ETHICS IN COMPUTER-AIDED DESIGN: A POLEMIC*

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ABSTRACT

It is one of the difficulties of the scientific approach to problem solving
that the variables need to be defined at the beginning of the investigation.
This is further exacerbated when computer based techniques are applied because
of the need to define variables explicitly. Current problem solving is
directed to handling only well defined problems in which certain variables
are assumed to be exogenous - the educational system schools people in methods
for manipulating problems at this level. It appears that computer-aided design
systems, in general, have not been able to incorporate any adequate value
systems within them nor have they been able to provide a means of examining
the problem in an ethos borader than the one defined at the outset. Both of
these difficulties are considered within the ambit of ethics. It is suggested
that subjective value systems can be easily incorporated with the use of
interactive computing but that the 'ethics of the whole system' present a
thornier problem.

INTRODUCTION

The gods did not reveal, from the beginning,
All things to use; but in the course of time,
Through seeking, men find that which is better.

But as for certain truth, no man has known it,
Nor will he know it; neither of the gods,
Nor yet of all the things of which I speak.
And even if by chance he were to utter
The final truth, he himself would not know it;
For all is but a woven web of guesses.

                                        - XENOPHANES

It is not the intention of this paper to present either a treatise on ethics
or on computer-aided design but rather to set forth some notions on the relation
between the two. The aim in presenting them is to provoke discussion about an
area, that those involved in developing the panoply of systems which can be
classified under the umbrella of computer-aided design, tend to forget and
neglect.

The rapid development of computers and the parallel growth in the mathematical techniques which are grouped under 'systems analysis and design' have resulted in a symbiotic relationship between the two within the context being considered here. If one takes the idea that one of the fruitful uses of computers is to have them manipulate models, then it seems reasonable to inquire about these models. Models may be deemed to be of three types:

    (i)   descriptive
   (ii)   predictive
  (iii)   prescriptive

Computer manipulatible models tend to be predictive in nature when the system is thought of as performing a simulation of the situation being modelled and are sometimes represented as prescriptive when the system is thought of as performing an optimization based on a defined objective. It is argued that simulation models tell you what will happen for a given set of conditions whilst it is further argued that optimization tells you what conditions are needed if some future situation is to occur. Neither of these two statements is an adequate description.

Fundamental to systems analysis is the idea of a subsystem: "there is a tradition in Western thought that parts of the whole system can be studied and improved more or less in isolation from the rest of the system" (1). It is common to listen to learned papers at conferences which commence with statements limiting the scope of the problem being considered. And then, at the end of the paper, the author concludes that he has now solved the problem without putting it back into its original context; without testing the validity of defining certain variables as being endogenous and others exogenous. Ultimately all variables must be endogenous. It is one of the difficulties of the scientific approach to problem solving that the variables have to be defined at the commencement of an investigation. This is further exacerbated when one wishes to apply computer based techniques because of the need to be able to define variables explicitly. In conversation one does not do this, even in philosophical analysis that is not a necessary condition - "the common confusion that makes people think they cannot understand an idea unless then can define it, forgetting that ideas are defined by other ideas, which must be already understood if the definition is to convey any meaning" (2). It is pertinent to ask why we seem to be able to manipulate subsystems with a relatively high degree of success when they are well bounded but fail when they are not.

Before attempting to answer this question, examine a hierarchy of decision-making in design in descending order of difficulty:

    (i)   recognition of problem
   (ii)   definition of problem
  (iii)   solution of defined problem
   (iv)   implementation of solution

(This dissection is not meant to intimate that each of these can be isolated from the others). A large part of the education of architects and engineers

is directed towards the solution of defined problems. The tools which have
been developed as part of a problem-solver's kit comprise largely techniques
for handling area (iii) above; this is more apparent in engineering education
than in architectural education but the same applies there also. Design problems
in structural engineering education are often presented in the form:

> Given a set of loading conditions and a structural type 'design' the
> members to satisfy specified criteria.

This is an elementary subsystem of structural engineering design. Less frequently,
the bounds of the defined problem are expanded so that the design problem may be
presented in the form:

> Given a set of loading conditions and a gap to be spanned 'design' a
> suitable structure to satisfy specified criteria.

It is hard to imagine an engineering school where exogenous variables as defined
by the instructors would be open to conversion to endogenous variables by the
student. In architecture schools, design problems are set up in a similar way
with the significant difference that criteria against which solutions may be
evaluated are not always specified.

Why is it that design education appears to be much more involved with the 'easier'
area of solutions of defined problems within well expressed bounds? The reason
can simply be expressed using the analogy of the apocryphal story of the man
who loses his car keys during the evening and spends the night looking for them
under the lamp-post not because that is where he lost them but because that is
where the light is: as Goethe said "Light, more light". Problem recognition
and problem definition are difficult to teach, therefore, they are not taught
although the definition of a problem affects its solution, but this feedback
loop is ignored.

COMPUTER-AIDED DESIGN

Computer-aided design systems are rarely set up to emulate the human designer,
rather they tend to utilize techniques which require computational capabilities
not exhibited by humans. But, at their current level of development, they are
set up to perform the decision-making in the well defined, bounded design
problem with specified criteria. This should not be surprising in light of the
above discussion. The boundaries of the design problem in computer-aided design
systems need to be fixed in some manner before the system can be operated. The
dictum 'if it cannot be computed, it cannot be included', is followed with
religious fervor although all such systems are often set up with numerous
non-compatible assumptions which are rarely, if ever, examined once made. More
often than not, these assumptions are not stated, either through a disregard of
them or because they are not thought pertinent to the problem: "many mathematicians
who lack sufficient ... training may jump to the erroneous conclusion that no
assumption is needed of no assumption is stated". (3).

This appears to be the crux of one of the fundamental difficulties of computer-aided design: in order to manipulate the problem with a particular set of tools, the problem is so constrained that it allows no feedback to the ethos from which it was extracted. No automated computer-aided design system provides the opportunity for examining the context and hence it will likely fail to solve the problem within any broader context than that defined by the exogenous parameters to that particular system, even though those exogenous parameters are endogenous variables for a somewhat larger problem.

Added to this difficulty is that fact that we appear to have only inadequate tools to handle the problem in its broader context (4,5), which undoubtedly accounts for the reason why computer-aided design systems fail to attempt to handle them.

Well-defined problems generally involve some value judgments in their formulation (definition) and, in part, it is this that adds to the difficulty of developing suitable algorithmic approaches to assist in their manipulation: "It is a fallacy to disregard criteria which involve value judgments as unscientific under all circumstances. There is a place for such value judgments and a need for them though this may not fit the prejudices of the promoters of the quantitative method as the only true scientific method" (6). Obviously, value judgments are made by individuals and groups as a matter of course in everyday life and there are areas in economics which aim at providing external measures of value - however, this continues to remain a thorny problem (7,8).

It would appear from the current state-of-the-art (9) of computer-aided design based on systems analysis that it has not been able to provide a satisfactory method of incorporating an adequate value system within itself nor been able to provide a means of examining the problem in an ethos broader than the one defined at the outset of the problem solution phase. Attempts to do so within the strict notions of scientific systems analysis have failed, possibly because those techniques are either inappropriate or inadequately developed: "if the only tool you have is a hammer, it is tempting to treat everything as if it were a nail" (10). Should it be inferred from this that systems analysis and the scientific approach are not just inadequate but need to be thrown over?

ETHICS IN COMPUTER-AIDED DESIGN

Both of these objections fall within the ambit of ethics because when one talks about subjective values one needs to entertain the notions of good and bad. When one talks about a problem within its ethos one needs also to entertain the notions of good and bad. "Every art and every enquiry, and similarly every action and pursuit, is thought to aim at some good; and for this reason the good has rightly been declared to be that at which all things aim" (11). "The problem of system improvement (as opposed to subsystem improvement) is the problem of the 'ethics of the whole system'. In some sense this use of the term 'ethics' may seem unusual, because ethics is a term often used to connote concepts of good and

bad with respect to individual conduct. Indeed, in ordinary discourse the basic underlying notion behind discussions of ethics is closely related to blame and praise ... Now, of course, the discussion of individual behavior does properly belong under the theme described here as the ethics of large-scale systems ... We could therefore sensibly ask whether an individual might have lived his life in a better way than he did, given the resources made available to him by the whole system. The point, however, is that we cannot judge improvement in an individual unless we have an understanding of the nature of the whole system in which the individual lives" (12).

Unfortunately, there is little in our educational system to equip us to handle ethical problems which arise when one takes the results of well-defined problems and attempts to examine them within the ethos from which the problem was extracted. Certainly, there are no algorithms available which would allow us to automate this class of decision-making. Western civilizations appear to have devolved ethical decision-making onto politicians who seem to be rather inadequately equipped to be the specialist in this area -- something which has bothered man for many centuries: "I want to know what is characteristic of piety which makes all actions pious ... that I may have it to turn to, and to use as a standard whereby to judge your actions and those of other men" (13).

Where does this leave systems analysis and computer-aided design? Should they be pushed aside because they are unable to perform in certain ways, and if so, what is to replace them? The advantage of systems analysis is that it takes care of the 'arithmetic' of a particular phase in problem solving, namely, that of examining the effects of changing values of variables within a bounded area and doing so in ways in which the human mind cannot compete. What comes out of this is not 'the solution' but something quite different: the results of this process build up the experience of the system user and hence allow him to learn at considerably less expense than trying to do the same in reality, rather than with some model. It has been argued that what can be handled this way are not the difficult problems (5), but this does not compromise the integrity of the approach. Rather what is needed is some procedure whereby the well-defined problem and its manipulations can be put back into the original value system and hence its original context so that the ethical decisions can be made. So far, only man seems to be able to make these decisions, hence, the need arises to include man in a computer-aided design system.

Computer technology has provided means whereby this may be partially achieved through the use of interactive computing. The use of interaction alleviates one of the earlier objections for it allows the computer-aided design system user, whether he is a professional or lay 'designer' to include his own subjective value system as part of the evaluation (14). Obviously, the level of interaction would need to be much greater than currently offered through the use of existing interactive languages (15).

The difficulty of deciding how to define the boundary of problems and then to allow exogenously defined parameters to become endogenous, particularly when they have only been implicitly defined is not assuaged through the use of

interaction. A number of avenues have been investigated with varying degrees
of success (16); dialectics seems to be one fruitful possibility (17) although
it works better in Marxist societies. The difficulty is in explicating the
Weltanschauung of the model builder - we are all limited by our imaginations
and are bound by our experiences and what we have learned - "the fact that our
knowledge can only be finite, while our ignorance must necessarily be infinite" (18).

Ethics provides the boundary for any model, the challenge, therefore, is to
develop procedures whereby models can be built to that boundary. Every model
built within that boundary tells something about the set contained within that
model but nothing about things beyond it. Popper, in talking about knowledge
generally raises the ethos problem: "The traditional systems of epistomology
may be said to result from yes-answers and no-answers to questions about the
sources of our knowledge. They never challenge these questions, or dispute
their legitimacy". The value of computer-aided design systems lies in their
abilities to manipulate well-defined problems without having to worry about
the 'arithmetic'; with the results of such manipulations one can test hypotheses
and learn more about ourselves and our world without necessarily being able to
solve all ethical problems in this manner.

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