TOWARDS A THINKING MACHINE

Edward Ihnatowicz

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A great deal of discussion among computer-artists is centred around the question of whether the computer should be treated as a tool or as a medium, with some purists insisting that the term 'computer-art' should be reserved for the latter. The distinction may appear arbitrary, but it is in fact important because it distinguishes those artists whose inspiration comes from outside the world of computing and who use the computer simply for convenience from those whose ideas have originated as a result of computing experience.

My own involvement with computing began very much as a matter of convenience with a large, mobile sculpture being half completed before the possibility of using a computer was even considered, but the resulting experience has left me thoroughly entrenched in the computing field and apt to regard any present-day artist unfamiliar with computers with some concern!

The sculpture in question was built for Philips, the electrical firm, for their permanent technological exhibition in Eindhoven, Holland, and was called the Senster. It was completed in 1971 and took three years to build. It consisted of a sensing head comprising a moving array of microphones and two close-range radar transceivers borne on the end of a 15 foot long, articulated arm, powered by electro-hydraulics and controlled by a computer. The computer provided the machine with a certain behaviour pattern which on the lowest level tried to determine the location of any sound in the vicinity as well as the presence of any rapid physical movement and then to use this information to generate a movement of the whole structure. If the sound was persistent and below a certain intensity the movement was towards the sound, or away from it if it was too loud or accompanied by any violent gestures. This simple strategy resulted, nevertheless, in a very complex behaviour due partly to the complicated acoustics of the exhibition building and partly to the behaviour of the visitors who frequently surrounded the exhibit in large numbers and in the case of the younger ones, with a sustained din. The atmosphere around the sculpture was much more like that of a zoo than an art exhibition and I am sure that the majority of visitors would have been surprised to learn that the constructor of this machine had any pretensions to being an artist.

They may well have been right, since the title of an artist is an accolade rather than a qualification, but certainly my aims were artistic, as is my background. I had a standard art-school education (Ruskin-Oxford) and any technology I know is entirely self-taught and merely sufficient to carry out my designs. The involvement of artists in science and technology is not a new phenomenon since artists, like scientists, have been traditionally involved in investigations of nature, or more specifically, those aspects of nature which the current technology accessible.

Speculation on the general question of what distinguishes the artistic approach from the scientific one are seldom profitable but perhaps a very personal view of such a distinction is worth making in view of the very technological nature of my work.

The scientists, it seems to me, tend to view the world as a vast, natural system, operating according to absolute and immutable laws which they try to discover by measurement and deduction, and they consider their own existence in it as being of no consequence. They are aware of the fact that all our knowledge is reducible to explanations of relationships within a floating frame of reference and are concerned about the difficulty of establishing a firm datum. In contrast, the essence of the artistic approach is to accept oneself as the only reference point and instead of explaining the world, to demonstrate the way in which it appears to one. This is not to say that such an attitude is a conscious one and that it exists at all is only an assumption. It is borne out, however, by the ease with which the work of most of the artists of the past can be accurately placed within its period and locality and even attributed to a specific person. It would seem that the artist acts here like a kind of anthropomorphic filter, choosing from the infinite number of possible aspects of reality those currently accepted as 'normal' with, perhaps, the individual deviations which at one and the same time identify him and constitute, often, his chief contribution This 'normal' view of reality changes continually and is, of course, frequently affected by the current scientific and technological preoccupations and discoveries and thus is easily detectable in the contemporary art. Consider, for example, the impact on art of the discovery of perspective, printing, photography or the Newtonian theory of colour.

At the present time the effect of digital computing on our appreciation of nature is of fundamental importance and the area where the possibilities it offers are, to me, the most exciting is that of a better understanding of natural methods of control or development, growth, movement and behaviour in plants, animals and ourselves. The techniques of digital programming have greatly increased our appreciation of natural shapes and processes because instead of merely marvelling at their complexity, beauty or functionality, we are now in a position to consider the methods and techniques employed by nature in their generation. The popularity of Conway's Life game reflects this interest, as do many programmes written to generate shapes reminiscent of trees, plants and flowers.

Even more intriguing is the possibility of investigating and simulating the behaviour of complete systems, both natural and artificial and their responses to changing environments because this leads us directly into the realm of perception which, to my mind, is the central problem of intelligent life.

A great deal has been said about the research field known as artificial intelligence, most of it uncomplimentary and deservedly so in view of the many exaggerated claims and unfulfilled promises; nevertheless the understanding of understanding must remain one of the most inspiring goals of our civilization. This is a very new and uncharted area and many claims have been laid there by such scientific disciplines as neurology, psychology linguistics, statistics and various computer sciences, to the point where the ambitions of any artists to enter the field may appear forlorn, if not actually presumptuous. The fact is, however, that no one has yet proved the suitability of any particular discipline for this type of investigation and, in view of the paucity of practical results, the game must be considered still open.

I should like to put forward a, no doubt biased, view of the difficulties which a purely scientific approach produces. The difficulties are to a large extent semantic in nature and have to do with the fact that scientists are fond of definitions, and that there are no satisfactory definitions for any of the relevant notions. Notions such as earning, perception, image, memory, cognition, knowledge, not to mention intelligence itself, are not in any absolute sense definable because they are all descriptions of relationships and attributes of natural systems and their environments. They can be demonstrated and appreciated more easily than defined or proved. If we can accept that a possible way of approaching the problem of cognition is through the study of the behaviour of artificial systems capable of simulating natural behaviour, then we must admit that there are very few guide lines for the design of such systems. Under such conditions it is at least possible that an artist's open-ended, pragmatic approach may be of value.

What I am suggesting here is that even if we cannot describe intelligence we can certainly recognize intelligent behaviour and that the characteristics of such behaviour are such as to make them, in theory at least, demonstrable in an artificial system.

There is a commonly held view that even if the use of models of cognitive systems is a necessity, their actual, physical construction is not, since any such model can be adequately simulated in a computer. If accepted, such an argument would seriously undermine the usefulness of the proposed artistic approach since it is especially in the area of design and construction of physical shapes and control and interpretation of physical movement that the intuitive approach might be expected to be of value. Computer simulation has a serious drawback, however, in that it neglects the possibility of interpretation of sensory data by means of physical, i.e.. mechanical interaction, and there are good reasons for believing that such an inter action is the key element in the process of perception. It is difficult, in fact, to talk about the process of perception and quite impossible to demonstrate it without reference to some physical system, since the perception we are talking about is not the perception of abstract notions but of physical entities; it is clearly impossible to demonstrate an awareness of a physical entity within a purely conceptual model.

Perception can be thought of as the process by which any cognitive system, natural or artificial, is informed about the state of its environment, It is not a measurable quantity and its existence in any system can only be established by an evaluation of its responses to the changes in that environment. Such responses are easiest to detect if they take the form of mechanical motion and this is one argument for construction of mechanical models. Another, and a more important one is that physical motion may be, in any case, a prerequisite of perception.

If we consider the possibilities of artificial simulation of perception, then a technique of measurement or comparison is a likely elementary candidate. This is because to perceive is to become aware of some property like size, colour, temperature or weight of some object or part of the environment or of the entire environment and this is only possible if this property undergoes a perceptible change or if another example of it is available. (If all the objects we ever saw were coloured blue we should not be aware of that fact.) Differences

must be measurable and thus the process of perception is basically one of measurement or comparison. The problem is vastly more complex, of course, but the concept of comparison is a useful one because it raises the question of natural standards for what is to be considered normal. An autonomous artificial system should not have to rely on pre-programmed or hard-wired standards but be capable of establishing them independently. In such a case the only immutable standards available to it are some aspects of its own structure. It is conceivable, for instance, that a system capable of moving itself bodily and of sensing the force exerted in the process might be capable of forming a notion of weight by comparing this force with that required to, say, remove an obstacle. Similarly, a concept of length could be established by noting the distance travelled or the range of movement of a limb.

Conceptualization is, of course, another problem but it can be thought of in a similar way and considered as the result of correlation of two or more types of perception relating to the same object or entity. If, for example, a system can establish a definite correspondence between a set of visual data and a set of tactile data, a possibility exists of formulating a concept or an idea of the object to which these data appertain. Visual and mechanical perceptions are eminently suited to this role because they overlap in the all-important area of spatial and kinematic characteristics. Visual sensing informs us in addition about the optical properties such as colour and transparency while the mechanical one about mass and dynamics, but both can inform us about sizes, shapes and movements of the same objects. In this way a concept can be seen to be not merely a perceptual record, but a means of complementing sensory data so that, for instance, an image of a known object may be elicited from its tactile exploration.

The important practical conclusion that can be drawn from such considerations is that the most basic type of properties that any cognitive system must be capable of perceiving is the mechanical one since it is through the consideration of the mechanical attributes that objects are most readily distinguished. The perception of visual images which is the most common form of perception we think of would seem to be much less important and only possible in conjunction with mechanical sensing.

One property of mechanical information which distinguishes it from most of the others is that it cannot be obtained passively. According to the quantum theory every form of measurements disturbs the quantity being measured, but it is never as apparent as when applied to mechanics. It is clearly impossible, for instance, to determine the stiffness of a spring without moving it. It appears, therefore, that the ability to perceive, or at least the ability to learn to perceive, depends on the ability to voluntarily disturb the flow of sensory information in a measured way which generally requires some form of physical movement.

This line of argument can be extended to include other types of information and is especially important in the case of vision which can be shown to be impossible in systems incapable of physical motion. This is well known to the psychologists who can demonstrate that cats, for instance, fail to develop an ability to see if prevented from moving during a specific learning period. That this should be so is easy to appreciate when we consider that vision is in

general, and in the case of pictures always, a process by which a three-dimensional reality is reconstituted from its two-dimensional optical projection. Clearly such a process can only take place in a system capable of appreciating the properties of solid objects and, as we have seen, this requires an ability to move.

The area of interaction between optical and mechanical systems is in fact where the most exciting developments can be expected, but at the present moment the data acquisition processing expertise in the two fields is grossly out of balance. On the one hand we have very highly developed television technology, and on the other an assortment of electro-mechanical transducers and data loggers designed for simple measurements. What is required is a method of producing a mechanical image of an object rather like an image which we form in our mind when, for example, picking up an apple in the dark. Techniques for obtaining this type of information are not as yet developed and will probably require the construction of manipulator arms with sophisticated control systems employing either a large number of parallel force and vibration sensors, or a precisely controlled sequence of exploratory movements, or both. The even more difficult problem which needs to be solved is the method in which such information should be encoded. This is, to my mind, the central problem of artificial intelligence, but it is also one which may show us the way in which such systems ought to be developed. It boils down to the essential question of what intelligence is, and it may prove that it is the process of correlation of sensory and motor function in the way which may lead to the establishment of profitable responses and behaviour patterns.

In writing this I am aware of overstating my case and oversimplifying the issues in the interest of clarity in a manner which will irritate tidy-minded people. I am equally aware that this is not the place where such esoteric arguments will be proved or disproved. Like perception itself they will need to be demonstrated. I hope, however, that these rather self-indulgent musings may illustrate the way in which high technology and computing in particular is capable of affecting at least some artists.

If the above considerations do not constitute a design for a practical cognitive system, they may perhaps indicate some of the conditions under which such a system might evolve. They also constitute the framework within which I hope to continue to work and provide the criterion for the design of any other cybernetic sculptures.