something similar.

Conversation

To increase the range of what we can experience, we share. We do this through the form of conversation. Conversation is a circular feedback mutual control mechanism in which all is assumed to be intelligent (Turing teaches us that intelligence is an attribute, not a property). Conversation admits that it will wander (while not becoming unstable). Conversation allows that we will find novelty, that ideas will move from one to another, developing, bifurcating and contradicting. Conversation is a medium in which we treat other participants as partners (that is, we attribute to them the properties we attribute to ourselves). Conversation is open, full of "misunderstanding" and consequent revelation. Conversation is an activity that exactly reflects the process of design, as we experience it.

In a conversation, we need to give to our partners: we have to be open-minded and generous, treating each as a worthwhile and distinct individual, otherwise we cannot hear what they have to offer. In acting this way, we affirm that we have these qualities. Conversation is a mirror: what we see into others is a reflection of ourselves. Thus, conversation affirms our distinction and generosity. It allows—it requires—us to exist as actors who play differently. It is the only model we know to permit communication, that respects the individuals involved.

Design, Cybernetics and CAAD

In the previous sections, a number of observations have been made about how Cybernetics can act as the theory of design, including some that suggest extensions to our understanding of design.

In this final section, I will indicate how some of these findings can drive computing so that CAAD can become much richer, and more capable of generating an improvement in quality of design through positive interaction. I could have told the story the other way round, but it seems

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[1] As noted earlier, Ashby argued that you could increase the intelligence of a person by restricting what he was working on: constant variety applied to a smaller problem space. Others have followed this notion of intelligence amplification. I handling creativity, in contrast, I propose that the problem space be kept as large as is wished: and we borrow the creativity of others.

to me, at the moment, to be potentially more productive to retain CAAD as an extension of design as we see it.

Can we, for instance, use the computer to build an equivalent of the studio: that is, to handle the problem of requisite variety/creativity amplification? Certainly. And we can use it to enhance the studio-like idea, too. If we draw on computers (for instance) and arrange so we can copy (computers are excellent at copying and distributing files), we can vastly widen the range of potential sharing by sending our drawing files to a vast number of other (human) designers/users. At the same time, by examining how users borrow, and what of what's offered them they accept, we can predict—that is, eventually learn to tune the material sent on. Finally, by tracing borrowing, we can return modified work (eg drawings) to original and earlier contributing authors (also learning about whether there are designers whose work seems to be drawn together in the (later) work of others). This also allows us to benefit from being "out of control": that is, from letting ideas come to us through our openness to receive them, rather than through our insistence that we force them from ourselves. We use the computer to make for better communication between (more) human designers, whose creativity thus becomes available to us, while also sending them feedback, enriching them, too. Thus, we benefit from incalculable complexity: and yet we are not lost. We have a way to interact—a model[1].

What about surprise, novelty, and the Black Box? The answer here is yes, too. We can treat the computer as a Black Box (not as a literal electronic Black Box, which probably no one would truly claim to understand, but as something that we develop understandings through interacting with and which we allow to surprise us). One way of putting this is that we stop insisting the computer "goes wrong" and, instead, see if these "errors" are not blessings. Another way is to use the computer in ways other than those apparently intended, usually by software manufacturer. I call this "abuse": using equipment in manners other than those the manuals tell us about, letting them surprise us.

This relates to the idea of the conversation, and the medium/partner. Can we treat CAAD as a medium? To treat it as a medium means to accept it has qualities of its own, that we cannot just say what we want for the medium will form it somehow. In much CAAD computer software the concept of a medium is already inherent, although the descriptive language is that of the tool (a medium is a tool that "kicks back"). We then work with a (human) partner through the medium of computing. But to really accept that CAAD is a medium will involve us in accepting that it changes what we do rather than attempting to command it to do our will. A medium is not a slave: it is already a partner.

At another level, too, we can hope to treat the computer as the literal (and non-human) partner in a conversation: to attribute to it the intelligence to join in developing the conversation itself. This may be a matter of putting

[1] There are associated problems. For instance, the enormous increase in material we face, and the need to order and filter it, is immediately apparent

the "AI" in CAAD: CAAIAD. However, work such as that of Frazer (Frazer 1995) may already be seen as doing this.

To participate in a conversation with the computer means either treating it as the medium of conversation (in which case it will change what we do), or as our conversational partner (in which case it will change what we do), or both (in which case…). It means we stop commanding, and set to listening, to see what's on offer.

There are other possibilities that computation offers through CAAD. We can surprise ourselves with calculations of great complexity that allow us to transform and visualise in ways never previously possible. We can fly through spaces, and one day we may really be able to mould them to our whim, on the fly. We can do things that are beyond us.

The argument given here, and the examples, tie in with the cybernetic understandings I have indicated and are enriched by them. They are imbued by the ideas of surprise, of being out of control (or at least not being fully in control), of openness and gratitude and watching how and where things take us, which I take to be the major attributes of design that differentiate it from other activities (and which make it so centrally human, so much the basis of how we understand ourselves to think, and therefore of our world).

Afterword

I describe just a beginning. I am limited by my imagination and to my imaginings. As I treat the computer more as a partner, it will tell me more of what it can do. More will be on offer, if I am willing to see it. I believe Cybernetics will help here, for Cybernetics and design are opposite sides of the same coin, and Cybernetics does, indeed, illuminate design. And computing.

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