Some Notes on the Impact of Computing on Design

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Introduction Computers have been potentially able to assist designers in their work for almost thirty years. A few pioneers have been using them for this purpose for more than twenty years but it is only in the last seven or so that use has become really widespread. Undoubtedly, the most widespread use of computers in architectural practice is for making production drawings - which they can do with an accuracy, speed and reliability difficult to achieve by manual means. But this use does not even begin to exploit the full possibilities that computer aided design opens up. What 1 want to do here is to introduce these possibilities and discuss what impact they might have on the way we design in the immediate future.

What computers can do First of all we must accept that computers as we know them today can do only three things: they can *compute functions,* that is to say, produce a string of symbols derived from another set they have been given (usually via mathematical calculations); they can *solve problems* (usually by the application of logic or mathematics); and they can *perform simulations,* (that is to say, act in a sense as though they *are* the thing they are simulating.) In all these activities, computers must also be repositories of information which they can use as needed. They do not have intuition, or imagination, or emotion, or judgement or any of those other things which we normally say are essential attributes of a good designer. But the things that they can do potentially give them enormous power as aids to the designer. This is because computing functions, solving problems and performing simulations are fundamental parts of designing and these are things that humans cannot do particularly well. (I will not argue here that these three things are the *only* things necessary to make a good design. Such an argument could, I think, be convincingly made.)

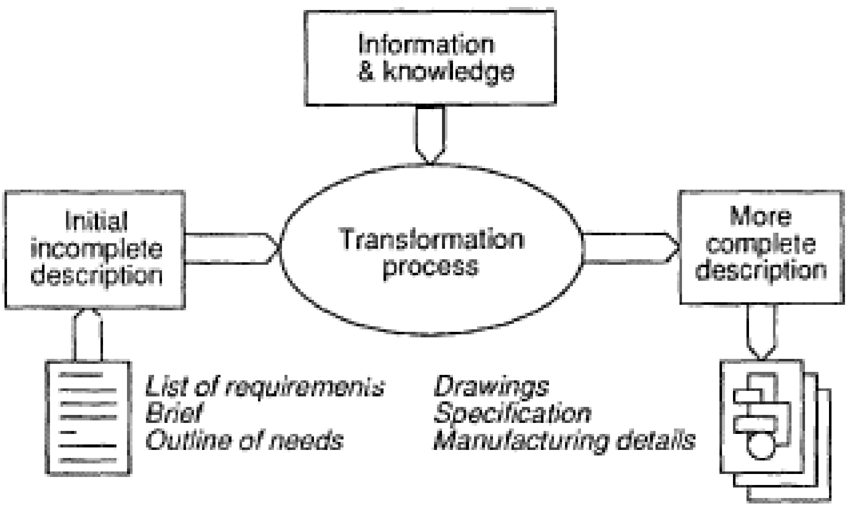

Figure 1. Designing viewed as a process of transformation where an incomplete description of an artefact is progressively changed to a complete one by the use of knowledge and information.

Design as transformation I shall take the view that the object of designing is to create an artefact which is fit for its purpose, easy to maintain, gives value for money, and has a coherent form. The coherence of form is essential to allow the artefact to act as a sign or symbol in addition to its avowed functional role. In order to design we apply knowledge and information to a process of transforming an initial, incomplete description of an artefact into one which is sufficiently complete to enable it to be constructed (Figure 1). What makes designing difficult is that we do not fully understand the nature of this transformation process. Clearly it can be seen to take at least two forms depending on whether, on the one hand, we are designing by means of modifying an existing artefact (as, say, when we make comparatively minor improvements to an existing house plan) or, on the other, working on a new concept.

Robust designing There is a sense in which we can view the first type of transformation as a *continuous* one where we move smoothly from the initial description (a previously complete, but improvable, design) to the final one without having to introduce any new basic concepts. If we plot the progress of "completeness" of such a design through time we would see a continuous curve. This would probably start with slow progress, improving in speed during the middle section and, finally, going back to slow progress at the end as we evaluate and polish our results. Note that the continuity of the line does not mean that there are no cyclic paths in our work: these would certainly come into being as we evaluate each stage in the progression (Figure 2). But, generally, all the movement is forward - because no new concepts are introduced and little inventiveness is needed. This form of designing can be called *robust* because we can usually be assured that, by progressively modifying something that already works, we can arrive at a better outcome.

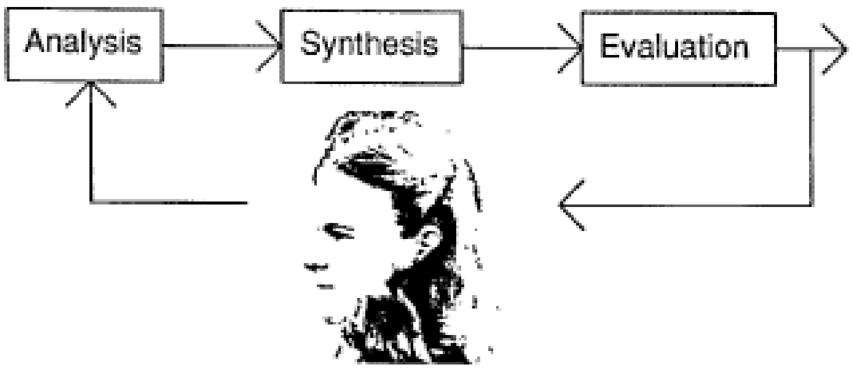

Figure 2. The cyclical process of designing where each concept is progressively refined through use of analysis, synthesis and evaluation.

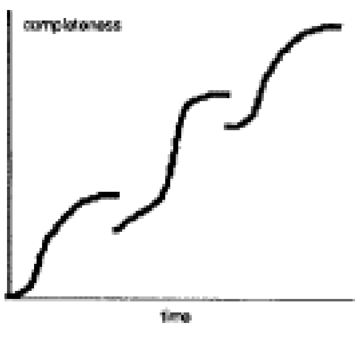

Figure 3. Plotting the progress of a design overtime results in a graph with discontinuities arising where new ideas supplant old and temporarily set back developments.

Brittle designing In contrast to the continuous type of transformation, we can also envisage a *discontinuous* progression. This would represent a form of designing where, as we work, we find that existing concepts give rise to new ones which supplant them and temporarily set back progress. This form of designing can be called *brittle* because we cannot always be sure that what we are doing will arrive at a feasible outcome. In this form of designing, discontinuities would appear in our graph (Figure 3). These represent the setbacks in progress where new ideas supplant the old.

Parametric variation If all designing were of the robust variety we could envisage a way of working with computers that would allow us to progress more quickly and with greater control than we do at present. We can call this *parametric variation.* It arises from the fact the any given design has a number of attributes which fully describe it and serve to distinguish it from all others. These attributes include its dimensions, shape, material, and colour as well as its performance characteristics such as strength, thermal response and so on. The attributes are not, of course, independent of one another. Indeed they are highly interrelated - but usually in a predictable way. By expressing these attributes as changeable parameters in a computer model which takes into account their interrelationships, we can simulate aspects of the behaviour of the design and use these to home in on further improvements. To be useful the models must not only express the interrelationships between attributes but also any constraints that limit the values of the parameters (although, the possibility of arriving at new ideas by relaxing constraints and ignoring interrelationships should not be overlooked.)

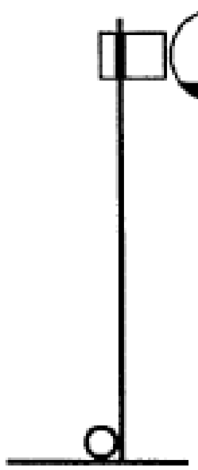

Figure 4. Rietveld's 1924 table lamp (from a copy in the Museum of Modern Art, New York)

Parametric variation: an example At the simplest level, we can work just with dimensional variations and constraints. To illustrate this approach let us take an existing 1924 design for a table lamp by Gerrit Rietveld (Figure 4), abstract its basic dimensional relationships and place constraints on certain sizes - the size of the globe should not be too small to house a lightbulb, the height should not exceed a certain amount and so on. Then, by varying some of the parameters, we can obtain a set of related designs which have a similar 'feel' to the original but are different from it - as in the case of a musical theme and variations (Figure 5). Furthermore, providing our model has taken into account au the necessary interrelationships - such as the sizes and weights necessary for proper strength and balance and so on - we can be sure that we have a collection of feasible and robust designs. The procedure we use to make the parametric variations can either be systematic or governed by our intuition. In either case, the method is ideally suited to computer working but difficult to do properly by hand.

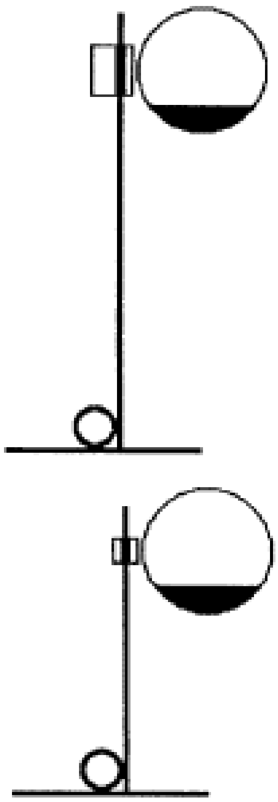

Figure 5. Two variations on Rietveld's lamp using a program which maintains relationships whilst allowing changes in dimension.

Functional parametric variation This approach to designing is not, of course, limited to variations which affect appearance: any aspect of performance can be similarly treated. Clearly, not all parametric changes have equal effects on the outcome. But, in complex cases such as exist in most architectural design situations, it is not normally easy to predict in advance which will have the most crucial effects on the result. Hence, in manual designing, a lot of time can be spent fine-tuning attributes which have no real impact on the performance of the final design. By using functional parametric variation to investigate and appraise design options systematically, designers are able more readily to identify the important factors in a design and the causal relationship between certain crucial parameters and performance. And this has an added bonus. Contrary to early fears of designers who thought that the introduction of computers would prevent them incorporating intuitive and aesthetic ideas into their projects, the use of this tool focusses increased attention on subjective value judgements. As objective and rneasurable aspects of performance are made more explicit, the necessary value judgements are forced to the surface of design activity and thereby themselves become more explicit. The result of this is to make clear to designers and their clients which judgements are based on qualitative criteria and which on subjective and intuitive concepts. Designing can only be improved by this clarification.

Limits to parametric variation Although it is always possible to create a parametric model of any design after it has been formulated, it does not seem possible *a priori* to setup a *generalised* model which possesses all the parameters needed for any arbitrary design. Thus, in the case of the Rietveld lamp, the parametric model does not have the necessary parameters to turn it into, say, an Anglepoise lamp no matter what variations are made. Thus, in the form that it has been explained, parametric variation is more suited to robust rather than to brittle designing.

The unified nature of designing But, during designing few of us are aware of the distinction between between the two forms and would not know, from moment to moment, which technique was being used. Two reasons for this are possible: one, that the distinction between the two forms does not really exist (at least in the form outlined); and two, that all designing is a form of parametric variation.

The catastrophe theory metaphor We can see illustrate the first possibility if, rather than seeing the two graphs (brittle and robust) as separate, we take a metaphor from the branch of mathematics known as 'catastrophe theory' and assume that we are looking at two 2-D cross-sections of a 3-D folded surface (Figure 6). The 3-D graph of this surface has, as two of its axes, time and completeness with its third axis represents 'inventiveness'. The more inventive and brittle designs are furthest away from the time completeness plane. If this is an appropriate metaphor, the implication is that a particular outcome can be reached either by a brittle route or by a robust one and that designing consists of finding the most effective routes in a particular case.

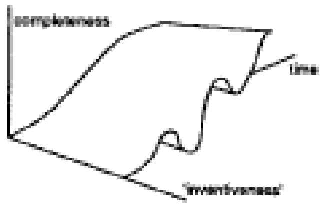

Figure 6. A 3-D catastrophe surface. The most 'inventive' routes to a concept lie on the folded part of the surface.

Prototype modification There is a large amount of evidence that suggests that, when confronted by a problem, experienced designers work from a set of *pre-solutions,* that is, proposals which are known to have value in certain situations. This has led me to suggest elsewhere that these pre-solutions are best seen as *conceptual prototypes* which are sufficiently general as to be widely applicable and sufficiently particular as to be clearly appropriate to the matter in hand. The implication of this is that, to be as useful in the early stages of designing as drafting systems are in the later stages, CAD systems will need to have mechanisms for incorporating, displaying and easily modifying these conceptual prototypes. My presentation will suggest some of the ways in which this might be done.

References

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