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MEN OR MACHINES: THINKING OR DOING

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ABSTRACT

The 'men or machines' alternative is a highly emotive one. There seems to be some justification in tipping the scales in favour of men being responsible where a task involves thinking, but less so where a task involves doing. This paper considers AI in design and robotics in construction as two distinct problems. It suggests that robotics in construction offers the better, more immediate return on research effort. Further, that it needs also to distance itself from the many issues currently being raised in AI which remain of little or no relevance to robotics.

1. Introduction

I was asked recently to review a published collection of the papers from the Joint International Conference on CAD and Robotics in Architecture and Construction held at Marseilles, June 1986(1). That collection of papers highlighted what, for me, was a rather apparent distinction between research in CAD and research in robotics.

Research in CAD, particularly where it deals with AI in the architectural context, has progressed over a number of years and targets considerable effort on such fundamental issues as overt knowledge, formalisms and models of design. Many learned papers actually pose as many basic questions as do they offer solutions to immediate problems. This is a healthy research environment and reflects the maturity of the discipline.

Research in robotics, much more so even than with Expert Systems and other 'high profile' aspects of CAD research, is inclined to focus on the most immediate issues: man and robot interfaces on site, the mechanics of a robot, the sensing and navigation characteristics of motions, for example. Fundamental social and moral questions appear not to be considered separately, and increasingly robotics is being perceived as a mere adjunct to AI research, sharing the same basic problems.

This sharing has the advantage of leaving robotics researchers free to concentrate on the development and implementation of work which brings the most immediate and visible results. It may in the long term however, disbenefit robotics research to be associated with the increasing number of difficult questions raised by research in AI. Questions which in fact have little or no relevance to robotics.

This paper will return to some of the basic issues in AI research, particularly with AI in architectural CAD, and try to relate those issues to robotics.

A conclusion is reached that suggests robotics research offers the more attractive target for research funding in terms of immediate gain, because many of the fundamental issues which plague AI are largely irrelevant to robotics. That of course is not to suggest that robotics is either the more interesting, nor the better long term investment.

2. Artificial Intelligence and Human Design

A common ambition of most research in the field of AI is to seek some formalised means of representing or displaying human intelligence. Thus it embraces a wide and often conflicting set of assumptions about the degree to which human intelligence potentially can or can not be replaced using computational processes. Its aim varies from the one extreme of intending machines effectively to replace people (so-called 'hard AI'), through an intention merely to 'support' human actions, to the other extreme of using computational processes to do no more than illuminate our understanding of what actually constitutes human intelligence (the so-called 'soft AI').

Distinctions between one extreme and the other are not well defined, and cause problems in relating AI to a process such as design. Design itself is poorly defined, and can be viewed from such a variety of perspectives that AI and human design can alternatively be considered as extremely well and extremely badly matched. Thus it is necessary to explore some basic assumptions about design, before looking at and then comparing it with AI.

2.1 Design Method

There is, at this time, no universally accepted description of what actually constitutes architectural design. The closest thing to consensus came in the late 70's, following a considerable swing between those who saw design as a quantitative process and those who believed it demanded a much more qualitative, human input.

The design activity was typically characterised by a process of analysis, synthesis, and appraisal (See Figure 1).

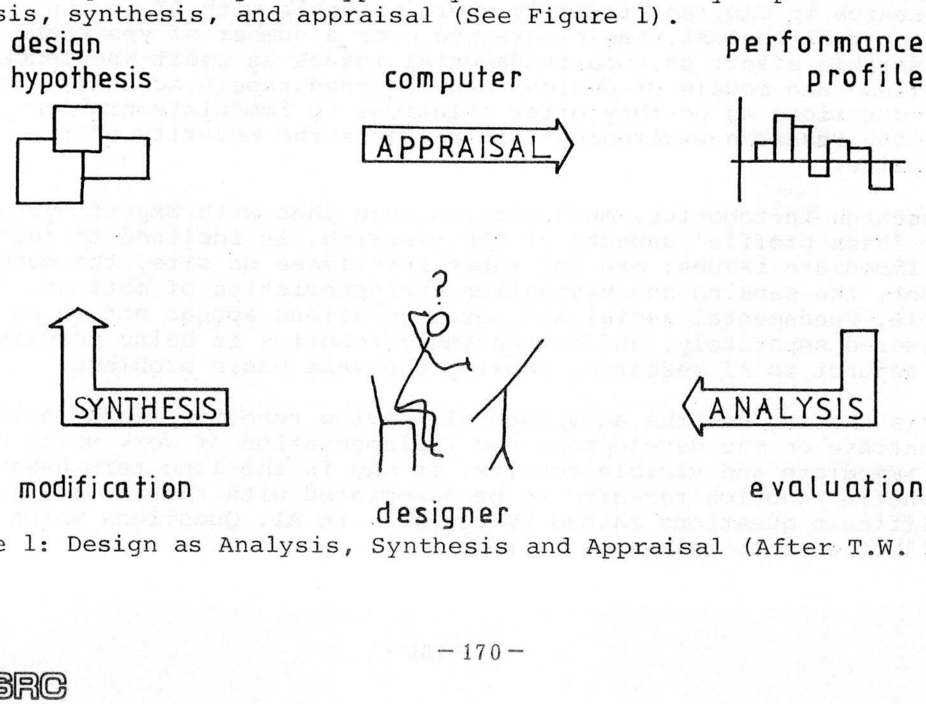

Figure 1: Design as Analysis, Synthesis and Appraisal (After T.W. Maver)

It was seen as involving the designer in generating a design proposal or hypothesis which could be evaluated and appraised on a range of cost and performance criteria. The designer would then analyse the implications of a given design hypothesis and regenerate a further, modified proposal. Thus design was seen as a cyclical, iterative process: analysis, synthesis, appraisal; generation and evaluation; induction, abduction, deduction; conjectures and refutations; depending considerably on the terminology used.

This paper will follow the lead of a number of authors (Bijl(2), Powell(3)) who consider design specifically in terms of the individuals own interpretation, manipulation and expression of designerly thought. Design is taken to be something learned through experience, where decisions intuitively accompany problem exploration, and can progress without the need for calculation(4).

> "We can choose to look upon design as something people do. Designed artifacts, the products of designing, are interesting only insofar as they tell us something about design. An extreme expression of this position is to say that the world of design is the thoughts in the heads of designers, plus the skills of designers in externalising their thoughts; designed artifacts, once perceived and accepted into the worlds of other people, are no longer part of the world of design".(5)

The suggestion made here then, is that design effectively revolves around an individuals inherent capacity to give form and understanding to a problem. The best that can be done to 'assist' design is thus to 'inform' designers. Inform, in the sense that seeks to enable designers to give their own concrete and self-reflective form to the relevant concepts, ideas and data presented to them. It is not sufficient in design merely to produce data, just as it is not sufficient merely to produce the knowledge which relates and composes that data, and not sufficient merely to produce the models which animate design knowledge. In addition to all of these things it is necessary to promote understanding, because only when understood and forming part of the models in a designers head, will the data, knowledge and models truly affect design.

2.2 Formalisms in AI

AI is founded on the notion of a formalism. This term refers to any abstract description of how human knowledge is represented and manipulated. The most common AI formalism is the so-called 'production rule', which currently dominates the field of Expert Systems.

For example, a typical format might be expressed as: IF a particular set of conditions, THEN a given conclusion/action. This representation is used to express the data and inter-relationships between data which comprise the 'knowledge base' for some discrete problem definition. A 'shell' or interpreter can then drive the knowledge base to act 'intelligently' in its dialogue with the user. Depending on the particular characteristics of a given shell, the system will respond to a query from the user by trying to match a required conclusion/action against those in its knowledge base. A test is then made on the set of conditions provided, to establish the truth of that conclusion/action, where each condition itself is treated as a quasi-query, recursively.

The production rule format is far from the only formalism applied to AI, however, it is the notion of a formalism itself which raises many of the fundamental questions increasingly clouding AI research. Demanding that knowledge be expressed overtly, external to the human mind, denies the intuitive, biological nature of human thought. It has become important therefore to distinguish between knowledge which can be made explicit, and knowledge which can not. Currently AI is limited to dealing with overt knowledge, and this places significant limitations on the role AI can play in any particular situation.

It is suggested that a balance exists between the usefulness of AI techniques applied to a given problem situation, and the effectiveness with which the necessary knowledge can be made explicit. Thus it is not a question of whether AI has any utility in contributing to the understanding of problem situations in general, but of how fully it can address a problem situation in some particular instance. Neither is it a question of the amount of knowledge being captured, but rather whether that knowledge is critical to the problem solving process.

2.3 The Role of AI in Design

Accepting the brief description of design given above, and recognising the limitations of AI at least in terms of formalisms, what role is there for AI in design? The suggestion would have to be that it is not simply a matter of setting a computer system to function as a human advisor might. The human advisor performs a richer process than we can achieve in AI currently, and in design particularly that difference is critical.

This is not to say that overt knowledge has no relevance to design. Overt knowledge after all is the measure of our capacity to express, and thereby to begin to communicate, understanding. The shortfall basically demands that AI be viewed as no more than an additional means of communicating information. Its role in design is not direct therefore, and is largely governed by our appreciation of various other aspects of design, such as how best to communicate and what actually constitutes acceptable design practice. The pay back from AI research in design may prove significant, but it is unlikely to be manifest in the short term.

3. Robotics and Construction

The development and use of robots in construction is being fueled by a tripartite need to increase productivity, improve the quality of the end product and reduce the dangers to which human operatives are currently exposed. Despite numerous successes in other industries however, the robot is yet to be widely established in construction. This failure is unquestionably due largely to the particular nature of construction work, when compared for example with motor car manufacture and the assembly of household appliances.

3.1 The construction Process

What distinguishes construction from 'factory-based' manufacturing industries, is its apparent absence of any set pattern or structure. On a building site the scale of work, the problems with mobility, the range of tasks to be performed and harshness of the environment, each place particular demands on the sensing and mobility of the robot. It is extremely difficult to extract a structure from the activities which go into a construction process, and even more so to impose structure through design(6). So it is that, whilst construction ultimately is just about the assembly of components, issues of sensing and mobility are technologically much more limiting factors than in other assembly processes. Further, because construction consists of complex and concurrent activities, the need for multiple and cooperative robot systems is also more acute. The notion of multiple robots raises problems of control and interfacing between robots.

In fact several categories of robot should be distinguished, with each having a different potential in construction. For example, they range from basic teleoperated robots (still under human control), through programmed robots (performing predictable and invariant tasks), to cognitive robots (which act to achieve tasks without human supervision or pre-programming). The construction process is such that the immediate applications have come in terms of teleoperated robots, functioning in particularly hazardous situations. However, it is often difficult to distinguish between teleoperated robots and more conventional technologies, so that the real awareness of the potential benefits from robots has come with the successful introduction of programmed robots.

3.2 The Role of Robotics

Construction is significantly different to most other manufacturing processes, and offers a fundamentally different role for robotics. Principally, this difference makes many of the features considered desirable in other industries, essential within the context of construction. Mobility, sensing and control, for example, each impose strict technological limitations on the progress being made in developing robot applications for construction. Given these critical limitations, where construction robots remain largely infeasible until basic technological problems are overcome, concern with cognitive robot development would appear considerably misplaced.

The role for robotics in construction is therefore to address the principal technological problems. The more fundamental issues raised by cognitive robots and AI more generally are largely irrelevant to construction at this point in time. The technological problems are not trivial. They do however relate to tangible tasks with firm measures of performance: the depth of fireproofing spray, the consistency of level in concrete finishing, the accuracy of a weld, and so on. The success of a programmed robot can be readily established because it is measured in terms of the end product.

4. AI and Robotics - Some Observations

It is always difficult in a discipline such as design or construction, which has little universally accepted theoretical basis, to draw firm conclusions. This paper has adopted a particular view of design, construction, AI and robotics which could justifiably be questioned in many respects. However, if design is accepted as something occuring inside peoples heads; if AI is limited by formalisms which manipulate only overt knowledge; if construction is devoid of structure; and, if robotics deals principally with technological problems (at least within the context of construction), then a number of observations can be made.

(i) The role of AI is not direct. In the extreme, it is as unreasonable to use an Expert System in place of a human advisor as it is to use a cardboard cut-out. The cardboard cut-out may communicate certain things to the design decision-maker, as might the Expert System. It is the communication process however which has the direct effect, and not AI or pictures per se. AI might ultimately provide a highly significant insight into design (and I would venture to suggest that it is very likely to do just that), but that insight will be dispersed in the short term.

(ii) The role of robotics in construction is to address technological problems. Compared to design where cost, aesthetics, function, comfort and many other disparate criteria make establishing success almost impossible, construction often has a clear measure of performance - quality, time, quantity. Technological problems are inevitably more attractive to those who fund research in construction.

(iii) Given the criticality of technological problems in robot developments for construction, the more fundamental issues of cognitive modelling and AI more generally, become increasingly irrelevant. Robotics research in construction should seek to distance itself from the considerable (and for robotics, stifling) number of basic issues now springing from AI research.

(iv) When AI and robotics are considered in terms of a 'men or machines' alternative, a significant distinction would seem to hold between those tasks involving thinking and those involving doing. Design is a thinking problem where the scales might reasonably tip in favour of men being responsible. Construction is more concerned with doing, and surely offers considerably more potential for machines to compete effectively.

5. Acknowledgements

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