# PARTICIPATORY ART AND COMPUTERS

Stephen Bell

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Identifying, analysing and composing the characteristics
of works of participatory art that use computer technology

by

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2006 edition*

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SYNOPSIS

During the twentieth century ideas about participation, in philosophy, politics, science and the arts have been combined with developments in technology to produce a considerably extended array of types and manners of participation. Within this climate of technological change an increasing number of artists have produced works of participatory art that make use of interactive computer technology.

Some writers have presented general analyses in which these works have been placed within the context of all art produced using computer technology. Others have drawn attention to aspects of these works which relate specifically to their own practice as artists. This research has identified a need for a general system of analysis of these works which can be remembered easily and applied in their critical evaluation and realisation.

The thesis proposes a system of analysis in which the principal characteristics are considered to be those which contribute to the degree and manner of control afforded to participants. The system can be applied in the composition of works as well as in their analysis. The system was evolved by comparing ideas and practices which emerged during the practical development of a participatory work called Smallworld with those reported by makers and critics of existing works.

Although the thesis addresses a special class of the use of interactive computer technology it is intended to contribute to the broader discussion of the use of computer technology in participatory situations.

***Abstract***

This research was initiated to determine the essential characteristics of participatory works of art that use computer technology.

Through comparing ideas and practices which emerged during the practical development of a participatory work called Smallworld with those reported by makers and critics of existing works a need was identified for a general system of analysis of these works which can be remembered easily and applied in their critical evaluation and realization.

The thesis proposes a system of analysis in which the principle characteristics are considered to be those which contribute to the degree and manner of control afforded to participants.

The system can be applied in the composition of works as well as in their analysis: it is demonstrated that the characteristics identified can be composed and that works can be considered to be compositions of changing degree and manner of control.

The system proposed is intended to serve as a paradigm for the development of further systems to analyse such works and to contribute to the evolution of a language with which to discuss them.

Although the thesis addresses a special class of the use of interactive computer technology it is intended to contribute to the broader discussion of the use of computer technology in participatory situations.

***Acknowledgements.***

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Finally I would like to thank my parents Judy and Dick Bell, without whose support I would not have been able to complete this undertaking.

S.C.D.Bell,
22nd September 1991.

***The structure of the thesis.***

The thesis is presented in 5 chapters, supported by 3 appendices.

Chapter 1 identifies the area of research.

Chapter 2 describes the characteristics identified by comparing existing works and through observations made during the evolution of the Smallworld suite of interactive computer programs.

Chapter 3 describes the evolution of Smallworld drawing particular attention to the characteristics identified through its development.

Chapter 4 discusses the higher order characteristics identified and a method of composing the characteristics identified in chapters 1 and 2.

Chapter 5 discusses the implications of the thesis and proposes topics for further research.

Appendix A is a selection of notes describing works and artists discussed in the main text.

Appendix B is a selection of photographic slides produced during the development of Smallworld.

Appendix C is a videotape of selected examples of images produced using Smalloworld.

***Methods of refererence.***

Sections and sub-sections within the main text are referenced to by number enclosed in brackets: e.g. (1.2.3) – subsection 3 of section 2 of chapter 1.

Bibliographic references are by name and date e.g. (Jones 91).

References to appendices A and B are by letter and number e.g. (A1.1)(B4).

## *PREFACE TO 2006 VERSION*

This version has slightly different in layout to the original document submitted for PhD examination in 1991.

Illustrations were originally bound on facing pages; in this version they are included in the text. A side-effect of this is that the page numbers have changed.

Diagrams have also been enhanced by using colour and some very simple corrections have been made.

Appendix C, originally a PAL VHS tape will be made available online.

SCDB
December 2006

## *Table of contents*

# *1. INTRODUCTION.*

During the twentieth century ideas about participation; in philosophy, politics, science and the arts have been combined in a creative synergy with developments in technology to produce a considerably extended array of types and manners of participation. Within this climate of technological change an increasing number of artists are producing works of participatory art that use interactive computer technology.

Some general analyses have been presented in which these works have been placed within the context of all art produced using computer technology (Ascott 66/67) (Cornock & Edmonds 73) (Cornock 77) (Reffin Smith 84) (Prince 86) (Wilson 83(i)/86) (Malina 90) (Krueger 91). Writers have also drawn attention to aspects of these works that relate specifically to their own practice as artists (Edmonds 75) (Krueger 83/85) (Wilson 83(ii)).

In this chapter, a need is identified for a general system of analysis which can be remembered easily and applied in the realisation and critical assessment of such works.

## *1.1 Identifying the area of study.*

The products of those artists who have explored the potential of computer technology as it has developed in the twentieth century are popularly referred to as “computer art”. Different intentions, practices and conclusions have been identified among these works and the artists who have produced them; sub-groups have been identified and sub-categories named (Prince 86) (Dietrich 86).

This research investigates the products and practices of artists whose work is generally termed “interactive computer art” or “interactive art” (Cornock 77) (Prince 86) (Wilson 86) (Malina 90). The terms have, however, been used in several senses so it is necessary to make clear which area of practice is addressed in the thesis.

### *1.1.1 Static, Dynamic, Deterministic and Behavioural art.*

In a 1977 paper, Stroud Cornock drew attention to the need for a language of description and analysis to apply to new forms of fine art practice developed during the twentieth century. Some of the newer forms had generated new modes of analysis but a range of work existed which had not. He asserted that the "communication model" of art (where the artist "transmits" ideas to an audience through creating a work of art) was inadequate as it could not be used to address works such as happenings and those that responded to external or environmental stimuli; it did not equip artists with an effective means of conceptualizing their aims and problems and communicating their ideas to others. (Cornock 77)

In 1973 a paper by Cornock and Ernest Edmonds had been published in which they proposed a means of examining the impact of the computer on art practice (Cornock & Edmonds 73). They defined an "art system":

> ... an activity as a result of which an art object may or may not be produced. (Cornock & Edmonds 73)

explaining that they saw the function of the computer in the arts as assisting in the specification and real-time management of such art systems.

They acknowledged that some saw an apparent threat of the machine, embodied in the digital computer, usurping:

> ... what is assumed to be the essentially human function of control of making art works. (Cornock & Edmonds 73)

They considered that this threat could only arise if attention was limited to what they described as the "traditional art situation"; the situation where there are:

> ... the artist, the art work, and the viewer, where the artist is an individual who makes all the decisions regarding the development of the art work, where the viewer is expected to be "cultured", e.g. familiar with a set of rules and conventions.
> (Cornock & Edmonds 73)

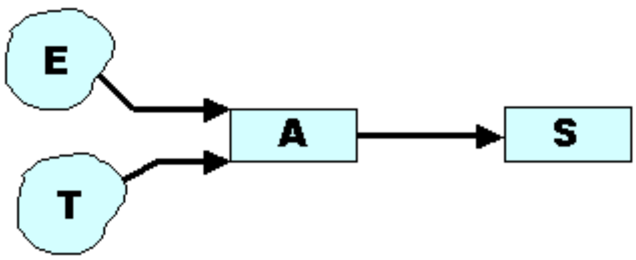
Although the computer could be programmed to mimic aspects of such a situation and lead to a replacement of artist by computer, they proposed an alternative approach abstracting the concept of "creative synthesis" from the traditional context and asking whether it could be achieved in other ways.

The viewer and audience in the traditional situation were replaced in Cornock and Edmonds' model by the term "participant". They proposed the substitution of a "dynamic situation" as an alternative to the traditional art situation, describing this dynamic situation as a "matrix". Their explanation of the matrix was illustrated with the diagrams reproduced in figure 1.1.1.a.

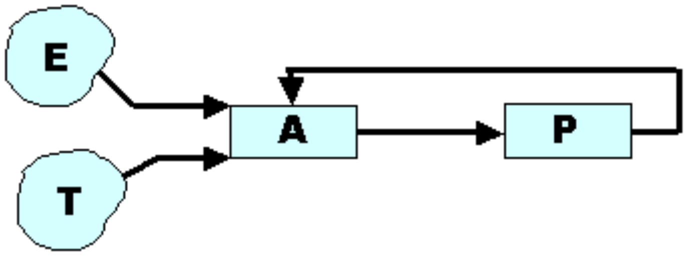
A model of the traditional situation was included in their diagrammatic progression towards a description of the matrix. Their interest was, however, in the possible contribution of the digital computer.

Figure 1.1.1.a (after Cornock & Edmonds)

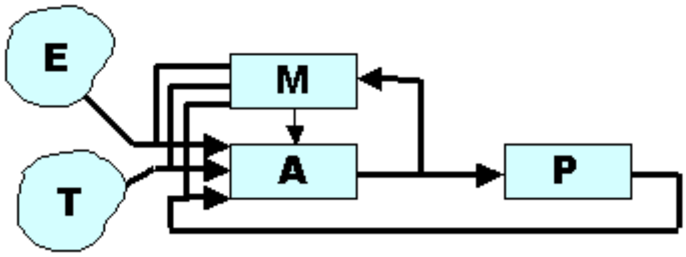

(a) *The static system:* the art work does not change; the familiar class of traditional art objects.



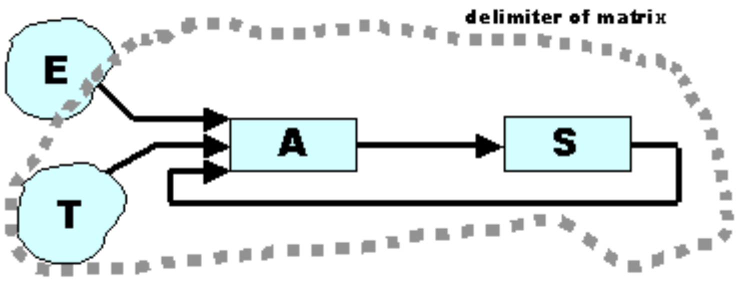

(b) *The dynamic-passive system:* an art object is caused to change with time by the artist's program (e.g. kinetic art) or is changed by factors in the environment (e.g. Calder's mobiles). The participant within such a system has no control and cannot alter anything.




(c) *The dynamic-interactive system:* extends the dynamic-passive system to include output from a participant to an artwork, leading to a feedback loop. The system can be very rich, though the speed with which the participant may exhaust the set of possibilities means that the result could lack substantial interest or value.




(d) *Dynamic-interactive system (varying):* A special case where an artist modifies the system or process in a way not allowed for in its original definition.




(e) *The matrix:* the total system within which the art system and the participants perform. A varying system leads to a varying matrix. Within the matrix the participant plays an integral and interactive part. The art work is the designed sub-system with which he interacts. A participant must be seen simply in terms of the inputs to that subsystem (as an exogenous variable); to try to design a system that takes a total account of a participant would present an incommensurable problem. Were it otherwise, we should suppose him to be predictable.

In his 1977 paper Cornock drew a parallel between his and Edmonds' separation of art practice into two kinds: *Static* and *Dynamic* with Roy Ascott's earlier classifications of *Deterministic* and *Behavioural* (Ascott 66/67). Cornock argued that in both systems of analysis the first kind resembled a declaration by the artist; the second a conversation between artist and audience:

> As with a normal conversation, it is of defining importance that both artist and user contribute (and are seen to contribute) to the interaction. From this it follows that the artistic process must incorporate both parties to the interaction. (Cornock 77)

Ascott had written that "The necessary conditions of behaviourist art are that the spectator is involved and that the artwork in some way behaves." (Ascott 66/67) He wrote that the computer was the supreme tool that the technology of the modern era had produced, as it was not just a physical tool but a tool for the mind; he foresaw human and computer interacting in creative endeavour, and the interaction of artifact and computer.

Ascott expounded a vision in which art would benefit from being part of a future "cybernated" society; the cybernation of society presaged a more fluid state of social and political control and intercourse where instant communication and rapid feedback would render old hierarchies of power obsolete.

In his description of the prospect of a cybernetic vision within art, Ascott argued that there was a need for direct action in the form of, "vigorous polemic and stringent criticism", to avoid, "the insidious complacency which attaches to the delusions of creativity" which Vasarely called, "the false and moderate avant-guard(sic)". There is an assertion implicit in Ascott's paper, echoed with less revolutionary fervour in Cornock's and Edmonds's observations in the early 1970s, that if the works produced were to have any value there was a need for critical discourse which recognised and addressed the works' special characteristics.

Ascott conceived, experimented with and developed the concept of a Cybernetic Art Matrix (CAM) as a means of ensuring the advancement of creativity in the envisaged cybernated society. A major characteristic of the cybernated society described by Ascott was its fluidity. Within this the CAM was seen as a transitional, disposable structure rather than an institution.

Cornock acknowledged that Ascott's model of behavioural art indicated a solution to the need for a new system of critical analysis but concluded that though his taxonomy was influential it was unsuited to everyday discourse (Cornock 77). He also argued that the taxonomy published in 1973 (Cornock & Edmonds 73) was also too clumsy for everyday use. He therefore developed a new taxonomy, illustrated in figure 1.1.1.b

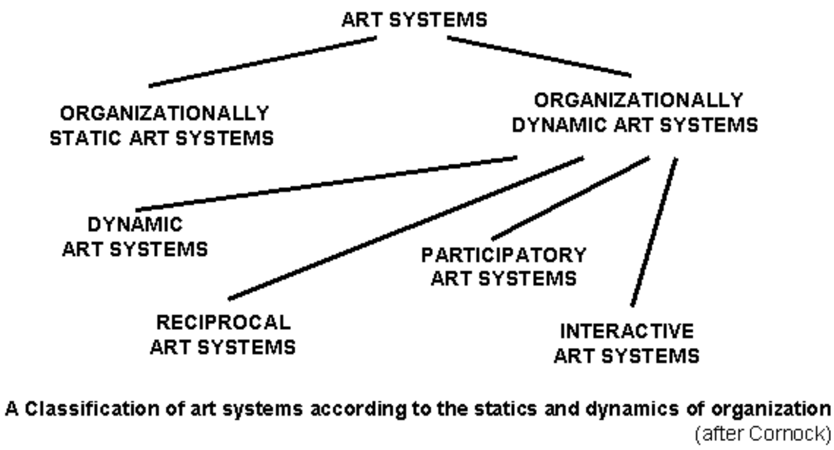



Figure 1.1.1.b
A Classification of art systems
according to the statics and dynamics of organisation.
(After Cornock).

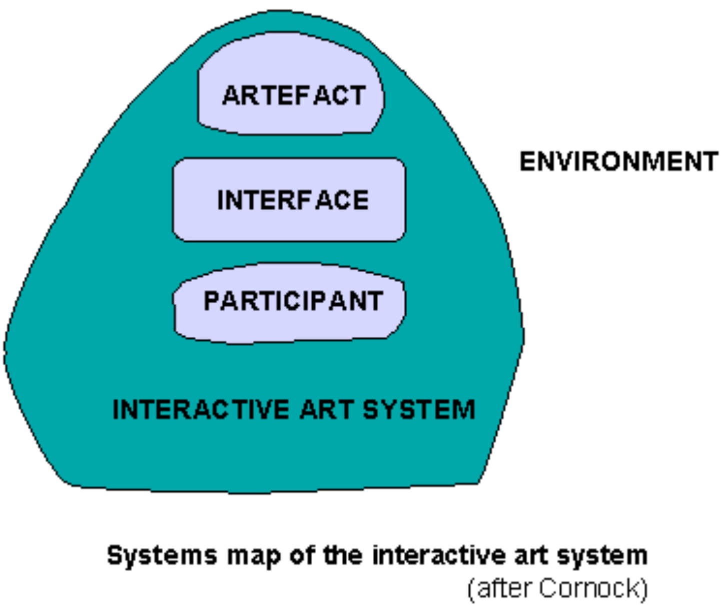
Cornock defined the categories of system as follows:

> *Dynamic systems:* the artefact in a work responds to environmental variables.
>
> *Reciprocal systems:* the system has a range of states and a human "user" moves the system from one state to another. This may be voluntary or involuntary.
>
> *Participatory systems:* the artist defines:

- a time
- a place
- a set of ideas or constraints

which constitute a matrix in which a work of art (signified by an event including the inter-personal reactions of a group of participants to the situation, rather than the physical presence of an artefact) can take place.

*Interactive art systems:* there is a mutual exchange between human and machine which is of an order approaching that of a conversation between two human beings. To achieve this, Cornock wrote, "it should exhibit the properties of a learning system." He illustrated such a system as depicted in figure 1.1.1.c




1.1.1.c
Systems map of the interactive art system
(After Cornock)

Cornock acknowledged that, "At the time of writing the interactive art system remains speculative.", but that he and Edmonds had pursued research into the "user" part of the system and that Edmonds had simulated an interactive art system using humans instead of machines (Edmonds 75).

Cornock's system provided a framework for discussion and for categorizing works, which he extended to encompass all art practice. He did not, however, suggest methods of evaluation. His restriction of use of the term "interactive art" to systems that include a computer can be misleading, as can his classification of participatory and interactive art as separate sub-categories of dynamic art systems, when, as will be shown later in this section, interactive art can actually be seen to be a sub-set of participatory art.

### *1.1.2. Artificial Reality.*

Myron Krueger is probably the artist who has written the most detailed account of his use of computers in participatory art. He has recently revised his book "Artificial Reality" in which he touched on many significant issues hat are referred to in this research, particularly in the sections that address the programmed worlds analogy (2.4), control(4.1) and composition(4.2).

An underlying premise of Krueger's original thesis was that developments in technology indicate that as a consequence of, "... the integration of all aspects of society by interconnected information, communication, and control systems." (Krueger 83), in the near future humans will live in what he called "Responsive Environments".

Krueger's book , based on his 1976 Phd. thesis (Krueger 76) recorded his development of a computer-controlled responsive environment that he presented as a paradigm for future human-machine interaction. He pointed out in the introduction that despite the wide use of machines, particularly computers, in everyday life:

> ... we rarely ask: what are the ways in which people and machines might interact and which of these are the most pleasing. (Krueger 83)

Krueger has developed his responsive environments in the pursuit of answers to this question.

His first involvement in participatory art was with a work exhibited in 1969 called “Glowflow” (A1.1), which he regarded as a “Kinetic environmental sculpture” rather than a Responsive Environment. He drew the following conclusions from his experiences with it, which were to guide his future research:

> 1. Interactive art is potentially a very rich medium which must be judged on its own terms.
>
> 2. In order to respond intelligently, the computer should perceive as much as possible about the participants’ behaviour.
>
> 3. In order to highlight the relationships between the environment and the participants rather than among participants, only a small number of people should be involved at a time.
>
> 4. Participants should be aware of how the environment is responding to them.
>
> 5. The choice of sound and visual response systems should be dictated by their ability to convey a wide variety of conceptual relationships. The tubes of GLOWFLOW did not have a sufficient variety of responses. They represented a single visual statement rather than providing a medium of expression.
>
> 6. The visual responses should not be judged as art, nor the sounds as music. The only aesthetic concern should be the quality of the interaction. The interactive experience may be judged by general aesthetic criteria: the ability to interest, involve, and move people; to alter perception; and offer a unique kind of beauty. (Krueger 83)

In the second edition of his book (Krueger 91), he added to 4:

> Just as we do not ask people to admire invisible paintings or listen to inaudible sounds, interactive art is pointless if the audience is not cued in to it. Computer techniques have provided us with

> many inexplicable experiences. We do not need artists to contribute to our frustration. (Krueger 91)

Krueger's general criteria with which to judge the quality of the interaction, described in 6, are not unique to participatory works that use computer technology. They place such work in the wider context of fine art practice rather than draw attention to its peculiar characteristics.

Over the years Krueger developed some fundamental principles. They are reproduced below and illustrate how he has been able to explore his subject in depth by rigourously delimiting his practice.

> (1) Computer art is fundamentally interactive. Other artistic uses of the computer are of interest, but they do not constitute a new artform based on the computer.
>
> (2) The quality of the interactive relationships is paramount. Traditional ideas of visual or musical beauty are initially secondary. Response is the medium!
>
> (3) If the responses are to be intelligent, it is imperative that the computer's grasp of the participant's behaviour be as complete as possible.
>
> (4) Real-time computer-generated graphics and synthesised sound offer the most powerful and composable responses.
>
> (5) Visual responses should be projected on an environmental scale, and other sources of visual stimulation should be minimized.
>
> (6) Participants should be able to understand how they personally elicit the responses. The experience is strongest when the interaction is between one individual and the computer.
>
> (7) It is desirable to think in terms of inventing a tool for exploring the interactive medium, instead of creating a series of discrete objects, each of which is a 'piece'. (Krueger 1985)

Krueger did not provide a method of analysis of the work he described. His reasons for this were made clear in his assertion that art history, art criticism and art appreciation have become deterrents to experiencing art (Krueger 83). There is a place, he argued, for a medium that can resist interpretation:

> The Responsive Environment can take steps to individualize the responses and to thwart analysis. If each person has a different experience, there will be less pressure to arrive at a "right" interpretation. Since each person moves about the space somewhat differently, each will receive different feedback, even if the controlling program is exactly the same. If there are many programs alternating control of the Environment, each participant's adventure will be unique. Thus, two people can exchange experiences, but since they have had no common experience they cannot analyse it to death. (Krueger 83)

In the second edition he added:

> Another reason for emphasising variety is to resist the pressure on artists to find a single, saleable style. (Krueger 91)

Despite his argument supporting a medium that defies interpretation, Krueger has brought attention to characteristics which can be used in the analysis of works. The fact that he presents a stance within the context of art practice also opens his own work to critical analysis.

### *1.1.3 The development of criteria of assessment.*

In 1990 Krueger was awarded the "Golden Nica" prize at the "Prix Ars Electronica" festival in Austria for his achievement in technical innovation in the generic field of interactivity. That the award was for technical innovation reflects the seventh of Krueger's list of guiding principles.

One of the judges in the festival was Roger F. Malina (the others were Roy Ascott, William Buxton, Donna Cox and Brian Reffin Smith). In the Compendium published by the festival organisers (Leopoldseder 90) Malina wrote a section entitled "Towards Criteria for Assessing Interactive Computer Art" (Malina 90).

Malina defined the category of work being discussed by explaining that they were works which did not exist without the element of interaction, and that computers enable a continuation in new directions of artistic research previously pursued in the making of transformable sculptures, happenings, and improvisational performances in theatre or music.

He noted two ways in which interactivity could take place in works:

- where the viewer interacted with the work directly

- where the viewer observed a participant or performer interacting with an artwork.

He described what he admitted were "incomplete" criteria for evaluating such work explaining that the judges tried to recognise excellence. A central criterion was that interactivity must be crucial to the works. If the works were presented in a format similar to non-interactive works, traditional criteria were applied. Malina recognised the "familiar dichotomy" between works which addressed issues (for example social and ethical issues) and those which emphasised process or concepts. Some works concentrated on the technology itself, others on the development of a new technology.

Another criterion was that the computer should be crucial to the realization of works. Malina argued that it may be useful to create a special category when a new tool is introduced, as was the case with computer graphics, but that it is no longer helpful to create a "ghetto" which has no theoretical basis. Interactive art made using computer technology, he believes, will not however be a temporary category. He identified the following capabilities of the computer, which can be used in making art.

1. The ability to be used in a real-time interaction which changes the internal state of the computer.

2. The capability of the computer to have in-built learning capabilities, so that the internal state of the computer evolves as interactions take place.

These two capabilities agree with the characteristics identified and discussed in (2.6.3).

3. The capability of the computer to be connected to other computers over large distances through the use of telecommunication networks.

This capability is discussed further in (2.4.3).

4. The ability to collect and disseminate signals through a large number of sensory modes, many of which are not directly accessible to the humans senses - and to connect these symbols in synaesthetic approaches.

The ability to extend human sense-abilities is discussed further in (2.4.4).

5. The ability to store large amounts of information which can be easily retrieved.

That works can make use of information retrieval is discussed further in (2.3.1).

Not all of these capabilities need be exploited in single works.

Malina noted that in the most complicated works each realization may be different. He likened the rules in some works to a generative "code" contained in the software:

> The specific result of this generative reproduction arrives from the interaction of this code with external stimuli.
>
> The most sophisticated interactive computer artworks are open-ended in the sense that the final outcome cannot be completely

> predicted by the initial artwork created by the artist - the artwork does not exist until the interactions take place. (Malina 90)

## *1.2 The need for a system of evaluation; the aims and intentions of the research.*

The writers discussed above envision the emergence of works and practices sufficiently different in character to other works and practices to constitute new art forms. The implication of all these writers with the exception of Krueger (who explicitly supports the idea of works that cannot be analysed "to death") is that there is a need for a method to evaluate individual works. Both Cornock and Malina state this explicitly. None of the writers, however, provide an easily remembered method by which this can be achieved.

It was therefore resolved that this research should be pursued with the aim of developing a means of identifying and analysing the essential characteristics of participatory works of art which use computer technology. It was also determined that the system should be easy to remember and apply and would have immediate value to the makers and critics of such works.

Although the subject studied constitutes a small, special class of participation the research was also intended to contribute to the broader discussion of the use of computer technology in participatory situations.

The intention of the thesis is not to lead to the kind of analysis which Krueger asserts can "kill" works, nor to provide a system for categorizing and labelling works like botanical specimens, but to provide the foundations of a method of analysis which can be used, in whole or in part, to enhance artists' and participants' abilities to realize works and which can be extended and adapted to reflect future developments in technology and practice.

## *1.3 Definition of terms.*

Initial research into "interactive computer art" revealed that the term "computer art" had come into disrepute as it tended to isolate works of art produced using computers and artists producing them from general art discourse (Reffin Smith 84). It was also found that the term “interactive” had been interpreted and used in a number of senses, some of which would exclude works of particular interest from the study. Therefore, rather than referring to “interactive computer art” or “interactive art”, the title of this thesis refers to “works of participatory art which use computer technology”.

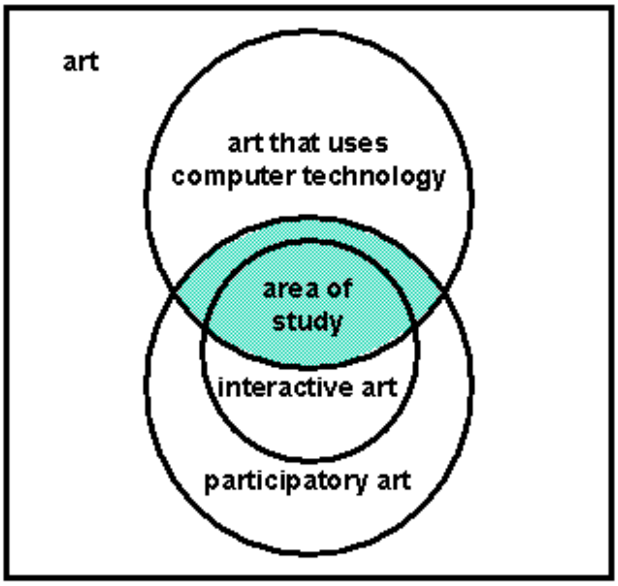



Figure 1.3.a
Venn Diagram showing area of study

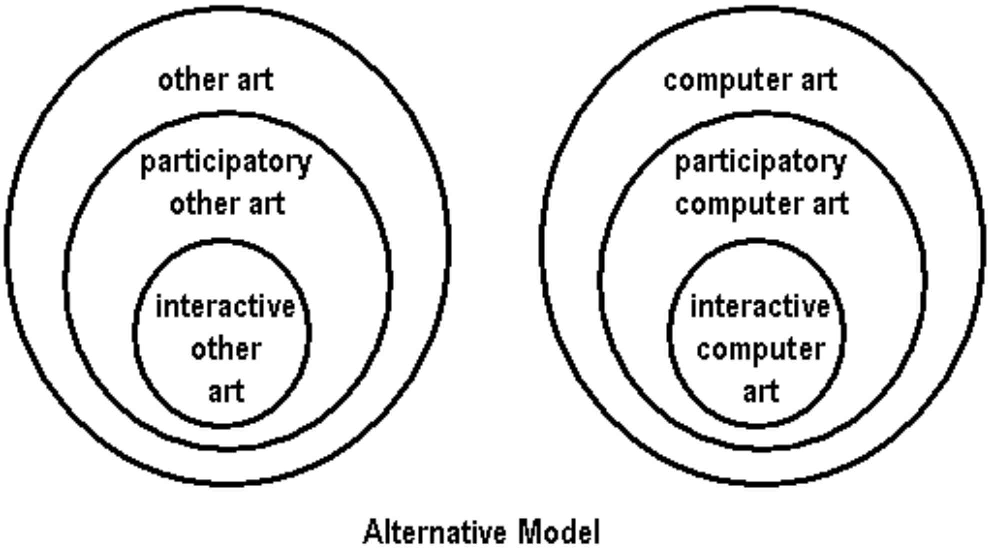



Figure 1.3.b

Figures 1.3.a and 1.3.b illustrate two different ways of presenting the area of art practice being studied. Figure a shows the model being used in this thesis. This nesting of interactive art within participatory art was derived from the dictionary definitions of participation and interaction:

The entry for "participation" in the Oxford English Dictionary (OED 61) gives:

> ... the act of participating.

and for participate:

> ... To take or have a part or share of or in; to possess or enjoy in common with others; to share.

For "interaction":

> ... Reciprocal action; action or influence of persons or things on each other.

and for "interactive":

> ... Reciprocally active; acting upon or influencing each other.

It can be understood from these entries that at least two things (or persons) are necessary for interaction to occur, and that interaction is not a one way event; both "interactors" contribute to and are affected by the interaction. It can therefore be seen that all interaction is participatory but not all participation is interactive.

The dictionary definitions do not indicate that there are degrees of participation and interaction and imply that a work is either participatory or it is not.

As "participation" and "interaction" have been used in several different senses by people writing about works of art, determining whether a work is participatory or not is not necessarily trivial. The notion that the audience for any work of art are ever really passive is debatable (Dewey 34). It is possible, however, to class works as participatory in an historical context:

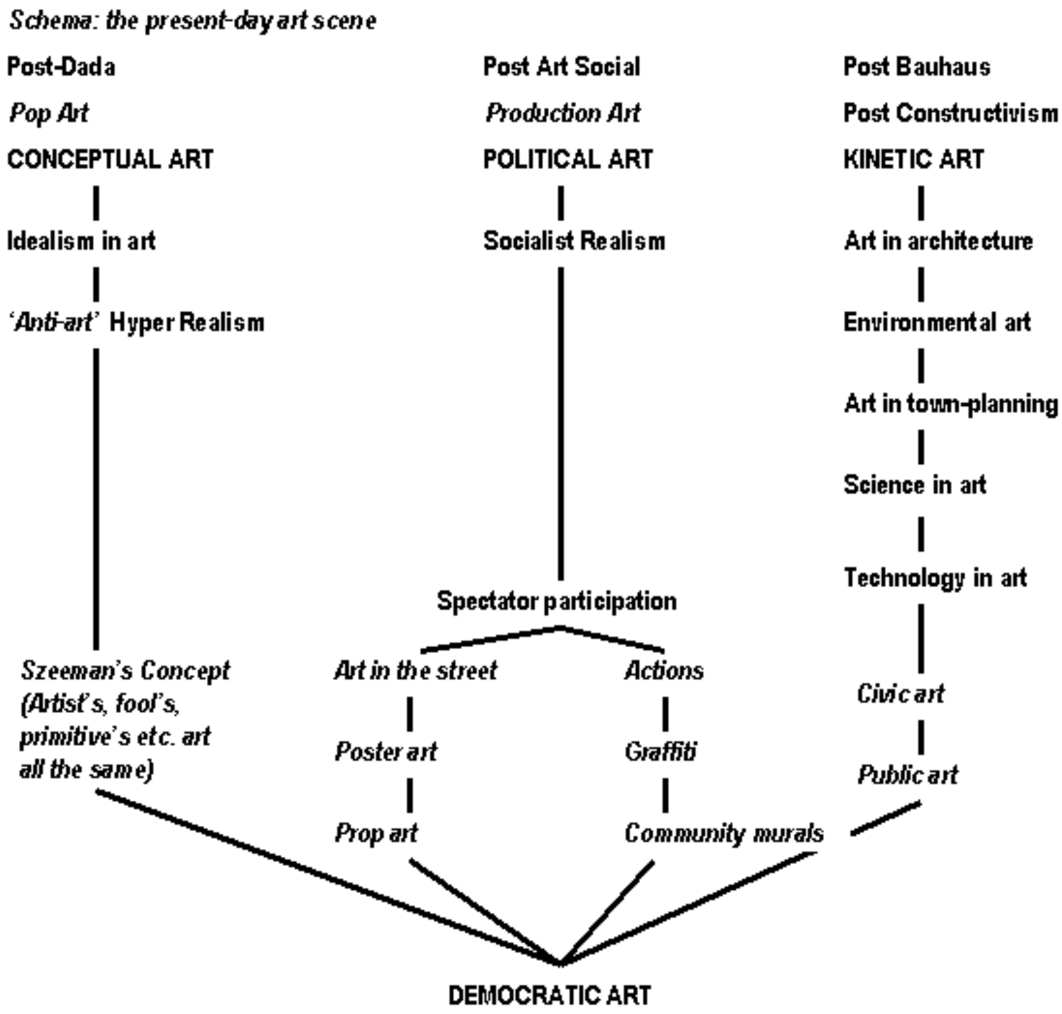



Figure 1.3.c
(After Popper)

Frank Popper interpreted trends in twentieth century art leading to a revolutionary form of art which incorporated spectator participation, that he referred to as Democratic Art (Popper 75). These trends are illustrated in figure 1.3.c. Ascott identified similar trends dating from the mid nineteenth century towards a form of art practice which he called "behavioural". He saw this as part of a wider social change (Ascott 66/67). Krueger also presented a picture of a move to a more participatory world which included art practice (Krueger 83).

Artists are influenced by the spirit of the age they live in (Rosenberg 67) (Praz 70), therefore as well as developing concepts of participation within art practice, the rise of interest in participation in art can be seen to reflect similar interests in other disciplines. Ann Richardson has provided an insight into this wider social context. She asserted that recent emergence of interest in participation was partly due to the ineffectiveness of older systems of government due to an increased population. New means were being sought by both the governed and those who governed them to enable them to communicate with each other (Richardson 83). From her discussion it can be concluded that the social and political climate in the late twentieth century also encouraged artists to experiment with new forms of participation.

Richardson argued that although participation emerged recently as a political concern, it is a very old idea. In art too, the idea that audiences to some extent already took part in the realization of works of art was well understood. Jean-Paul Sartre wrote that:

> It is the joint effort of author and reader which brings upon the scene that concrete and imaginary object which is the work of the mind. There is no art except for and by others. (Sartre 50)

> The imagination of the spectator has not only a regulating function but a constitutive one. (Sartre 50)

It only takes one person to read a book or view a painting or sculpture, but in many traditional works a number of people participate in what Robert Bocock described as an “art ritual”.

> It would be possible to say that all activity which involves viewing and appreciating the arts is aesthetic ritual action, in that a group of people, or separate individuals, relate to symbols of an aesthetic type. At base minimum this is ritual action, as distinct from action of a rational, technical kind. Having said this, however, it is possible ... to go on to differentiate within the arts, on the basis of the fact that some works are more “ritualistic” than others. (Bocock 74)

Bocock presents a model of how to approach the question of whether works are participatory or not. To paraphrase Bocock; some works are more “participatory” than others. This does not answer the question but as the intention of the research is to identify characteristics rather than to classify works it does not pose too great a problem.

Having acknowledged that all works of art are to some extent participatory and that some works may be considered more participatory than others, for the purposes of this research participatory art is taken to be work produced in the context of the growing interest in participation in the second half of the twentieth century which exhibits the characteristics identified; the identification of the characteristics in effect demarcates the subject.

A distinction could be drawn between works in which the participation is explicit and those in which it is implicit; physically active participation is more explicit than physically passive mental contemplation of work but can it be said to be *more* participatory? In this research it has been more useful to be able to discriminate between *types* rather than *degrees* of participation. It is more useful, for example, to determine whether the audience is participating in the conception, physical execution of the work, or simply responding to it, without assigning the work a position on a scale relative to other participatory works; to do so would serve very little purpose.

Just as some works may be considered more "participatory" than others, some works may be considered more "interactive" than others. Again it has been found more useful to be able to determine different *types* of interaction than to determine *degrees* of interaction in works.

## *1.4 Method.*

Examples of work and existing critical material were reviewed in parallel to the practical development of a participatory work (Smallworld) which acted as a testbed and generator of ideas. By actively pursuing the development of a work it was possible to test and compare characteristics and working criteria generated directly through practice with those identified in other works to form a more thorough understanding of the subject.

The same approach was followed when it became apparent that a method of describing and analysing the relationships between the identified characteristics should also be developed.

# 2 CHARACTERISTICS OF WORKS OF ART THAT USE COMPUTER TECHNOLOGY.

In this chapter the characteristics identified by comparing existing works and through observations made during the development of Smallworld (3) are described.

Benoit Mandelbrot observed that:

> ... depending on the criteria used, different observers may disagree as to the number of distinct dimensions latent in the same object. Where one observer sees a zone having its characteristic D, others are likely to see only a gradual transition which may not deserve separate study.
> (Mandelbrot 82)

Ernst Gombrich wrote that if the language of critics is read literally it may seem senseless, but as metaphor it may:

> ... occasionally be acceptable to those who are able to test it against their own experience.
> (Gombrich 79)

In the light of this wisdom it is therefore expected that the value of the characteristics identified in this thesis will depend on their usefulness in practice.

The chapter is presented in 7 sections each of which addresses a different general class of characteristics:

Section (2.1) addresses the characteristics associated with time and the number of participants in works.

Section (2.2) addresses the characteristics associated with the physical interface of works.

Section (2.3) addresses the characteristics associated with the programmed interface.

Section (2.4) addresses the characteristics associated with programmed worlds.

Section (2.5) addresses the characteristics associated with communication.

Section (2.6) addresses the characteristics associated with who or what participates and where it happens.

Section (2.7) addresses the characteristics associated with feedback.

## 2.1 Time in works and the number of participants.

### 2.1.1 Participation, Interaction and time.

In the definitions of interaction in (1.3) it is not explicitly recognised that the contributions of the participant or participants occur in time. They can, however, occur at the same time or at different times.

The top part of figure 2.1.1.a is based on a table included in the notes of the 1987 Siggraph course in Advanced Computer Animation (Rosebush 87). The diagram illustrates thirteen different temporal relationships between two events: x and y. Numbers have been added to aid reference. If the two events are taken to be the actions of two participating agents the table can be applied to events in a participatory work.

Where events are occurring at the same time they may be described as *synchronous*, where events are taking place at different times they may be described as *asynchronous*. Events described by cases 1, 2, 4 and 5 may be described as asynchronous and case 3 as synchronous. All the other cases include a combination of synchronous and asynchronous events.

In cases 10, 11, 12 and 13 one event causes the other to start or finish but the other events are not causally related. In a participatory interactive work, cases 14 to 21 may be added by amending existing cases to include those where one event *causes* the other to occur.
In the case of *asynchronous* participation and combined cases, the action of one participant precedes the action of the other and it is possible to consider the second action as a reaction to the first.

If the second action is considered a response to the stimulus of the first, the first participant may be considered to be the initiator or cause of an interaction.

A human observing or participating in an *asynchronous* interaction will generally attempt to interpret events by applying some kind of cause-effect reasoning.

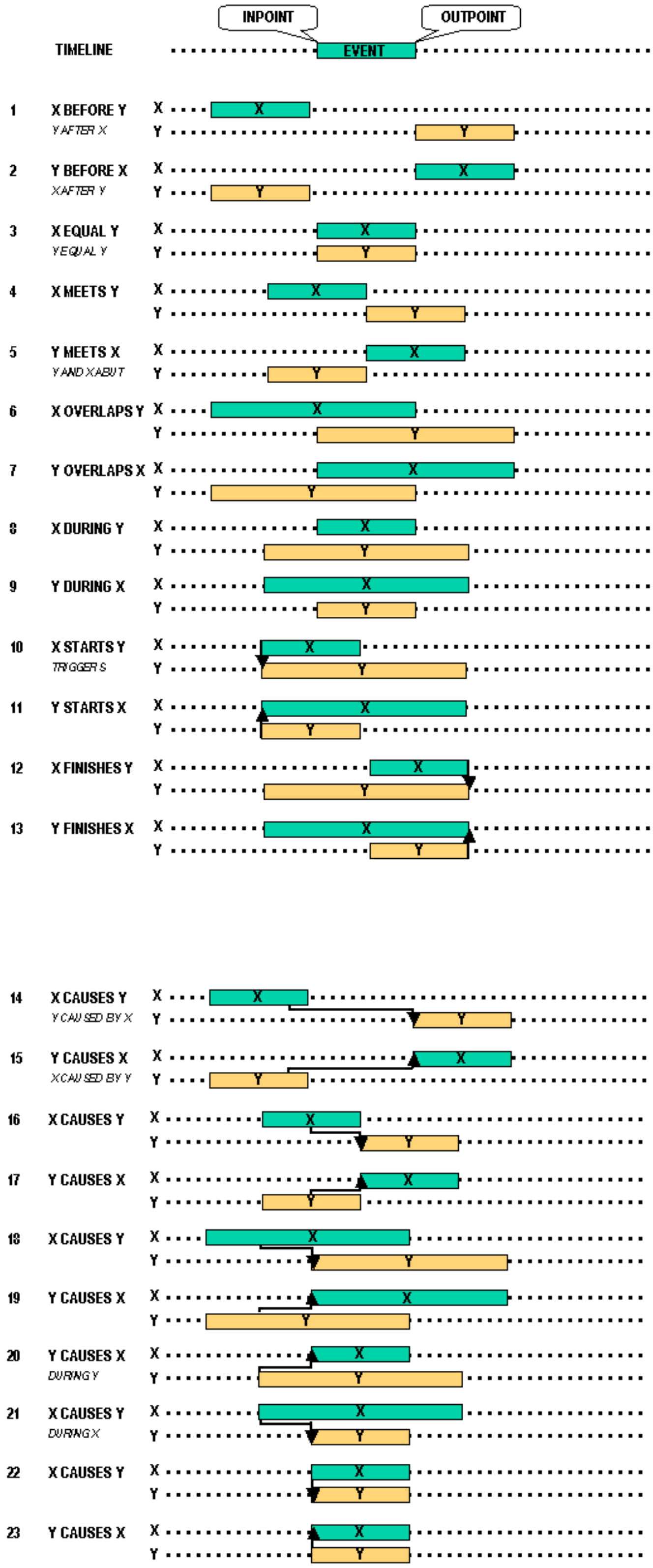

INPOINT
OUTPOINT
TIMELINE
EVENT
1 X BEFORE Y
Y AFTER X
2 Y BEFORE X
X AFTER Y
3 X EQUAL Y
4 X MEETS Y
5 Y MEETS X
Y AND X ABUT
6 X OVERLAPS Y
7 Y OVERLAPS X
8 X DURING Y
9 Y DURING X
10 X STARTS Y
TRIGGERS
11 Y STARTS X
12 X FINISHES Y
13 Y FINISHES X
14 X CAUSES Y
Y CAUSED BY X
15 Y CAUSES X
X CAUSED BY Y
16 X CAUSES Y
17 Y CAUSES X
18 X CAUSES Y
19 Y CAUSES X
20 Y CAUSES X
DURING Y
21 X CAUSES Y
DURING X
22 X CAUSES Y
23 Y CAUSES X

Figure 2.1.1.a

The time-delay between action and reaction needs to be sufficiently short if a relationship between the two actions is to be recognised and it is to be confidently identified as interaction. This is particularly important if the artist, as recommended by Krueger , intends the participant to appreciate that they have caused an effect by a given action (1.1.2). It was found that determining what constitutes a sufficiently short delay is a task that is best accomplished by adopting the recommendations to be discussed in sub-sections (2.7.2) and (2.7.3).

Identifying cause and effect in a *synchronous* interaction might be considered more difficult, yet it is something that humans are well able to manage in some cases as illustrated by the following example:

When throwing a ball, the ball moves at the same time as the human moves their hand; yet there is no doubt as far as the human is concerned that the human is causing the ball to move.

Amendments to the synchronous case 3 may therefore be added as cases 22 and 23.

Cases 10 to 23 can be used to represent interactive relationships. Cases 1 to 9, where there is no causal relationship, may be misinterpreted as interactive.

The various classes of event described also have duration. Time is used as an ordering element in the system proposed for organising the characteristics identified in the research to be discussed in chapter 4.

The instantaneous responsiveness of *synchronous* interaction makes the interaction more explicit and may thus be considered to be qualitatively more interactive than *asynchronous* interaction. It is more useful, however, to consider that synchronous interaction is more *responsive*.

The longer the time-delay between action and response in *asynchronous* interaction, the less responsive it may be considered.

In human-computer interaction, if a cursor-arrow moves across the screen almost instantaneously in response to the user moving a mouse there is little doubt that the human is causing the graphic to move. This was noted in the DEPTH program of Smallworld where moving the mouse caused the image to rotate effectively instantaneously (3.5.2.iii).

Too large a delay can cause problems: In some examples of "virtual reality" (2.4.3) technology current in late 1989 a small but noticeable time-lag between user input and graphic response can compromise the effectiveness of the intended illusion.

### *2.1.2 The number of participants.*

In the cases listed in (2.1.1) the relationship is between *two* agents.

When interaction is between more than two participants, attributing the cause of a particular response, and thus recognising the interactive relationship, can prove more difficult.

Krueger remarked that when there were a large number of people in the room in "Glowflow" (1.1.2) (A1.1), it was hard for people to tell whether they or someone else had elicited a particular response.

Cornock and Edmonds noted that it has always been the case that the artist is also a participant and that participants do not all have to react in the same way (Cornock & Edmonds 73).

Wilson's work has included several participants and a program simulating human behaviour (A2)

### *2.1.3 Symmetry in participation.*

In participation there may be an even distribution of actions and contributions between participants, or the participants may adopt different roles, with different degrees of contribution. This balance of roles can change during interaction.

Interaction may be considered *symmetrical* when each participant partakes equally in the activity or *asymmetrical* when there is an uneven distribution of roles.

In many board games, the rules are specifically designed to ensure that each player has a balanced opportunity to take part; interaction between the players in these games can be considered *symmetrical*. A work that mimics such a situation can be considered to exhibit symmetrical interactivity (3.2.2.v).

An example of *asymmetrical* interaction is the interaction between questioner and competitors in a quiz as they have different roles.

The degree of symmetry may be measured in terms of the duration of participants' actions (2.1.1), the extent of their control over events (4.1) or by combinations of the characteristics identified in this thesis.

### *2.1.4 Observing and intervening in participation.*

The sense in which an event is considered participatory or interactive can depend on how it is observed. This becomes particularly significant if the observer is also a participant in the event.

Once observed, participation may be interpreted as:

- intelligently motivated
- automatic (non-intelligent)
- intentional
- accidental

These effects are considered further in sections (2.5) communication, (2.2) and (2.3) interface, (4.1) degree and manner of control and (2.7) feedback, respectively.

If observers can intervene in an event, the manner of their intervention can affect the way they observe interaction; they may, for example, wish to time an intervention to coincide with a particular occurrence.

The manner of observation can therefore be seen to combine with the manner of intervention to affect the way interaction is interpreted. Possible manners of intervention are listed below.

<u>Manners of observation:</u>

A) as if outside the system

B) as if inside the system

C) as if one of the interactors

with a view of:

(i) all of the interactions

(ii) some of the interactions

(The degree to which the observer can control what is observed from the points of view can also vary).

<u>Manners of intervention:</u>

A) none

Able to:

B) affect start conditions

C) intercede directly while events continue

D) pause events and intercede directly

E) act through surrogate designed and released for specific purpose

F) act as one of the interactors with limited (similar) behaviour options

G) act as one of the interactors with unlimited (special) behaviour options

These different manners of intervention were discussed in (Bell 90).

The manners of observation and intervention can be combined to give very different degrees of involvement and are exploited, for example, in computer games (4.1.9).

Observation of interaction does not only occur in participatory works. Interaction has been observed or imagined by artists and has been depicted in some non-participatory works for centuries; in the form of painting, sculpture, drama etc..

Participants may themselves be observed, by other interactors or by non-participants, and this may affect their interaction. The effect of being observed on a participant's “performance” may be significant; some may become self-conscious and embarrassed if watched by non-participants (Weizenbaum reported that some people preferred to consult his Doctor program in private (Weizenbaum 76) ), others may appreciate an audience (For example, Arcade-game players).

Participant performance is considered further in sub-section (4.1.7).

### *2.1.5 Summary.*

*Participation can range from synchronous to asynchronous.*

*Synchronous interaction may appear to be more interactive than asynchronous interaction.*

*The shorter the time-delay between action and response in asynchronous interaction, the more responsive it may be considered.*

*There are at least 14 different time-related types of interaction between two interactors.*

*There can be more than two interactors.*

*The number of interactors can affect the degree to which an interaction can be apprehended.*

*Participation may be symmetrical or asymmetrical.*

*Participants can observe and intervene in interaction in different ways, the combination of which can lead to different degrees of involvement and thus different types of interaction.*

*Participants may be observed and this can affect their behaviour and hence the type of interaction.*

## 2.2 *The physical interface.*

In any participatory work that uses interactive computer technology there has to be a physical interface between the program and the participant.

### 2.2.1 *Human-program input/output devices are still being developed.*

Stephen Wilson included a table of input and output devices commonly used in computer technology in his book "Using Computers to Create Art" (Wilson 86). It is reproduced in figure 2.2.1.a.

| |
|---|
| **INPUT AND OUTPUT CHARACTERISTICS AND DEVICES** |
| **Inputs:** |
| Light (light pens, photocells, cameras) |
| Sound (speech and music recognition) |
| Position (joysticks, tablets, mice) |
| Temperature |
| Humidity |
| Electronic radiation (radio, infrared, ultrasonic waves) |
| Time |
| Laser imaging systems |
| Touch |
| Psychological characteristics (brain waves, stress response) |
| Keyboards and bar code readers |
| |
| **Outputs:** |
| Light (CRT images, switched lights) |
| Sound (music, speech) |
| Movement and switching (motors, solenoids, robots, appliance controllers) |
| Printers and plotters |
| Humidity |
| Videodisks and tape players |
| Electromagnetic radiation (radio, infrared, ultrasonics) |

Figure 2.2.1.a

Shackel, in his analysis of the relationship between human and computer (Shackel 87) made the comparison between human and computer communication links reproduced in figure 2.2.1.b.

**SUMMARY OF PRESENT STATUS OF HUMAN-COMPUTER COMMUNICATION LINKS**

| **Human Channels** | **Computer Devices** | |
|---|---|---|
| Input | Output | |
| Eyes | Visual Displays | Several basic types exist (with many different manufactured versions). |
| Ears | Aural devices | Research prototypes and some production versions. |
| Nose | ? | Doubtful use except for fault detection. |
| Skin | Tactile Displays | Research on aids for the blind. |
| Input | Output | |
| Hands | Manual controls | Many types exist. |
| Arms | Arm controls | Several types but only in vehicle simulators |
| Legs | Leg Controls | (e.g. steering wheels, pedals, joysticks). |
| Voice | Voice controls | Research prototypes, and some production versions with vocabulary about 50 to 200 words (isolated speech) and recently some to 1000 words. |
| Head | Head controls | Research (some prototypes and a few military versions). |
| Eyes | Eye position or movement controls | Research (mainly for military). |
| Muscle potentials | Bioelectric controls | Tailored systems for direct electo-physiological control of prostheses; research on direct control by brain electric signals. |

Figure 2.2.1.b

Richard Bolt provided an overview of more experimental developments up to the late 1980s in his book “The Human Interface” (Bolt 84). The technology continues to develop and the direction of development is so unpredictable that forecasting what will happen to the technology beyond a few years in the future has little value (Gaines & Shaw 86). In this thesis, therefore, a general, machine independent discussion is pursued; existing devices are used in examples, but it is anticipated that most devices will be superseded or elaborated upon in time.

The input/output (I/O) routes of humans, as might be expected, are important determinants of the characteristics of human-computer interaction and have therefore been used to shape this section as, unless there are remarkable advances in bio-engineering, they are less likely to change than the technology.

Although the human may be considered to be interacting with a “virtual machine” (i.e. what they perceive of the combined system of the program, database and physical computer hardware (Maher and Bell 77)), in the thesis interaction will generally be considered to be between human and program(s) via I/O devices.

### *2.2.2 The relationships between human, program and I/O devices.*

Figure 2.2.2.a depicts an overview of the relationship between human and program.

The roles of the physical input devices of human and program can be placed within this wider scheme.

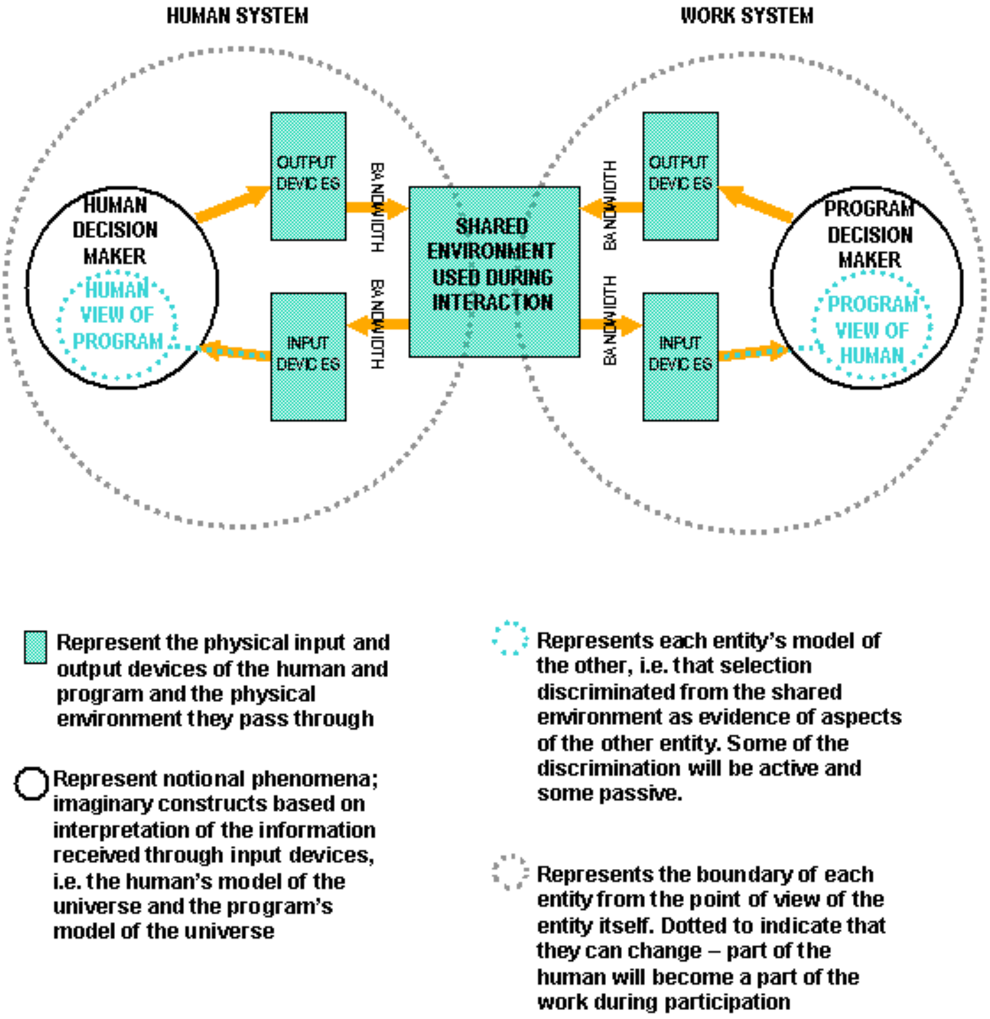



FIGURE 2.2.2.a

### *2.2.3 Fundamental human input/output devices.*

Humans have developed ways of using the fundamental output devices provided by their physical body to share input and output with other humans to a degree that would be hard to document completely. When the devices that have been developed to extend these means of input and output are taken into account the task becomes formidable.

The fundamental input devices of a human are ears, eyes, nose, tongue and skin. They have been extended not only by the use of tools like microscopes and telephones but also by being assigned particular roles; different senses are used to receive different kinds of information, dependent on both whether it is the most efficient route, and whether it is the conventional means of receiving particular kinds of communication.

Humans have developed means of output that can be sensed by other humans:

Voice and slapping parts of the body (e.g. clapping) can be used to cause sound output which can be input via human ears.

Appearance, i.e. visual output, can be changed by gesture and posture, to be input via the eyes.

Other peoples' skin can be touched in more-or-less intimate ways; from shaking hands to making love, slapping to physically attacking.

Human control of the smell or taste of the body is either subconscious or demands use of external devices (e.g. washing, applying perfume).

The devices chosen for output and the way they are used depends on what the output is intended to achieve in the human's interaction with the environment. Arguably the most sophisticated forms of output have been developed to enable humans to communicate with each other. The output devices chosen depend on the nature and circumstances of the human's decision to output something.

### *2.2.4 Fundamental computer technology input/output devices.*

At the fundamental level the input and output of programs are best described by Wilson's laws of computer input and output; input and output are electronic signals. These signals can be interpreted by programs:

Wilson’s Law of art and computer input:

> Any kind of physical event in the world that can be converted to electrical impulses can become information for the computer to manipulate and for artists to explore. (Wilson 86)

Wilson’s Law of computer output:

> Any event that can be activated by electrical impulses can be controlled by computer. (Wilson 86)

Conventions have been developed so that similar uses of devices will lead to similar interpretations by programs, for example: The ASCII code (American Standard Code for Information Interchange) used to represent keyboard input.

A work that uses computer technology may make use of these conventions to convey input to a program or special interpretations may be devised.

### *2.2.5 Sound as input and output.*

Spoken language, singing and other sounds made by use of the body are important to human communication and very sophisticated; the complexities of messages being transferred can be modified by stresses, intonations, pauses, etc.. Humans can both send and receive sound messages over short distances without aid and over extremely long distances with special tools.

This is an obvious choice of interface where humans are concerned, but it has proved difficult so far to produce a technology capable of enabling programs to match human performance in this area.

Research continues into speech and musical human-program communication and the consequences of a successful sound I/O are as yet barely conceivable. Modest success has been achieved and Bolt discussed the subject further in relation to the “Put that there” sound and gesture input system developed at M.I.T. (Bolt 84). Beyls “Oscar” (Beyls 88) (2.5.2) is an example of the advances being made in music recognition programs.

Sound can also be used as a means to determine the physical location of something, be it human or machine.

From a human position sound is not directional in the sense that the human does not have to be facing the source of the sound to hear it, although facing the source of the sound can improve reception considerably. In the cases of listening to stereo sound or live concerts, the location of the listener, direction they are facing, acoustics of the venue and other factors become very significant. Listeners can, however, be fooled into believing a sound is emanating from a different location from the real source by visual cues, as in ventriloquism.

Sound sensing technology can be used to indicate the location of a human or object to a program (A3.2).

### *2.2.6 Vision as input and output.*

Using current technologies vision is the easiest route to use as output from a program to a human; as text or graphics on a screen or as hard copy.

Visual input to a computer is possible but as with speech, programs are currently no match for the human capacity to interpret visual input.

Human vision is able to receive information from an extreme distance, although at astronomical distances there is a considerable time difference between light being emitted and received. Acuity is also reduced by distance.

At terrestrial ranges vision can detect visible signals faster than audible ones and vision can for most practical purposes be considered instantaneous.

Any visual input that can be converted into electric signals can theoretically be processed by a program. Krueger's work shows the most advanced application of vision input to a computer program used in the context of participatory art (A1). David Rokeby's work uses a similar technique to monitor the human visual output of movement (A15).

Human vision is directional; the human must face something to see it.

The range of electromagnetic radiation that humans can interpret visually is limited but can be extended using tools such as image intensifiers, radio telescopes and infra-red cameras. Computer technology can enable a program to receive input over a wide range of the electro-magnetic spectrum, including heat, which could be used as involuntary input from a human.

### *2.2.7 Touch as input and output.*

Touch as a form of human-human communication route is reserved for special occasions, it is most often used formally : hand-shaking, back-slapping, embracing etc.. Touch of an exploratory nature is reserved to encounter groups, some sports, making love etc..

Without mediating technology touch is of necessity a short range communication route.

Touch as a form of input to programs from humans is very common; keyboards, mouse, joy-stick and touch sensitive screens being common examples. Touch is less common as output but is being researched as for example at M.I.T. Media Lab. where joy-sticks are being experimented with which output forces to the human using them (Wright 89). Ihnatowicz's "Bandit" can be identified as pioneering this kind of output and input to computer (A3.3). A transatlantic "telephonic arm-wrestling" contest was held between Norman White in Paris and Doug Back in Toronto, using physical feedback to the participants (de Kirckhove 91) (A4.2)

Krueger observed in the "Metaplay" exhibit (A1.2) a set of phenomena that he called "Videotouch".

> People feel that their images are extensions of their identities,
> What happens to their images happens to them.  What touches
> their images,  they feel  (Krueger 85)

The input is actually a combination of visual information and participants' senses of their physical pose.  The combination of I/O routes is discussed in sub-section (2.2.10).

It is worth noting with regard to who communication is between (2.5.1) that some humans like to communicate with animals,  particularly pets,  by touch.

The "Dataglove" and "Datasuit" of V.P.L.,  Exos Inc.'s "Dextrous Hand Master" and the,  "Virtuality", devices of W Industries Ltd. may signal the future of possible applications of touch I/O within works.  These companies manufacture and sell systems that incorporate devices that monitor body movements.

Krueger described the GROPE system developed at the University of North Carolina,  where movement of the user of a manipulator that is represented as a computer graphic is constrained to prevent the graphic representation of the manipulator being moved through imaginary objects represented in the programmed world (Krueger 83).

Physical feedback can be provided to users by stimulators built into the manipulating devices that are activated when the user "touches" a notional object.

Touch may be used as output from a program in a manner similar to the "feel" of a car's performance.  In some simulators the whole simulator cockpit moves to simulate the attitude changes of the simulated vehicle.

### *2.2.8 Smell and Taste as input and output.*

Humans can control their taste and smell by the use of devices such as perfume.

Perfume can be used to communicate over a distance. Taste necessitates physical contact and is associated with the most intimate human-human and human-object communication.

Smells detected by humans are powerful memory cues, the “atmosphere” of a physical location has much to do with associated aromas.

In a less intimate role taste in humans is used to detect foulness in food and can be used to identify the source of a wine. The difference between a badly prepared meal and a well prepared one can communicate a considerable amount between humans through taste.

Computer systems do not currently make use of smell and taste for input and output in human-computer interfaces. Wilson’s “Time Entity” installation (A2.7) made use of pine trees to create an atmosphere, but this did not play a role in the human-program interaction. Participants in Chico MacMurtrie’s “The Trees are Walking” (A14) were, however, able to trigger the release of scents.

### *2.2.9 Other input and output.*

Devices used for monitoring human autonomic systems may be used as output to a program. Alpha wave monitoring, lie detection techniques etc. may provide a program with extra input from the human, but the participant’s degree of control of such output could not be expected to be particularly high.

Couchot’s use of blowing (A5.1) is an intriguing method of human output and could possibly be responded to in kind by a machine.

Krueger mentions the senses of balance and momentum as inputs to humans (Krueger 83). These can be combined with forms of touch input as, for example, in flight simulators.

Involuntary, or unintentional output from programs is also possible: the sound of a computer reading and writing data to disks can often be interpreted by a computer user as significant feedback regarding a program’s activity.

## *2.2.10 Combining input and output devices.*

The various classes of devices or routes described above can be used on their own or more often in conjunction with each other. The 21 possible combinations are described in figure 2.2.10.a.

**COMBINING INPUT AND OUTPUT DEVICES**

| | |
|---|---|
| **A** | sound |
| **B** | vision |
| **C** | taste |
| **D** | smell |
| **E** | touch |
| | |
| **F** | sound + vision |
| **G** | vision + taste |
| **H** | taste + smell |
| **I** | smell + touch |
| **J** | touch + sound |
| | |
| **K** | sound + vision + touch |
| **L** | vision + taste + sound |
| **M** | taste + smell + vision |
| **N** | smell + touch + taste |
| **O** | touch + sound + smell |
| | |
| **P** | sound + vision + touch + smell |
| **Q** | vision + taste + sound + touch |
| **R** | taste + smell + vision + sound |
| **S** | smell + touch + taste + vision |
| **T** | touch + sound + smell + taste |
| | |
| **U** | sound + vision + touch + smell + taste |

Figure 2.2.10.a

When it is considered that these may be separated and combined further as input and output there are 21 X 21 = 441 possible input/output configurations. This is illustrated in figure 2.2.10.b.

| | OUTPUT | sound | vision | taste | smell | touch | Sound+vision | Vision+taste | Taste+smell | Smell+touch | Touch+sound | Sound+vision+touch | Vision+taste+sound | Taste+smell+vision | Smell+touch+taste | Touch+sound+smell | Sound+vision+touch+smell | Vision+taste+sound+touch | Taste+smell+vision+sound | Smell+touch+taste+vision | Touch+sound+smell+taste | Sound+vision+touch+smell+taste |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT | | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U |
| sound | A | | | | | | | | | | | | | | | | | | | | | |
| vision | B | | | | | | | | | | | | | | | | | | | | | |
| taste | C | | | | | | | | | | | | | | | | | | | | | |
| smell | D | | | | | | | | | | | | | | | | | | | | | |
| touch | E | | | | | | | | | | | | | | | | | | | | | |
| sound+vision | F | | | | | | | | | | | | | | | | | | | | | |
| vision+taste | G | | | | | | | | | | | | | | | | | | | | | |
| taste+smell | H | | | | | | | | | | | | | | | | | | | | | |
| smell+touch | I | | | | | | | | | | | | | | | | | | | | | |
| touch+sound | J | | | | | | | | | | | | | | | | | | | | | |
| sound+vision+touch | K | | | | | | | | | | | | | | | | | | | | | |
| vision+taste+sound | L | | | | | | | | | | | | | | | | | | | | | |
| taste+smell+vision | M | | | | | | | | | | | | | | | | | | | | | |
| smell+touch+taste | N | | | | | | | | | | | | | | | | | | | | | |
| touch+sound+smell | O | | | | | | | | | | | | | | | | | | | | | |
| sound+vision+touch+smell | P | | | | | | | | | | | | | | | | | | | | | |
| vision+taste+sound+touch | Q | | | | | | | | | | | | | | | | | | | | | |
| taste+smell+vision+sound | R | | | | | | | | | | | | | | | | | | | | | |
| smell+touch+taste+vision | S | | | | | | | | | | | | | | | | | | | | | |
| touch+sound+smell+taste | T | | | | | | | | | | | | | | | | | | | | | |
| sound+vision+touch+smell+taste | U | | | | | | | | | | | | | | | | | | | | | |

Figure 2.2.10.b

The following examples show how the system may be used to classify works.

| | | |
|---|---|---|
| Senster (A3.2): | F/B | |
| | human input: | sound + vision |
| | computer output: | vision |
| Smallworld (3): | E/F | |
| | human input: | touch |
| | computer output: | sound + vision |

Figures 2.2.10.a and b indicate both how many potential routes of I/O may be exploited and also how particular works may be classified according to the I/O routes used.

Simply classifying works has little value, but the system can be used as an aid to critical discussion of works by drawing attention to common features which can then be compared. In the examples above the way visual output is used in “Senster” and “Smallworld” may be compared but it would be more difficult to compare their approach to input as different classes of device were used in each work.

Discussion could also, for example, revolve around the importance of sound output from “Senster” ’s mechanism.

Many of the possibilities included in the diagrams are not currently available, but the potential for future works is indicated.

Further characteristics of I/O routes have been noted in sub-sections (2.2.5) and (2.2.9). For example, works may be classified according to the distance covered by the routes:

contact I/O
remote I/O via electronics
remote I/O via wave propagation
etc.

If these characteristics were included the diagrams could be extended further.

The comparison of the I/O routes in conventional interaction and the I/O routes used in a work indicates the existence of another characteristic:  the conventionality of the use of physical I/O routes.

For example: touch is normally used for a different kind of communication between humans than between human and program.

Conventionality is discussed further in (2.3.1).

### *2.2.11 Summary.*

*The fundamental I/O routes of humans are unlikely to change as the technology continues to develop.*

*Interaction can be seen to be between human and program via I/O devices.*

*Fundamental human I/O devices have been extended by the use of tools. They have also been assigned particular roles.*

*The fundamental I/O routes discussed were:*

*Sound*

*Vision*

*Touch*

*Smell*

*Taste*

*Other I/O routes may be developed.*

*There are 21 possible combinations of the fundamental I/O routes.*

*There are 441 possible I/O configurations between two participants based on these 21 combinations.*

*These I/O routes can be classified further according to characteristics like the distances they cover.*

*The use of physical I/O devices can be conventional or unconventional.*

## *2.3 The programmed interface.*

The changes in state of the various I/O devices described in (2.2) do not mean very much until they have been interpreted. Bolt illustrated the need for interpretation as follows:

> How do we know that a certain wave of the hand is indeed a *gesture* and not simply a hand waving idly in the air with no relevant intention behind it? Certain hand movements - or eyeblinks, shoulder shrugs, or whatever - *attain* to gesture in the eye of the beholder by virtue of the context in which they are employed. They are perceived as gesture because of the observer's cognizance of that context. (Bolt 84)

The changes in I/O devices must be interpreted by human and program if they are to be part of human-program interaction in a work. The characteristics which emerge when considering this aspect of works are discussed in this section.

### *2.3.1 The role of convention.*

The role of convention is clearly important in the interpretation of inputs and planning of outputs.

The degree to which conventions in typical human computer interfaces are affecting participant expectations was noted when considering responses to questionnaires about Smallworld (3.4.3) (3.5.3).

Conventions can be as simple as the direction a pointer on a screen moves in response to the movement of an input device like a mouse, or as complex as the pull-down menu and windowing systems adopted by many program designers.

Convention is less important when a participant is not familiar with the kind of computer interface being used in a work, but the conventionality of the interface of any work is nevertheless an important characteristic.

Krueger argues that participants should be able to understand how they elicit responses (A1.2). One strategy to achieve this is to use familiar or conventional interface techniques. As the history of art shows, the conventionality of a medium does not prevent the content from being unconventional. Conventions can, therefore, also be useful if participants are intended to attend to unconventional material accessed by using a familiar interface rather than to the interface itself.

Hypermedia techniques have been developed (A6) as a convention of data organisation and retrieval that appears to be gaining some support as they enable programs to be designed without recourse to learning complex programming languages; once a participant has learnt the basic "point and select" principles of their use increasingly complex databases of work may be accessed. It can be argued that hypermedia systems are likely to lead to works that are too conventional, or even banal, but to a considerable number of artists and participants, conventionality may be used to advantage.

Conventional ways of organising interfaces may be generated from guide-lines such as those proposed as a series of 30 proverbs by Gaines and Shaw to aid the design and evaluation of computer systems (Gaines & Shaw 84). Such criteria may be applied to determine the conventionality of the programmed interface of a work.

Alternatively, with the establishment of conventions in human-computer interface design there is material for the artist in the role of iconoclast.

Some artists will continue to make the unconventionality of the interface an important characteristic of their work. Ihnatowicz's works had unique interfaces (A3) and much of Wilson's work relies on the unconventional nature of the interface (A2). Krueger's work is interesting in that he has developed a kind of interface that could become conventional yet currently gains much from being unconventional(A1). The decision to adopt some conventional approaches in the development of Smallworld is discussed in (3.5.5) and (3.6).

### 2.3.2 *The use of icons.*

It is now common to use “icons” in graphic interfaces; graphic symbols that when selected by use of a pointing device indicate to the program that particular commands should be followed. It is apparent from a recent paper discussing their usefulness in interfaces that a great deal of research still needs to be done before their value can be fully exploited (Rogers 89).

The kind of interface chosen by an artist should take account of the time that the participant will have available to learn how to use it (4.1.7). Experienced users apparently prefer command-based systems (i.e. systems where commands are typed in using a keyboard) to icon based systems; new users find icon-based interfaces easier to learn and use. This is significant to artists using a screen-based interface (as in some versions of Smallworld) and users of hypermedia type systems. It is also significant that Rogers reported that when using a display based system users do not learn the content of the visual displays in the same way as they learn a set of command names, instead their behaviour is guided by what is seen on screen from moment to moment; the information on the screen needed to perform a particular operation is used and then forgotten.

### 2.3.3 *Content and order.*

Whether the programmed interface is conventional or not, the way it is used can transmit information at a meta level (Reffin Smith 84); the content of this transmission may vary between the conventional and the unconventional; between the explicit and the ambiguous.

In the program, information must be represented symbolically. David Marr has described a representation as, “a formal system for making explicit certain entities or types of information, together with a specification of how the system does this” (Marr 85). He gave as examples: Arabic and binary numerals, music scores etc.. He also wrote, however, that:

> ... there is a trade off; any particular representation makes certain information explicit at the expense of information that is

> pushed to the background and may be quite hard to recover.
> (Marr 85)

This supports Reffin Smith's remarks on the inevitable transforming effect of human-program communication (Reffin Smith 84).

In his discussion introducing "A Representational Framework for Vision", Marr wrote:

> Vision is a process that produces from images of the external world a description that is useful to the viewer and not cluttered with irrelevant information. (Marr 85)

The filtering is positive if irrelevant information is dispensed with, but will have a negative effect if relevant information is lost.

When considering the information received or sent by I/O devices in a work the degree of efficiency of any filtering process is clearly significant.

Marr was discussing an automatic filtering process. Cornock and Edmonds anticipated a process that assists conscious information filtering in participatory works: the seeking of order (Cornock & Edmonds 73).

Susan Tebby, writing about concepts of order remarked that:

> It is a part of the natural process in man that he attempts to order those things which are in apparent disarray, and to group things from a larger group. He does this according to certain sensibilities and criteria within himself, and also to certain laws outside himself. Those laws are a consequence of the inherent characteristics of those things being ordered. (Tebby 83)

The degree to which a work may be perceived as ordered can be considered a characteristic.

With reference to sub-section (2.3.1), the conventionality of the order perceived can also be considered characteristic.

The tendency to seek order can be exploited in the design of a work and is discussed further in (4.1.7) as it relates to the need to measure performance.

### *2.3.4 Summary.*

*The changes in I/O devices must be interpreted.*

*Conventions for interpreting changes in I/O devices are emerging.*

*Conventions can be used in three ways:*

- *to produce predictable or banal work*
- *to access unconventional content*
- *iconoclastically*

*Artists can choose to develop unconventional interfaces.*

*Unconventional interfaces can <u>become</u> conventional.*

*New users find icon-based systems easier to learn to use.*

*The behaviour of users of display based systems is guided by what is seen from moment to moment; the information needed on screen is used and then forgotten.*

*The programmed interface can transmit information at a meta level.*

*Some information in an interface may be made explicit at the expense of other information.*

*This "filtering" can be positive or negative.*

*It can be anticipated that a participant will seek order in an interface.*

*The degree to which an interface in a work can be perceived as ordered is characteristic.*

*The conventionality of the order perceived is also characteristic.*

## 2.4 *Programmed worlds.*

An increasingly common approach in interactive participatory work is to use the computer technology to represent an imaginary world or place designed by the artist and to enable the participant to interact with it. Smallworld (3) is an example of this approach, as are Krueger's "Videoplace" (A1.4), Jeffrey Shaw's "Legible City" (2.4.1) and the work of Matt Mullican (2.4.1).

In the early 1990s the approach is receiving popular attention due to the combination of several technological devices which enable head-mounted presentation of stereographic animated imagery which changes as the user moves his or her head, giving the impression that they are inside a programmed world. The user's illusion of immersion in a "virtual reality" is further enhanced by the use of devices that monitor hand or body movement like VPL's Dataglove and Datasuit. "virtual reality" is discussed in 2.4.3.

Artists using computers, including those whose work is not participatory, often take advantage of the freedom to design imaginary worlds that are governed by different rules to those that appear to govern actual physical space.

This section addresses the degree and manners in which programmed worlds can appear similar or different to the actual world, the factors that contribute to the effects of these characteristics, and issues raised by this approach to works.

### 2.4.1 *Visual similarity to the actual world.*

One of the characteristics of works that represent programmed worlds graphically is the visual similarity of the images on screen to the actual world. The similarity depends to a large extent on the technology and visual conventions used to represent the programmed world. The physical world appears three-dimensional, therefore the use of I/O devices that simulate the visual characteristics of three dimensions in programmed worlds can increase this visual similarity significantly.

Mullican's work, reported in February 1990 (Pye 90), which is intended eventually to be interactive, included an animation through which the viewer was taken on a tour and shown parts of a city represented as 3D computer graphics. The features of the part of the city where the journey started were recognisable as architecture but became less and less familiar during the course of the journey into other parts of the city. The transition from the familiar to the unfamiliar, from the realistic to the non-realistic was an important part of this work as it drew attention to the fact that the city was programmed rather than a representation of an actual city.

In Shaw's "Legible City" the buildings were replaced by words, presented as 3D computer graphics, which could be read as the participant navigated around the composition (LeWinter & Baron 90). Shaw based his composition on the street-plan of Manhattan. There was little similarity between the visual appearance of the programmed and actual cities except in the plan of the streets. References to non-visual aspects of the city were used to enhance the experience (2.4.2). A physical semblance of an actual vehicle was provided by the device used by the participant to control their journey, which consisted of a kind of push-bike.

Shaw wrote in a statement about his work for "Der Prix Ars Electronica":

> The research and development of various mechanisms and codes of spatial representation has been a major preoccupation throughout the history of Western Art. The application of three dimensional computer imaging technologies in this context has a revolutionary meaning. Instead of the traditional activity of art as a representation of reality, the artwork can now become a simulation of reality within which the viewer's point of view is located. "The Legible City" is a first example of this possibility of the digital image to evoke a three dimensional virtual space which the spectator can enter and explore.
> The spectator is able to use a bicycle to interactively travel in a video projected three dimensional virtual image space. In the first realized version of this work the image space in which the bicyclist can travel is based on the ground plan of Manhattan, New York ... using real-time computer graphic technology, the city is visualised by solid three dimensional letters that form words and sentences along the sides of the streets ... the actual

> Manhattan architecture of buildings is completely replaced by a new architecture of text. (Shaw 90)

Both Mullican's and Shaw's work can be seen to owe a lot to the development by the Architecture Machine Group of the "Movie Map of Aspen Colorado", described by Bolt which enabled a user to navigate around a computer model of the city and see recorded photographic images of their imagined current location, read from video-disc, presented on a monitor (Bolt 84).

In the programmed world in Krueger's work the participant is represented by a surrogate figure on screen. The visual similarity between it and the participant is very close as the image is input by video camera, except that the surrogate is represented as a 2D silhouette (A1.4).

In Smallworld, recognition of the degree to which verisimilitude could be achieved in novels by encouraging readers to "fill in the gaps" led to an approach that favoured sparseness of information and a reliance on the human tendency to anthropomorphise phenomena (2.5.1) (3.1.4).

The participant's comparison of experiencing the works and experiencing the actual world is an important factor of all these works yet they each use a different visual approach.

Mullican's and Shaw's programmed worlds are related to cities. It can be argued that Mullican's city is more like a city than Shaw's, as its architecture looks more like buildings, yet Shaw's city plans are based on actual streets and Mullican's is an imaginary formal city.

In Krueger's programmed world, although the visual representation in silhouette is quite stylized, the activities of the participant's surrogate mimic events in the actual world; "strings" are plucked and "objects" lifted (A1.4). The familiarity of the way these objects may be "manipulate"' is important: participants can use a lot of their motor knowledge of the actual world when interacting with the programmed world to corroborate the impressions from the visual display.

Smallworld eschews visual imitation and uses a symbolic representation of events.

Gombrich drew attention to J.J.Gibson's identification of characteristics of our world that we usually accept as natural:

> ... which provide opportunities for tremendous economics in reducing the amount of information to which we have specially to attend. These economics increase progressively as we are confronted with a familiar environment, where the objects we encounter conform to expectations... (Gombrich 79)

There are implications here when relating the realism of interactive participatory works to a participant's familiarity with them. There is also a relationship with conventionality, discussed in sub-section (2.3.1), and the conscious filtering of information (2.3.3).

Gombrich noted that the difference between recognizing a real snake in the actual environment we occupy and identifying a wavy snake-like line is considerable. A snake-like shape can however be seen as a living serpent and can be endowed with a "presence" independent of the degree of naturalism employed by the artist. The process depends, according to Gombrich, at least as much on what he calls the "beholder's share" as on the artist's wish to portray reality (Gombrich 79).

Krueger recorded that when participants expected interaction in "Glowflow" (A1.1) they experienced more than was actually there.

An impressive flight simulator, which uses a relatively crude graphic representation of a landscape, is often found on Silicon Graphics IRIS workstations. Despite the fact that there are no sound effects and the participant is not in a simulated cockpit, the apparent existence of the imaginary world being "flown" through can be enhanced when further evidence of it's existence can be provided by fast and appropriate feedback. During the imaginary flight the "pilot" builds a convincing three-dimensional map of the imaginary world in their mind as the "aircraft" responds to their instructions. There is a difference between simply watching a film taken from a pilot's eye view of an aircraft flight (which can have a great effect when shown using IMAX cinema systems of Imax Systems Corporation, Toronto) and using a simulator as no matter how convincing the illusion of flight is in the cinema, when using the simulator the user can relate changes of views to their physical control of the program. In doing so they build a non-visual memory of motor-activities that can be associated with other memories of particular events during participation.

As visual similarity to the actual world can vary considerably in works it is an obvious characteristic to discuss when comparing works. Works can also exhibit similarity to the actual world in other ways.

### *2.4.2 Non-visual similarity to the actual world.*

To imagine alternative realities appears to be a fundamental human ability. For example: when reading a novel, which affords the reader no opportunity to see or actively test an imaginary world's existence, the reader can still build a convincing mental image of the world in which the story is told and can identify strongly with the characters and events described. Travel book writers develop special skills to exploit this ability in readers. These writers are able to establish a verisimilitude by relying on the reader's ability to extrapolate from information presented to them by the writers.

It can be argued that to a large extent the actual world occupied by humans is imaginary. Rudolf Arnheim argued that a work of architecture is never seen in its entirety by anybody; a mental image is synthesised from partial views (Arnheim 77). The same is true of any non-transparent three-dimensional object.

Much of the actual world, rather than being experienced directly, is experienced indirectly at second or third-hand and through interpretation of reported information. Familiarity with and trust of the medium through which the information is received can add to the degree of realism assigned to the information, i.e. the degree to which the recipient believes the information represents an actual event.

Television viewers are so used to seeing actual events on television that presenting something fictional on T.V. can encourage the suspension of disbelief necessary to interpret the representation as realistic. A less visually detailed image can often be interpreted as more “real” than a more detailed one: Poor quality amateur film-footage of an actual event will be considered more real than the professional quality film in a “disaster movie”. It has also been observed that when focussing a T.V. camera on a photograph of a scene and adjusting the focus whilst looking at a T.V. monitor some people will feel as if they are focussing on a real scene rather than a photograph; an effect which does not occur so readily if a higher resolution computer monitor is then used. This appears to be because the T.V. image, through familiarity, is considered to be more “real” although less detailed.

The degree to which a programmed world can be believed to exist may not therefore necessarily depend on a detailed visual representation.

The degree of realism in Ihnatowicz’s “Senster” was not solely dependent on visual “realism”. “Senster” looked a bit like a lobster claw but it was evidently man-made. It appeared intelligent when it actually was not (A3.2) because people extrapolated from the behaviour they witnessed, using their imaginations.

When participatory works appear to respond more or less intelligently non-visual realism can be identified that is related to the apparent intelligence of a work. In an interactive work the extent of realism of the apparent intelligence can be explored further but, as Gombrich wrote, there is a difference between representation and reality. We can continue looking at and exploring the actual world, using artificial means if necessary. An image is, however, strictly finite (Gombrich 79).

Gombrich was referring to *images* of the actual world but the same can be said of actual intelligence and simulated intelligence; we can continue to explore actual intelligence but programs that are apparently intelligent have limits; they may, for example, only be able to play chess.

Programmed worlds can, however, *appear* to be infinitely explorable. When using a fractal approach to programming, for example, continued closer and closer investigation of a shape can appear to reveal finer and finer details (Mandelbrot 82).

Physical feedback and information other than the visual can also be more or less similar to that in the actual world. There are few artists who have access to equipment of the degree of sophistication of aircraft simulators, but the degree to which works that pursue non-visual realism approach closely to actual situations can be considered to be characteristic.

The degree to which participants can be led by a system's responses to believe that they are actually interacting with something other than a programmed work is the interactive equivalent of trompe l'oeil in painting; where a painter deliberately paints a picture that will fool the viewer into believing that they are looking at an actual object rather than its painted image.

"Realism" also depends on believability as well as accurate simulation.

Humans have made representations of imaginary and real things for centuries and have populated imaginary worlds with imaginary characters. In some cases the imaginary world and its characters can appear more significant than events in the actual world, as in soap operas and religions. The willing suspension of disbelief by participants is essential for the realisation of many artistic works, where, for example, actors imitate the personalities and behaviour of characters.

A situation is now approaching, however, heralded in computer games, and works like Wilson's "Time Entity"(A2.7), where representations of characters can be given apparent autonomy; they will, in fact, cease to be representations and effectively become the characters. To some extent this happens in Smallworld where participants have been heard to remark that the creatures in it appear to be real, although it has yet to reach the stage of A.K. Dewdney's fictional "Planiverse" (Dewdney 84), in which humans are mysteriously able to contact an inhabitant of a two-dimensional world.

At a conference at Preston, U.K. in 1989 two of the speakers, Jasia Reichardt and Simon Biggs, drew attention to the implications of the developments of the programmed worlds approach to human-computer interaction.

Biggs drew attention to the prospect of humans being able to simulate and build the creatures of their mythologies:

> As we learn to radically alter our environment, using genetics to create life forms and computers to synthesize data, what will our
> relationships be with the things we create? What are our fears and desires? How will they shape their own destiny and our response to them?
>
> In the final analysis, humanity's relationship with the world has evolved as its ability to control and shape it has developed. Now we have available the means not only to edit nature but also to produce it. Traditionally this has only been an option in the symbolic universe - exercised by the likes of artists and magicians.
> (Biggs 89)

Reichardt drew attention to the possible obfuscation of reality in contemporary culture:

> One cannot attribute it solely to the rise of computer generated images, but until the last 30 years it belonged either to trompe l'oeil in art or to camouflage in war. Now it is everywhere.
> (Reichardt 89)

The programmed world may also have symbolic references to the actual world like the texts in Shaw's "Legible City" (2.4.1).

> ... the city is constituted physically by the three dimensional arrangement of words into streets, and the city is constituted psychologically by the meaning these words carry as they are read by the bicyclist travelling through these streets. The texts have been written as eight separate storylines that have a particular relationship to Manhattan - for instance monologues spoken by Mayor Koch, Frank Lloyd Wright, Donald Trump, Noah Webster, a cab driver, a tour guide, an ambassador etc.. Each storyline has a specific location in the city, and each is

> identifiable by the particular colour of its letters. Thus the bicyclist/reader can follow one storyline by following its colour and also recognise his/her shifts from one storyline to another because of the colour changes. (Shaw 90)

The degree to which an imaginary world, though clearly fictional, appears *believable*, is evidently an important characteristic of the programmed worlds approach to works.

Believability does not necessarily rely on a direct visual resemblance.

In Smallworld the participant can vary the rate at which events take place and they can record and re-run events. This degree of control over events is far from "realistic" in its treatment of time. The degree to which the participant's influence on Smallworld can change is also far from realistic and yet it can still be believable. The program that generated apparent predator-prey behaviour was not based on the same motivations as actual predator-prey behaviour but can be interpreted as such by a participant using the observational tools they would use if observing actual predator-prey behaviour (3.1.3). Being a participant in Smallworld is similar to using a scientific instrument that extends the users sense-abilities (Wilson 83) to observe microscopic or distant events. Such instruments do not necessarily rely on visually realistic imagery, but can still be used to make sense of actual phenomena.

### *2.4.3 Is the participant inside the environment or outside looking in?*

The degree to which participants feel themselves to be *in* a programmed environment can vary, as can the degree to which the imaginary world is presented as part of the actual environment. Humans are quite able to read themselves into an environment presented graphically and this may be exploited to a greater or lesser extent.

Some works actually exist in the same environment as the participant; the programmed world is part of the actual world.

This is illustrated clearly in Kikauka's "Misplaced Affection" (A7).

Ihnatowicz's works also occupied the actual world; their sculptural presence was both visual and physical. In the case of "The Bandit" the work was actually manipulated by participants (A3.3).

Krueger's world is presented in silhouette and the participant is represented in it. The interaction is via the surrogate representation which enters the world *for* the participant. Rather than being presented with a direct view of a place, in Krueger's work participants are presented with something that could not normally be observed without being monitored through a scientific instrument of some kind; the participants see themselves (or more accurately their representation) from the outside. It is still possible, however, for them to imaginatively "project" themselves into the programmed world.

Mullican's and Shaw's "cities" are presented as projections on screens, viewed as if through a windscreen from the point of view of a driver in a car , using the conventions of perspective to present the participant with a view similar to something they could see naturally without the assistance of instrumentation. They are presented with a window onto a world that does not impose on their actual world physically, although the cycle in Shaw's work presents an enigma; it is in some way in both worlds, acting as a bridge between the two.

A participant enabled to navigate through these imaginary environments may be led to build up mental images of the programmed world and their current position relative to features that they have identified. This principle is used to navigate around information retrieval systems like the "Dataland" experiments at M.I.T. . Bolt noted that this human ability to navigate around imaginary architectures was recognised around 500 B.C. by Simonides whose "Method of Loci" consisted of a mnemonic technique of committing material to memory by associating it with detailed locations and features in an imaginary environment. "Dataland" 's success depended on the familiar spatial arrangement of realistic representations of data (Bolt 84).

In Krueger's "Psychic Space" (A1.3) the participant could navigate through a maze represented on screen by walking around the room. The maze could not be seen except on screen but effectively intersected with actual space in a similar way to Shaw's bicycle's intersection with the programmed environment.

In both these examples the programmed worlds intervened physically in the actual world to some degree. When imaginary worlds are represented totally on computers their location becomes ambiguous because they only exist in the imagination - like places described in books. Yet unlike the imaginary worlds of books several people may explore them and interact with each other at the same time and the routes of exploration in these places may be determined more freely than in the imaginary worlds of stories in books.

In some works participants can communicate over long distances via programmed worlds or "places". We are, as Krueger remarked, being provided with more and more methods to enable us not only to perceive events at a distance but to act at a distance via remote control. Malina noted that this can be an important characteristic of interactive work produced using computers (1.1.3). This potential has been explored extensively (Ascott 84) and a recent issue of Leonardo, co-edited by Ascott and Carl Eugene Loeffler, was dedicated to the subject of Art and Interactive Telecommunications.

> The new telematic systems of computerised communications are giving rise to a new, felt quality of human presence, ... . Simply put this is a quality of being both here, at this place, and also there, in many other places, at one and the same time - both here-and-there or here-or-there, simultaneously or asynchronously. The play is with presence, place and time - the intermingling of presences, of space and time. This is a strange experience, new in the repertoire of human capabilities. To meet others in dataspace, mind to mind, virtually face to face, at no matter what geographical location, or in multiple, dispersed locations, in real time or in computer-mediated asynchronous time, is exhilarating. It is also demanding. (Ascott 91)

In the U.S.A. there is a computer network club where people control the behaviour of surrogate characters in a graphically presented programmed world who form relationships and even get married. (Antenna 89)

Several Silicon Graphics IRIS workstations can be networked together and, using the flight simulator several "pilots" can appear to be flying and dogfighting with each-other in the same imaginary space.

Krueger wrote that:

> ... our sense of "place" is based upon the ability to communicate. The place created by the act of communication is not necessarily the same as that at either end of the communication link, for there is information at each end that is not transmitted. The "place" is defined by the information that is commonly available to both people. (Krueger 83)

Recognising the genius loci or "sense of place" is an important part of the experience of architecture; it could also be a significant component of the experience of these programmed places. The interface is certainly not just a space in the physical sense, but it can be sensed to be a "place". If the interface is sensed as a place, it is possible for it to have a genius loci. The interface is in fact a *sense* of place rather than an actual place. The virtual architecture of a human-computer interface might therefore be able to evoke responses similar to those created by actual architecture. When this is the case, the sense of place in a work can be considered one of its characteristics.

When considering the peculiarity of a sense of place when no actual place exists, it is worth noting that the sense of place depends on the assignment of meaning through creative interpretation by the human imagination.

Saussure wrote that linguistics:

> ... works in the borderland where the elements of sound and thought combine; their combination produces form, not substance. (Saussure 59)

Lao Tzu stated that:

> Clay is moulded into vessels,
> And because of the space where nothing exists

> we are able to use them as vessels. (Lao BC 300)

Like the combination of the elements of sound and thought and the space where nothing exists in Lao Tzu's vessels the space in a human-computer interface has an implied form, but a form none-the-less. In the human interpretive imagination the forms of imaginary places of human-computer interaction can be as recognisable as the insubstantial forms of language and the emptiness of a vase.

The "sense of place" in some interactive participatory works may share characteristics with actual architecture, but freedom from physical constraints will also lead to new types of place.

The imaginary space being considered has already been elaborated in fiction by writers like William Gibson, who described it as Cyberspace; a matrix of networked programs that people are able to project their disembodied consciousnesses into using in a near-future technology (Gibson 84).

As well as being explored in the dystopic fiction of "Cyberpunk", this non-space is being explored by developers of "virtual realities". A term derived from a seminal article by Ivan Sutherland in which he wrote:

> The screen is a window through which one sees a virtual world. The challenge is to make that world look real, act real, feel real. (Sutherland 65)

Jeff Wright, struggling to explain the concept as understood in the late 1980's wrote:

> At first glance, the idea of a "virtual reality" may seem difficult to comprehend, as the dictionary definitions of the two words are contradictory: Virtual means "existing or resulting in essence or effect, though not in actual fact, form, or name," while reality means "the quality or state of being actually true, or that which exists objectively and in fact."
>
> One definition of virtual reality might be an illusion that is so good that we respond to it realistically. At a very basic level,

> television offers a kind of alternate reality. When we watch a scary movie, even though we know that what's happening to the actors on the screen isn't real, our physiological and emotional responses to the action can be similar to those which would occur if we were in those situations ourselves.
>
> Now imagine how much more real that experience would be if we could step inside the movie scene, see the things as solid, three-dimensional objects, touch and move them, change them, react to them, and have them react to us. Imagine, further, the ability to bring others with you to explore it.
>
> Providing that kind of capability is the goal of virtual reality technology.
> (Wright 89)

The entry in the 1991 "Art and Telecommunications Glossary" in Leonardo (ATG 91) described virtual reality more succinctly:

> Virtual Reality - this term encompasses all computer-generated environments that enable users to simulate entry, through use of bodily peripherals such as datagloves and head-mounted computer-graphic displays, into a 3D multi-sensory data construction involving sound effects, dynamic 3D graphics and, lately, tactile simulations of a real-life environment. (ATG 91)

"Cyberspaces" and "virtual realities" promise to become new kinds of imaginary worlds in which humans can explore important mythical and psychological dramas as well as accomplishing practical design, communication and information-retrieval tasks. The degree to which a work makes use of the concepts of cyberspace or virtual reality is another characteristic that may play a part in works.

There is also, associated with virtual realities, a phenomenon that users have experienced, but due to the current newness of the technology remains to be explored fully: after using VR equipment the user can have a memory of the sense of the place they appeared to occupy that is so powerful that it is temporarily superimposed over the actual space the user returns to on "leaving" the virtual world. They are momentarily disoriented and in some way in two places at once. This may be a passing phenomenon experienced due to lack of familiarity with the equipment, but it may also be an area for future exploration by artists.

Virtual realities differ from the "Responsive Environments" foreseen by Krueger (Krueger 83) which are not imaginary environments but actual environments that respond to human needs.

The concept of virtual reality is so appealing to many people that Gibson has been moved to comment that some people reading his books appear to have missed several levels of irony (Horizon 91).

The degree to which programmed environments are actual or imaginary can be identified as another characteristic of works that pursue the programmed worlds approach, as can whether the participant is physically or conceptually inside the programmed world or observing it from outside.

### *2.4.4 Extending human senses of the actual world.*

Wilson referred to the significance of the use of computer technology to extend what he calls sense-abilities - human senses - to provide humans with access to stimuli that could not be sensed before. His examples include medical screening and sound amplification (Wilson 86).

Krueger has made works that present people with a view of themselves that they would not ordinarily see, by delaying the display of the silhouette (A1.4).

This ability to extend human senses is not, however, an effect unique to the use of computer technology. For example: the artist, Terry Pope's optical devices extend the user's visual perception by use of mirrors to remarkable effect (Pope 64) (Brisson 82).

Artists have for centuries been altering the way people interpret what they sense by means that do not exploit computer technology.

Once information is represented as data in a computer it may be re-presented in many ways. In Smallworld, for example, the effects of displaying the same data in different ways could be explored by comparing the shapes produced by the DEPTH, FIRE, TRACK and MOVIE programs (3).

The effect of representing scanned data in different ways in scientific applications is well developed and interestingly the use of "realism" to assist the identification of mineral deposits by representing them as surface features like lakes and woodland rather than in arbitrary colours has proven to be advantageous (Robertson 87).

### *2.4.5 Summary.*

*Computer technology can be used to represent imaginary worlds and to simulate the actual world.*

*Visual similarity to phenomena in the actual world is not essential to the convincing representation of a programmed world.*

*Participant expectations and imaginations can contribute to the realisation of a work.*

*The apparent intelligence of a system can be seen as a form of realism.*

*The passage of time can be realistic or non-realistic.*

*Realism relies on believability as well as accurate simulation.*

*In an alternative approach, the truth can be seen to be hidden in works that pretend to be something other than what they actually are.*

*Participants can place themselves in several relationships with the programmed world. They can be:*

- *outside looking in*
- *outside looking in but controlling a surrogate within the programmed world*
- *imagined to be inside a "virtual" environment*
- *inside an actual responsive environment*

- *interacting with the programmed world as if via a scientific instrument*

*The location of programmed worlds can be ambiguous as they are often completed in the imagination of the participant.*

*Several participants can interact with each other in a programmed world.*

*The interface can be considered to be a "sense of place".*

*The programmed world may extend participants' senses of themselves.*

## 2.5 *Communication.*

Interaction between human and program can involve communication. Communication, in the sense of passing information, can be one-way or it can be interactive. This is represented in figures 2.5.a and 2.5.b; the arrows indicate the direction information is passed.


Figure 2.5.a


Figure 2.5.b

In some works the information passed from participant to program may appear to be fairly simple, for example: pressing a key. The context in which this simple signal is passed, however, can lead to a more complex interpretation of its significance.

### 2.5.1 *How much communicators need to know about each other.*

Krueger proposed that if the work is to respond intelligently it must understand as much as possible about the participant's behaviour (1.1.2). Currently this implies that the programmer must in some way include in the program as much as is known about likely human behaviour in the situation the participant will be confronted with.

Ihnatowicz's "Bandit" (A3.3) had software specifically designed to work out the sex of the participant, but that was all it could "know".

The task of writing programs that recognise human behaviour or "know" a lot about them has proved difficult. It has led to a remarkable amount of research during the past forty years, but as Gaines wrote of man-computer communication, we lack knowledge of the human's mental "world model" and the difficulties of constructing adequate models of the world within computers have been barely realised.

> ... we cannot program that which we do not understand ...
> (Gaines 78)

Gaines referred to our lack of understanding of both parts of the upper half of the diagram reproduced in figure 2.5.1.a

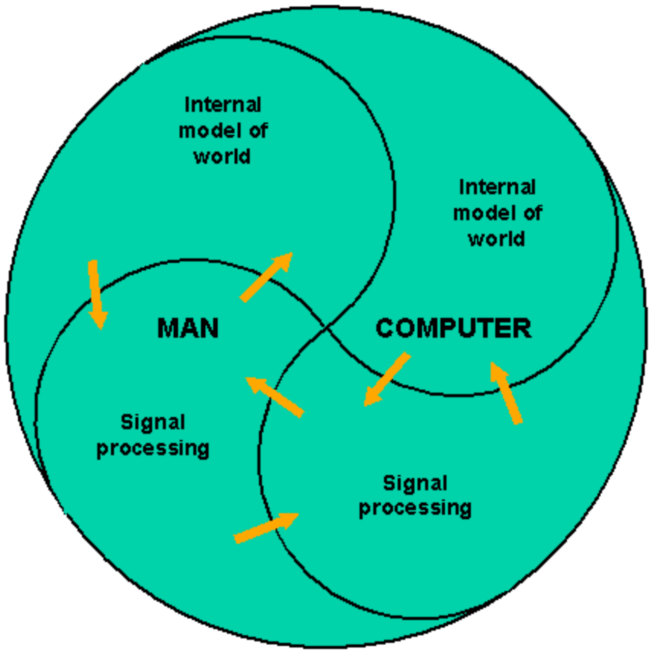



Figure 2.5.1.a
(After Gaines)

He wrote that it is necessary for a program to have a world model similar to a human's when it is intended that human and computer communicate.

> The processes of man-man communication that we wish to extend to the computer seem dependent on some assumption that those communicating share much of their internal world models - not in a Jungian sense ..., but at least as related domains of knowledge ...
>
> The "world models" of man and computer can be considered separately from *the* "world". It is our common "hallucination" that is significant, not its source or accuracy. This is significant because it emphasizes that much of the "world" relevant to discourse is not the hard empirical world of the physicist, but rather the constructed, imagined world of artist, novelist, and poet - the world of concepts and possibilities that we ourselves fabricate. We can speak of "unicorns", "beauty" and "god", as readily as we speak of "length", "atoms" and "physical dynamics" - perhaps more readily because myth, emotion and faith are buried deeper in human nature than is our veneer of numeracy and measurement. (Gaines 78)

If both Gaines and Krueger are correct, the nature of future works would appear to depend on the development of artificial intelligence techniques, otherwise programs will not be able to understand as much as possible about participants.

Artists are already involved in A.I. research; notably Harold Cohen and Stephen Wilson. Cohen's program "Aaron" (Cohen 83) was designed to recognise compositional features in the work it produced; its artificial intelligence was addressed to aspects of the human world model of Cohen himself. Wilson's work addressed more general aspects of the human model of the world (A2).

Considering the success of Ihnatowicz's "Bandit", which only had very rudimentary guide-lines for its deliberations, it would be better to modify Krueger's principle (1.1.2) to; "It is imperative that the computer's grasp of the participants behaviour be as complete as *necessary*".

If the interaction is to be symmetrical (2.1.3) another principle must be included; "The humans grasp of the computer's behaviour should be as complete as necessary". This reversal actually makes the principle appear less convincing if we consider how much, and what, humans actually know about each other. It has been suggested that an important faculty of a human being, perhaps the most important, is that of trying to see things from another human's point of view; to empathise with them. Humphrey identified a functionality in the human that he referred to as the "inner eye":

> The inner eye may have evolved for one purpose and one purpose only - to enable people to read the behaviour of other people like themselves - but with it we have the capacity to make OUR MINDS the measure of all things. (Humphrey 86)

When exercising this ability, humans do not limit themselves to empathy with other humans. Just as there is a powerful inclination in some humans to treat anything animate or inanimate, including images, anthropomorphically, so also is there an inclination to empathise with anything being anthropomorphized.

There is evidence that through empathy a human can identify so closely with a human or non-human object involved in some event that they will react as if involved in a similar event. In Krueger's "Videoplace" participants often identified with their image so much that when the image was jumped upon and moved off screen by the "critter" they felt as if they should also move (Krueger 85).

This ability to put oneself in another person's place was crucial to human evolution according to Humphrey. It may well be crucial to the evolution of programmed intelligences and their communication with humans. Humphrey claimed that:

> Human intelligence and human social systems have developed hand in hand. (Humphrey 86)

If Humphrey's interpretation of evolutionary patterns is correct, it would seem that programmed intelligence is more likely to evolve through computer programs communicating with each other rather than with humans.

It then becomes necessary to consider whether it is actually necessary for a computer's world model to coincide with humans'. It would appear to be more sensible to follow the pattern identified by Humphrey and have programs put themselves in the humans' place, i.e. see humans as programs, using whatever functionalities that constitute *their* "minds" to be the measure of all things.

When looking for a model for human-program communication it may be profitable to accept Gaines' assertion that we cannot program that which we do not know and consider how humans communicate with non-human animals, like dogs, even though they are different creatures. And even speculations about how humans might communicate with aliens (Minsky 85).

Some people appeared to try and communicate with Ihnatowicz's "Senster"; the communication was not necessarily actual but people appeared to try and form some kind of relationship with the work by trial and error. They appeared to interpret its behaviour as if it was a kind of animal, or at least something with a responsive intelligence.

With regard to human-program communication, McDonald and Concklin posed the question: as most humans are not remarkable in their use of language why make computers super-human?

> Most of us, as we speak, notice when we have left something out or inadvertently given the wrong emphasis, and we correct our mistakes by interrupting or modifying what we are about to say next; in explanations we use feedback from our audience such as questions or puzzled looks to dynamically adjust our vocabulary and level of detail. (McDonald and Concklin 82)

With "Senster" (and also with "SAM") (A3.2) (A3.1) people appeared to be using feedback in the way discussed by McDonald and Concklin. The communication was fairly simple; of the order of "I am here" or "Come here".

The relationship appears on video somewhat like that between a man trying to get a puppy to understand what is meant by the command "sit". (It appeared like this and yet "Senster" did not incorporate a dog behaviour program). The similarity is only partial. the relationship built between dog and human is based on provision of food, shelter, etc. and is far more complex than any between a human and a program so far.

It is also worth noting that although the dog is a social animal and humans and dogs have evolved in close social proximity, communication between human and dog is still limited compared to communication between human and human. Perhaps, following Humphrey's argument, because dogs see humans as if humans were dogs.

Dogs, it is worth noting, although commonly held to be less intelligent than human beings, may still initiate communication.

One of the characteristics of communication in works that can be identified, therefore, is the degree to which communication is initiated by the participant or program.

The world model of a program, or its model of the user, may also be considered as a characteristic of a work.

The degree to which communication is important in the work and the degree to which a human world model is incorporated in the work can be seen as further characteristics.

The need for a world model in the program approximating to humans' as closely as possible is, however, predicated on the belief that it is necessary for communication between human and program. Even if this belief is accepted, the model as a characteristic only becomes significant if communication is important to the work.

### *2.5.2 Who the communication is between.*

As well as considering how essential communication is in a work and how it can be achieved it is also necessary to consider who the communication is between, who initiates the communication, and the means through which the communication occurs.

Cornock and Edmonds' models of creative situations (1.1.1) offer some guidance in building a model of communication in an interactive participatory work that uses computer technology, but theirs is a general model of art practice.

The communication in the human-program relationship in a work can be considered in the following ways:


Figure 2.5.2.a

In figure 2.5.2.a the artist is using the program as a means of communicating with the participant concurrently. The computer facilitates exchange.

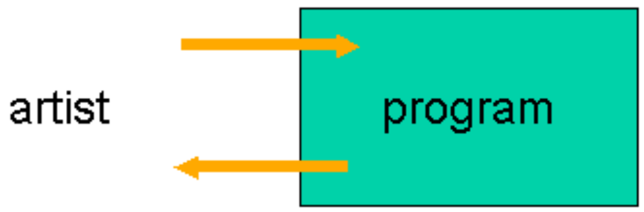



Figure 2.5.2.b(i)

In figure 2.5.2.b(i) the artist is using the program as a device for reflective activity. Participants can then be allowed to share this facility, as illustrated in figure 2.5.2.b(ii). In the second figure the program is autonomous (i.e. the artist does not control it actively).

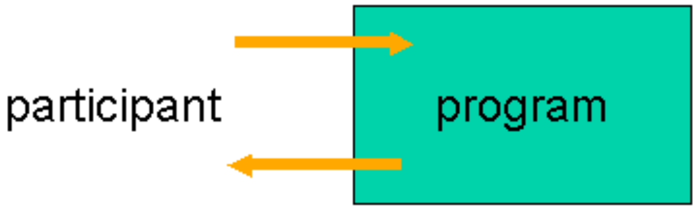



Figure 2.5.2.b(ii)

The communication in these cases is essentially between human and human via the program.

The world models used to interpret this kind of communication are as good as they can be as the communication is actually human-human and the world models of artist and participant are used.

In the case illustrated by (b), however, the modification and checking using feedback mentioned by McDonald and Concklin (2.5.1) can not be done by the artist; it must be built into the system; controlled by the participant and/or the program.

It has already been seen that it is currently not possible for a program to communicate with a human like a human, although while considering potential characteristics it would be unwise to assume that this will never be possible (Horizon 90). In the meantime many different approaches are being followed in Human-Computer Interface research and are well documented in the journals like the International Journal of Man Machine Studies and proceedings of conferences dedicated to the subject.

Although the range of possible communications can be implicit in the design of the program it is possible for communications to occur that are not explicitly planned by an artist. This constitutes a special case illustrated in figure 2.5.2.c.

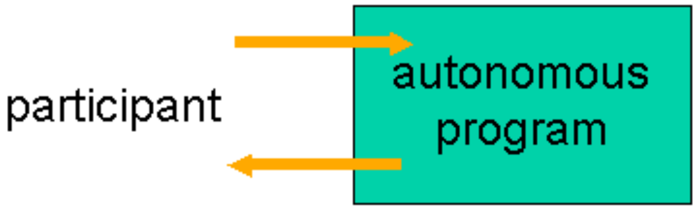



Figure 2.5.2.c

The communication between participant and program in this case is between participant and an apparently autonomous entity or entities. It is possible that the participant will initiate and continue communications unforeseen by the artist.

An interesting example of human-program communication in the actual world is that of Peter Beyls' "Oscar"(Beyls 88), a computer program that is intended to simulate a living musician. In this case the communication being simulated has a reference in the actual world; just as it is possible to recognise the "realism" of a photo-realistic graphic representation of a programmed world (2.4.1), it is possible to compare "Oscar" 's behaviour to that of a human musician.

Beyls wrote:

> This research is specifically performance oriented - the audience is a witness of the behaviour of both the human (myself) and the digital performer (Oscar) and how they interact and exchange musical ideas. It is important to note that responsibilities are shared and shifting back and forth between man and machine. It is their objective to produce exciting music in a COMMON effort.
>
> ...
>
> Also, I want to stress that Oscar does not have the ambition to "understand" musical structures as such. People have this wonderful ability to infer a meaning from perceived sonic structures. Individual interpretation produces data which bears

> semantic information although the underlying mechanisms are still poorly understood. With Oscar, we are more inclined to study musical streams as abstract patterns evolving in time. We express interest in very general phenomena such as structural and time-varying relationships, degrees of independence, how and when changes occur, the dynamics of a system, levels of complexity, etc.
>
> However, Oscar was explicitly designed to support conversations with humans. When talking about communications that make sense for both parties, we must convey a meaning. Communication is successful if we succeed to induce a certain understanding in the receiver of the idea or concept the transmitter had in mind. The exchange of meaning is at the heart of communication. Since music is an abstract language, meanings remain elusive and every single individual brings his own algorithms to decode the message. This is a powerful feature since "musical" listening requires motivation; the ultimate musical experience for me might be a nightmare to someone else.
>
> Inference in human beings is biased by culture - in its widest possible sense. Not so with machines - they possess the ability to listen to given specific perceived stimuli and infer a meaning, given a clearly specified context. The inference mechanism is completely open ended, it is only limited by the imagination of the programmer. Oscar's ear is more apt to deal with abstract events. Musically speaking, this shift towards abstraction may be likened as an evolution toward fine grain control i.e. from harmonic systems, to mictrotonality, to work on the timbral level, and finally, to abstract musical gestures, be it from the micro- or macroscopic point of view.
> (Beyls 88)

Beyls illustrated in his writing how the interpretation of the signals passed must be interpreted by the program for them to have significance and how this must be explicitly planned for by the programmer.

As discussed in 2.1.2 there can be more than two interactors. In Ihnatowicz's "Senster" (A3.2) or White's "Facing out, Laying low" (A4.1) for example, there could be several humans vying for the work's attention.

Figure 2.5.2.d illustrates this kind of situation.

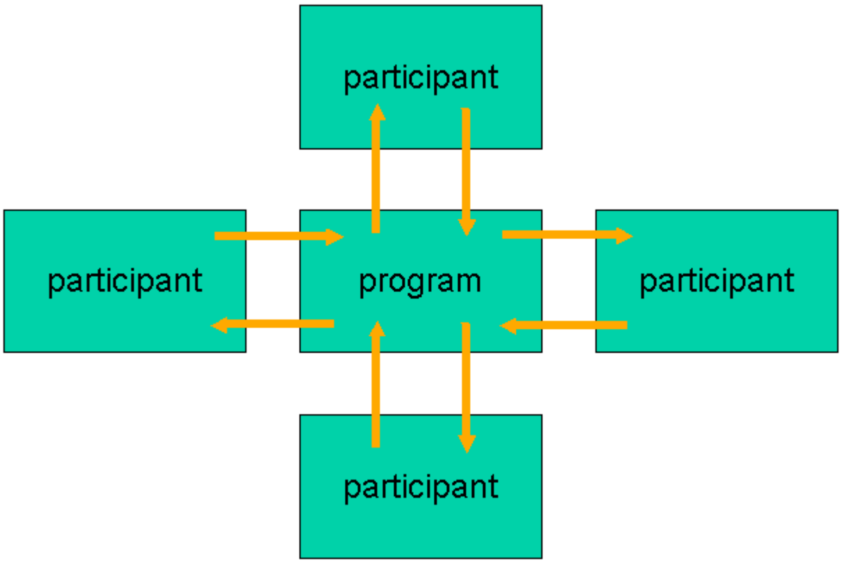



Figure 2.5.2.d

Further combinations are possible; there may be a program or programs behaving as participants, as in Wilson's "Interactive Computer Theater" (A2.2). This kind of situation is illustrated by figure 2.5.2.e.

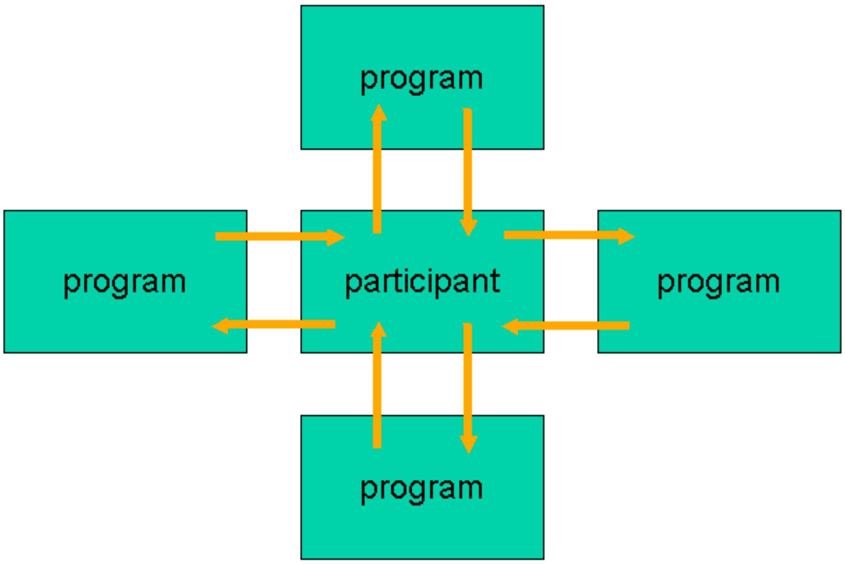



Figure 2.5.2.e

The participant may be interacting with several programs or sub-programs as in Smallworld (3). Such a case is illustrated by figure 2.5.2.f.

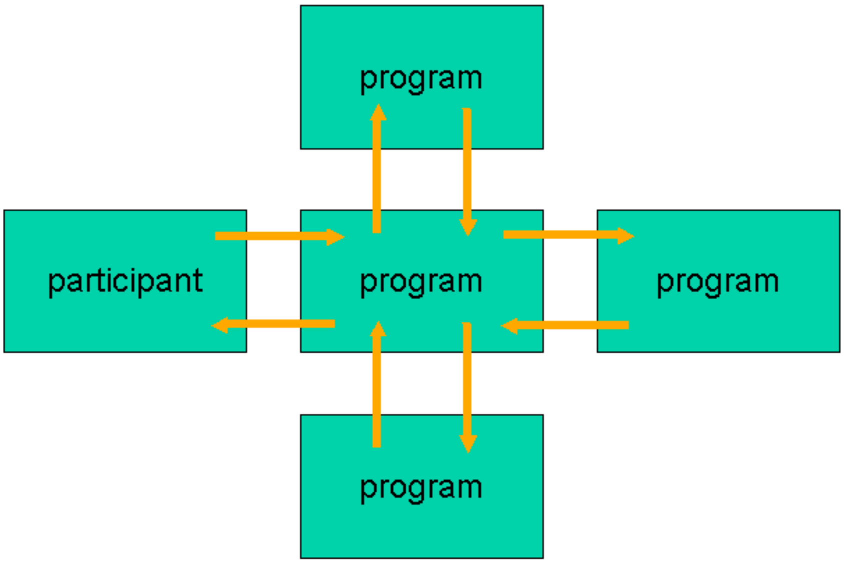



Figure 2.5.2.f

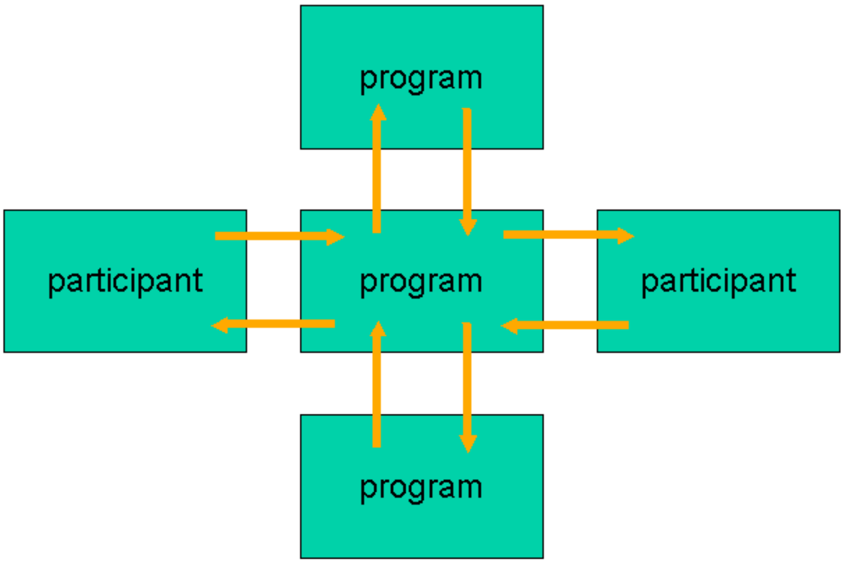



Figure 2.5.2.g

Recalling Popper's association of participatory art and democratic art (1.3) it is worth considering how democratic these multi-participant works are. Potentially they can allow participants more freedom than democracy - they may be afforded almost deity-like powers over other participants. The degree of control that participants have over events in works can also, however, be very restricted. The participant may also be intentionally duped, as in Wilson's "Responsive Linking Piece"(A2.1), or frustrated as in Krueger's maze version of "Metaplay" (A1.2). Participation does not inevitably lead to a kind of democratic art; communication of information, or the lack of communication, or the facility to communicate can be used in participatory works, as in government, to affect the balance of control.

If the work is successful as a work of art a communication will occur at a meta level, in the sense that any work of art communicates the artist's vision or concept, the work being the medium for that communication.

### *2.5.3 Summary.*

*Programmed intelligence is more likely to evolve through computer programs communicating with each other rather than with humans.*

*It is probably more profitable to consider communication between human and non-human animals as a model for human-program communication.*

*Animals can initiate communication with humans; programs may also be designed to do so.*

*The world model of a program, or its model of the participant, can be a characteristic of a work.*

*The similarity between the program's world model and that of a human's can be characteristic of work.*

*The degree to which communication is important in a work can be characteristic of a work.*

*The work may be used as a means for the artist and participant to communicate concurrently.*

*The artists may use the work for reflective activity and then allow participants to use the work for reflective activity.*

*Communication may be between human and program.*

*If communication is between human and program, feedback facilities may have to be built into the system to allow for modifying and checking signals.*

*The type of communication in a work can change dynamically.*

*Communication can be between several participants.*

*Programs can be seen to be participants.*

*If the work is successful as art there will be a communication at a meta level; the work being the medium for that communication.*

## *2.6 Who or what participates in the interaction and where it happens.*

Considering communication in participatory works led to the realisation that no matter to what degree communication plays a part in the interaction, it is useful to identify who (or what) participate.

### *2.6.1 Prejudices and expectations.*

There is evidence that participants' experiences of a work will depend on their expectations. Krueger noted that peoples' interpretations of the responsiveness of a work depended on how responsive they are led to believe it will be in advance (Krueger 83). Experience during the development of Smallworld indicated that people who were familiar with conventional uses of computer technology expected similar conventions to be followed in a work presented in a conventional manner using keyboard, mouse and graphic monitor.

It has been noted that there is often a difference between how the user believes a program works (based on the information in the interface) and how it actually works. In cases where this occurs the user is using a "virtual" machine, rather than interacting with the actual computer they interact with an imaginary one .

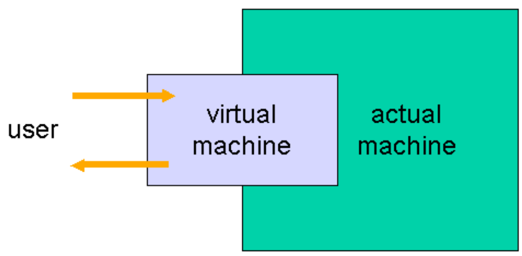



Figure 2.6.1.a

In many cases in computer systems this is the whole intention of the system: flight simulators are meant to exhibit behaviour as close to a real aircraft as possible.

In other cases the interface can behave like an actual system but is patently different: In computer graphic programs that emulate painting and operating systems that use a desktop metaphor, for example.

In these cases the interaction is with a virtual world of the type mentioned in the section on programmed worlds and reality (2.4). If the user is familiar with the actual situation being simulated they can be fairly confident about what to expect and can use their imaginations to fill in a lot of detail . Their expectations will prejudice their experience.

Even at the level of programming, where the intention is to enable people to communicate instructions to the actual machine, there is much that can be hidden from a casual programmer, making it possible to write working programs without understanding how the computer works. The virtual machine represented in the functionality that can be described in the language in this case has to coincide fairly closely with the actual one, but computers can be used to simulate other computers and programmers can be allowed to carry practices over from the use of one language into the use of another.

In participatory works the importance of considering prejudice depends on the degree to which the artist wishes to direct the participants' attentions to particular aspects of the interaction.

If the artist's intention is to lead participants to experience and attend to a kind of interaction that is believed to be new or even unique, careless indications that the interaction is like another kind of experience during instruction or pre-publicity may prejudice the participants' capacity to apprehend that which the artist intends them to.

Yet, it may also be necessary on occasion for the artist to carefully lead the participants into a particular frame of mind. Titles are used with continuing success to this effect, "Senster", "Time Entity" and "Smallworld" being example

The degree to which the virtual machine perceived by the participant supports their understanding of computers and coincides with the actual computer can therefore be identified as a characteristic.

The degree to which the artist uses devices like titles and pre-publicity to prejudice the participants interpretation of the work and thus incline them to attend to particular aspects of the work can also be identified as a characteristic.

Another characteristic identified is the degree to which the fact that a participant has been told in advance that a work is interactive leads them to believe the work to be more interactive than it actually is.

### 2.6.2 *Where the interaction happens.*

To whatever extent the artist intends the participant to attend to the interaction it is clear that in any consideration of who (or what) interacts with whom (or what) the means of interaction, the interface, should not be ignored.

The following diagrams were produced by introducing a representation of the interface into the diagrams used in sub-section (2.5.2).

The diagrams include representations of the actual interface and the imagined interface as perceived by the participants, illustrating that the direct interaction is with a more-or-less imaginary interface which mediates with the program.

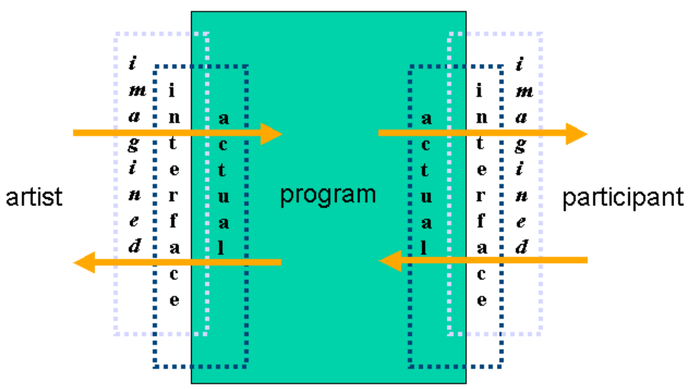



Figure 2.6.2.a

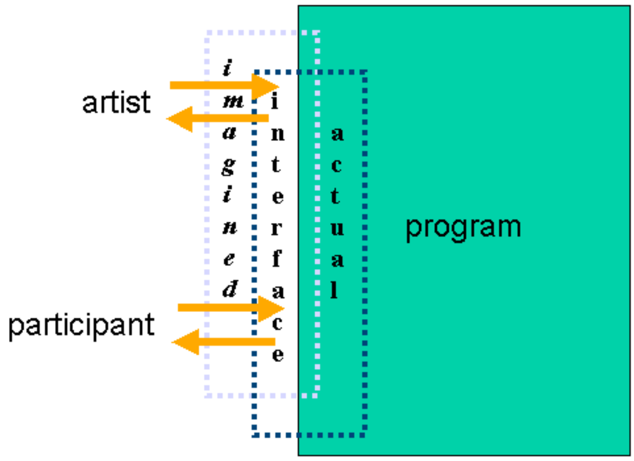



Figure 2.6.2.b

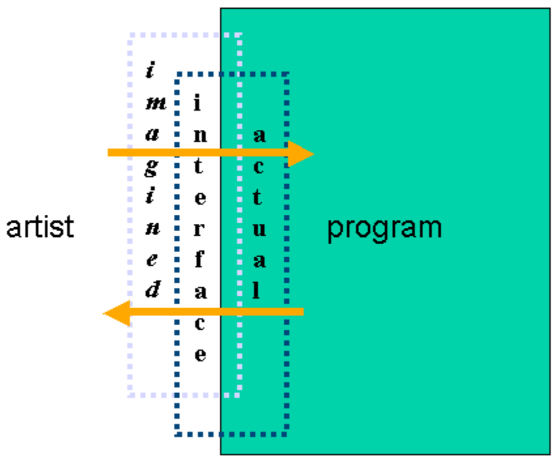



Figure 2.6.2.c

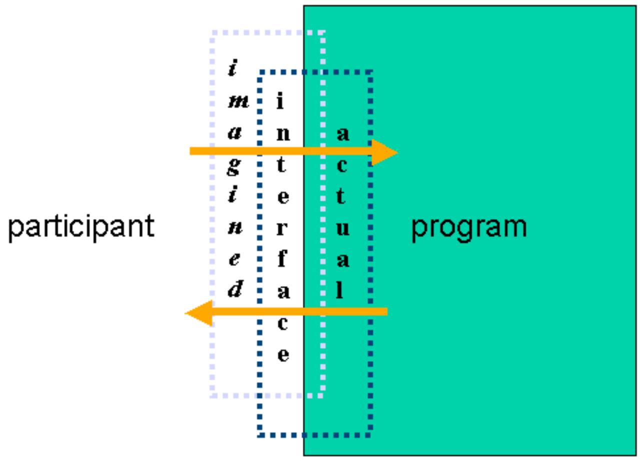



Figure 2.6.2.d

The degree to which the interaction perceived by the participant is with the program is always likely to be at least one step removed;  the interface mediates the interaction.

As has been shown,  the participant may interact with an interface that relies on a large imaginative contribution on their part and the imagined interaction may not be with a computer at all,  but with an animal or aircraft etc..

Interaction with a largely imaginary interface is qualitatively different from interaction with an actual interface.  The degree to which interaction is at an imaginary or actual interface is important to a work and can therefore be identified as a further characteristic.

As was pointed out in (2.4.3),  interaction can take place in a place that is more or less imaginary.  When considering who or what an interaction is between this becomes important not only to works that follow a programmed worlds approach but to all works in which the interface may be more or less imaginary.  Arnheim's description of a work of architecture as "... an object that never has and never will be seen in its entirety by anybody" (Arnheim 77) can also be applied to the interface at which interaction occurs between human and program.  The more that an interface relies on an imaginary contribution from participants,  the more likely it is that each participant will interpret it differently.

### *2.6.3 What happens to information during and after interaction.*

Reffin Smith has expressed concern about the transduction of information at least twice in interaction between human and human via a computer, arguing that we must have a sufficient theory of "... the way the information changes ..." (Reffin Smith 84). He wrote that in such a process some things are lost and some are gained, and if one is not conscious of this process it can go unheeded.

> In the cases of where the result conceals its origins, I argue that it also conceals part of what it represents. And so although we may not then experience problems due to knowledge of its transductions, we are still being fooled, still not able properly to 'make sense of it'. (Reffin Smith 84)

The implication of Reffin Smith's argument for makers of and participants in works is serious if apprehending the effect of the transduction is an essential aspect of the work; unless both the participant and maker are aware of the way the computer transduces the information, they are liable to have an incomplete and essentially misleading experience. He argued:

> No longer (if it ever was the case) is it sufficient merely to "experience" the work without any knowledge of its production. (Reffin Smith 84)

Reffin Smith illustrated the situation with the diagram reproduced in figure 2.6.3.a.

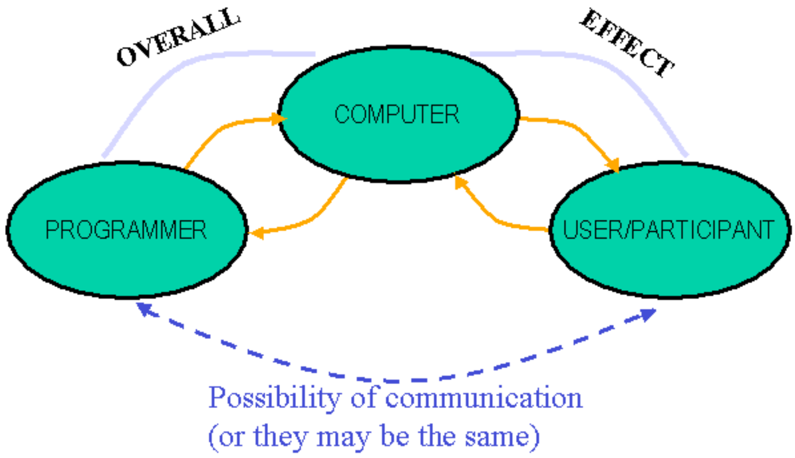



Figure 2.6.3.a
(After Reffin Smith)

In this research it was determined that to counter this possibility the maker of the work should use the same interface as the participant as much as possible (2.7.4). The interaction, and communication if present, will then tend to be through what is represented and changed in the interface rather than through the program. This is similar to the situation represented in figure 2.6.2.b, which illustrates the situation described by Cornock and Edmonds where the computer facilitates exchange (Cornock & Edmonds 73) and in Krueger's "Metaplay" (A1.2).

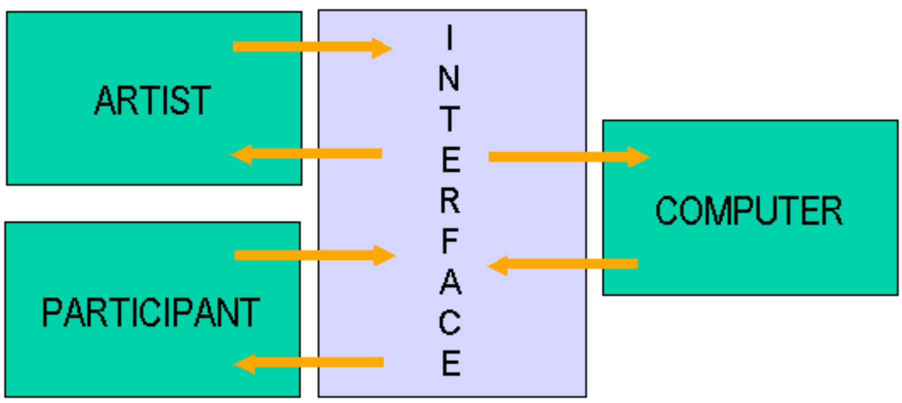



Figure 2.6.3.b

Figure 2.6.3.b illustrates the situation where a computer controls changes in the interface between artist and participant.

The positive potential of the transformation of information has been discussed by Loren Means (Means 84).

Considering figure 2.5.2.b(ii) further it can be seen that if the artist makes the work sufficiently independent of his or her direct control, the computer may be partially reprogrammed in the course of participation; the change in the information kept in the computer after one participant has encountered the work and interacted with it may then affect the interaction of the following participants. A situation like this occurs in work like Wilson's "Memory Melody" (A2.4) where the contributions of participants are recalled later, in contrast to works like Kikauka's "Misplaced Affection" (A7) which are reset after each participant have experienced them. These differences are illustrated in the following diagrams.

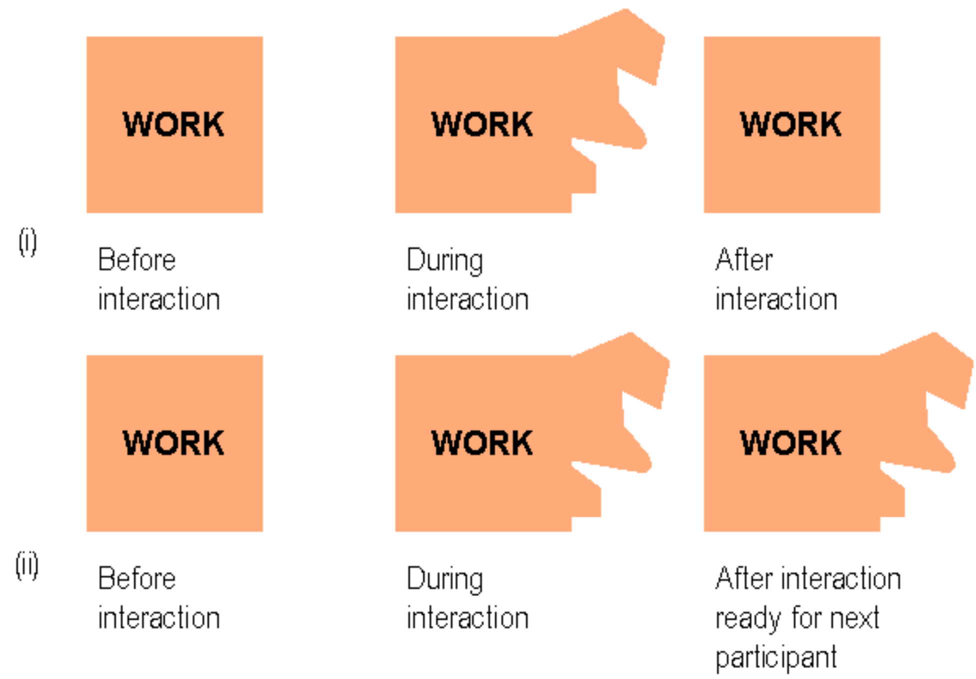



Figure 2.6.3.c

The degree to which interaction between human and human is channelled via the interface or via the computer has been identified in this sub-section as a characteristic of works. Also, the manner and degree to which information is changed in the interaction between human and computer.

The degree to which changes made during the interaction effect later interactions with the work can also be identified as a characteristic.

The changes may be made directly or indirectly, intentionally, incidentally or accidentally.

These characteristics are significant in the light of Malina's observations regarding the ability of computers to have their internal state changed during interaction and the capability of the internal state of a computer to evolve as interactions take place (1.1.3).

### *2.6.4 Programmed personalities.*

In "Colloquy of Mobiles" (A8) the machines were identified as male and female. Ihnatowicz's works "SAM" and "Senster" (A3.1) (A3.2) exhibited behaviour that has been likened to that of animals. Wilson's "Time Entity" (A2.7) deliberately set out to give the impression that an autonomous entity existed. Smallworld (3) drew direct analogies with animal behaviour. In (2.4.2) the possibility of giving programmed characters apparent autonomy was discussed. When considering who or what participates in the interaction in a work the potential of programmed personality must be considered further.

The characteristics identified in the previous sub-section (2.6.3) will contribute considerably to the similarity of the behaviour of a work to an animal or human. Animals and humans can be changed by interaction and to a greater or lesser extent are able to recall the interaction; humans can to a large degree remember experiences and recall if they have interacted with a particular human before. An interactive work that exploits the computer technology's capacity to be reprogrammed and have data recorded in it changed, so that it behaves differently as a result of participant's interactions with it, will have a very different character to one which is reset after each participant has interacted with it. In some circumstances it may be made to appear that a work remembers an interaction and "learns" from it (1.1.1) (1.1.3).

The extent to which this can be achieved will contribute to and depend on developments in programming research, and may enhance the quality of "realism" discussed in sub-section (2.4.2). It will also contribute to the kind of relationships that may be formed between participants and a work.

Participants can interpret the behaviour of a work as cooperative or uncooperative, consistent or inconsistent, etc.. It is common, even among experienced computer users, for people to respond emotionally to an unexpected behaviour of a program as if the machine is exhibiting evidence of a consciously motivated perversity. Assigning personality to machines and even talking to them is a fairly common human practice. The possibilities for creative exploration of relationships between humans and programmed personalities is likely to be a rich area of expansion, especially if a work can be made to recall previous interactions with particular participants and change its behaviour accordingly. The prospect of a simulated pet appearing whenever someone dons their virtual reality kit springs to mind; needing to be fed, trained etc..

The relationship between individuality and personality may be explored if several copies of the same programmed personality are involved in separate and different, interactions; the degree to which the programmed personalities behaviours change reflecting their separate experiences and hence exhibit individuality would be an interesting comment on the nature/nurture debate regarding human personality.

The potential sophistication of the relationship between works and participants opens up a significant new area for artistic investigation.

The implications of research pursued at LUTCHI into the subject of human-computer cooperation provided some interesting ideas as to how programmed personalities might be used (COM 89).

It was observed, for instance, that if the part of a program simulating a cooperative partner were to be modified by interaction with the user, to the extent that its behaviour would eventually mimic the user's too closely, the advantages of a cooperative relationship between different partners would be compromised to the extent of being negated.

The possibility of a participatory work beginning to mimic aspects of its participants' personalities may not have been achieved yet, but it may be possible in future.

The degree to which a work appears to have an individual character or personality can thus be identified as a further characteristic.

The degree to which a work can respond to the personality of a participant can be identified as another.

Krueger commented that:

> The way the Environment treats its participants will reflect the attitudes of the artist. (Krueger 83)

For example:

> While in some programs the Environment may be willing to cajole the participant into a conversation, in others it might choose not to bother. (Krueger 83)

This has an interesting resonance with the idea of programmed personalities. It is also exemplified in White's proposed "Helpless Robot" (A4.3). Kikauka's "Misplaced Affection" can also be seen to address this characteristic of an interactive environment (A7).

The fact that the early works produced by Cohen's "Aaron" (2.5.1) looked like Cohen's paintings suggests that it is certainly possible for a work to encapsulate some of the personality of the artist.

### *2.6.5 Summary.*


*Participants can be led to have expectations that prejudice their experience of a work, for example: they can imagine a work to be more intelligent than it actually is.*

*Titles and pre-publicity can be used to incline participants to attend to particular aspects of the work.*

*Computer users, including programmers, often interact with a virtual machine rather than the actual machine.*

*The virtual machine perceived by the participant can support or refute their understanding of computers and may or may not coincide with the actual computer.*

*Interaction is with a more-or-less imaginary interface which mediates with the program.*

*The degree to which interaction is at an imaginary or actual interface can be characteristic of a work.*

*The degree to which the computer may be reprogrammed during interaction by a participant can be a characteristic.*

*The degree to which information can be changed in a work from one participant to the next can be a characteristic.*

*The degree to which interaction between human and human is directed via the interface or via the computer can be a characteristic.*

*It may be made to appear that a work remembers an interaction and "learns" from it.*

*New relationships will be possible if the work can recognise a participant and modify its behaviour accordingly.*

*Works may eventually be able to mimic aspects of participants' personalities.*

*The degree to which a work appears to have an individual character or personality can be characteristic.*

*The degree to which a work can respond to the personality of a participant can be a characteristic.*

## *2.7 Feedback.*

### *2.7.1 Positive and negative feedback.*

Feedback does not stand alone but is part of a cycle of communication as described by McDonald and Concklin (2.5.1). The feedback to the communicator in their example is the questions and puzzled looks from the audience. In any participatory work that relies on human-computer interaction or human-human interaction via a computer-moderated interface, there are likely to be characteristics of feedback which may be identified and used to inform discussion.

Human and program can be considered as interacting systems. One of the ways that a system can use to check whether it is modifying its world model correctly to coincide with that of another system it is trying to communicate with is feedback; clues and indications that suggest that the correct assumptions are being made. These clues may or may not have anything to do directly with the particular communication being made.

If both systems are capable of and likely to modify their world models in order to communicate with each other, the systems will be both sending and receiving feedback.

Feedback can be sent out by a system to let another system realise that it has apparently misunderstood, or understood the communication. The feedback may be positive; confirming an assumption, or negative; challenging an assumption. The feedback may also include “noise” or “artefacts”; unintended signals that can distract or mislead the recipient of the feedback.

Misinterpretation is not necessarily a bad thing as it may lead to originality in the communication, but more often it is negative, leading to an unsatisfactory conclusion. Without efficient feedback it would be hard to determine whether both systems had reached the same conclusion or ones close enough to be considered satisfactory.

### *2.7.2 Speed of Response.*

To be able to quickly check and correct a falsely interpreted signal can be an advantage. If the participant sending the signal, be it program or person, does not receive fast and continuing feedback they may compound an error before recognising that it has been made.

As interaction is a time-based activity, speed of response can also be significant when a work is considered as a composition (4.1.5).

With regard to programmed personalities (2.6.4) it is worth noting that the speed with which a person responds to a communication can be interpreted as a sign of the recipient's interest in, or regard for the sender. Whether a hasty response is a positive or negative sign can be based on the context and, when communication of more than an elementary kind is intended in a participatory work, this should be taken into account.

Speed of response also has a bearing on the consideration of characteristics of interaction in time (2.1.1).

### *2.7.3 Feedback used to direct participant attention.*

The changes to the interface in the PLANT program in Smallworld led to the generation of new kinds of shapes and demonstrated that a change in the interface can affect the behaviour of the user and lead them to set new goals and develop new heuristics (4.1.4).

This was an important lesson as it supported the emerging theory that the artist should spend a considerable proportion of time participating with a work in a similar way to that in which participants will. Only then can the interface be tuned to present feedback that will lead participants to attend to those aspects of the interaction the artist intends them to. This is an essential practice if the artist intends to communicate with the participants via the interface, and some of the negative possibilities of transduction described by Reffin Smith (2.6.3) may also be countered.

The degree to which a participant's activities may be considered unpredictable, contributing a "random" element to a work can also be affected by the use of feedback to direct attention. It can also be used to effect the apparent control a participant has over events.

The extent to which feedback is used to direct the attention of participants can thus be identified as a characteristic.

### *2.7.4 Feedback to artist from work.*

Exploiting the computer as a general purpose machine demands a particularly wide-ranging scope of attention, as the artist is continually re-designing the medium and the tools used to alter it, as well as changing the work itself. The tendency to neglect practicing in the medium as an artist in favour of solving common algorithmic problems or becoming involved solely in re-designing or extending the medium is evident in the practice of many artists who use computers. Krueger actually came very close to advocating this as one of his maxims:

> It is desirable to think in terms of inventing a tool for exploring the interactive medium, instead of creating a series of discrete objects, each of which is a "piece". (Krueger 85) (1.1.2)

Kenneth Knowlton recommended that (rather than trying to produce better computer art):

> ... the more appropriate challenge is to create better environments for the development of art-making tools. (Knowlton 86)

This may appear to be a suitable recommendation, but if adopted by artists, the evidence indicates that they should avoid developing the medium at the expense of the development of their art practice. If they do not, adopting Knowlton's recommendation could actually encourage the situation which led him to title his paper in the Siggraph 86 Art Show catalogue "Why it isn't Art yet" (Knowlton 86).

Knowlton argued that artists must have a more complete command of the tools, including being able to build, redefine and/or augment them. They should also have control over the programming side. This echoed the assertion made by Julian Sullivan in 1981:

> With certain exceptions, such as in conceptual schemes, I support the view that the artist should be entirely familiar with and in command of the technique, otherwise there cannot be a properly productive interaction. (Sullivan 81)

The difficulty for artists using a rapidly changing technology is, however, to identify an appropriate technique or strategy with which to achieve this goal. A decision to keep pace with developments can lead to the tendency among some artists to become involved in computer programming to the detriment of their practice as artists. This appears to be a special case of a pattern of behaviour recognized by Weizenbaum where programmers become fascinated with programming at the expense of their involvement in wider issues (Weizenbaum 76). In “The Creative Computer” the artist David Em was reported to rely on experts:

> Otherwise, he feels, it is all too easy to dissipate all one’s energy in just getting the equipment to work. Too many artists he knows have learnt programming and now spend all their time writing software and never producing any art. (Michie & Johnston 84)

Similar patterns of behaviour have recently been researched further by Margaret Shotton in a study of computer dependency. She advanced the idea, however, that such behaviour may in the end lead to “the development of wondrous inventions and ideas.” (Shotton 89).

Harold Cohen was quoted in Michie and Johnston, illustrating a contrasting approach to Em’s:

> We know already that no one makes art by finding some tame programmer to write a few graphic subroutines. In the years that the game has been going on, not one single art-work of major importance has resulted from it. When you consider that

> a parallel case in printmaking would be that of a printer who has no idea of what art is, working for an artist who knows nothing about printing technology and doesn't want to find out, there is absolutely no reason to assume that one will. (Cohen 82)

In the development of Smallworld a tendency was detected for attention to swing between several interests; in the effect of program changes on shape; in phenomenon-generating algorithms; and in the means of presentation. These attention swings continued as the project evolved and became particularly evident when the need arose to learn new programming techniques to realize particular aspects of the work.

If learning a complicated programming technique threatens to lead to the obsessive behaviour described above, leaving other aspects of the work totally unattended, a decision must be made as to whether to temporarily abandon learning the new technique while the threatened aspects are supported by more attention, or to pursue learning the new technique regardless of the effect on other aspects of the work even if they might atrophy. In the development of Smallworld the first strategy was generally followed.

Dewey, considering how the artist experiences what the audience does wrote:

> The artist embodies in himself the attitude of the perceiver while he works. (Dewey 34)

Artists may arguably learn so much about the technology by becoming very involved in programming that they are no longer able to put themselves in the place of their audience. In some practices this may be beneficial, but when developing participatory works, assigning time to use the work in the same way as a participant is essential, as was found to be true during the development of Smallworld (3.7.2).

It is hard to identify feedback to the artist from participatory works. In the development of Smallworld feedback was sought explicitly through the use of questionnaires (3.3.4) and it was determined that ideally the work should be able to monitor and analyse participant behaviour. However artists receive feedback it is a characteristic which will have an important formative effect on the direction that such works will follow in future.

### *2.7.5 Types of feedback.*

The physical aspects of the interface were discussed in section (2.2). As they are the routes that feedback follows a short recap is appropriate.

The nature of the feedback is an important quality of a work: the human can only sense feedback of five kinds: Visual, Auditory, Taste, Smell, Touch. The computer, as Wilson points out must eventually have any feedback converted into electronic signals.

The most commonly used primary route of feedback from program to human is visual; as text or graphics.

Sound is used as a secondary form of feedback, often used as warning, or (as in the case of Smallworld) beeps acknowledging user actions. In sophisticated systems dedicated to musical exploration, for example Beyls' "Oscar", a programmed musical duettist, sound became the primary route of feedback (2.5.2).

A less well developed route of feedback is touch. Ihnatowicz's "Bandit" (A3.3) would modify its movements according to the force applied to it and this could be sensed by the participant. More usually any physical touch feedback is secondary; as in the motor-feedback regarding the position of the hand and arm when using a mouse or keyboard. Once a user is proficient in the use of I/O devices much feedback becomes learnt and is recognised automatically rather than being attended to consciously. In some technologies, such as cars, the touch feedback becomes primary; people can drive "by the seat of their pants" - the road conditions and behaviour of the car can be *felt* much better than it can be gauged through any other feedback route. Baumann's description of getting the feel of magnetic fields (A9) illustrated a kind of touch feedback.

Taste is not yet used for feedback in interactive works, and the use of smell is uncommon (2.2.8) (A14). The technology used for "scratch and sniff" cards and books could quite possibly be adapted and used.

### *2.7.6 Learning automatic responses to feedback.*

It is important to consider to what degree the participant is intended to attend to the feedback in a work and the route the feedback follows, and how long it will take them to learn how to respond automatically.

Loftus and Loftus wrote about memory as an aspect of the human cognitive system in a way that can be considered in conjunction with feedback . They described an interpretation of the cognitive system which consists of three layers of memory: Sensory, Short Term and Long Term (Loftus & Loftus 83).

All the information received from the senses can be considered as being part of *Sensory Memory* . There is a large capacity but information is forgotten in less than a second. This information is filtered through to the short term or working memory.

*Short Term (Working) Memory* is identified with consciousness. It has a relatively small capacity; can hold about seven items which are easily forgotten (in less than a minute) but “rehearsal” (repetition) will lead to no forgetting.

*Long Term Memory* is described as the repository of general knowledge. Its capacity for information is virtually unlimited and it may take decades or more to forget.

These ideas become useful when considering works in which the significance of the feedback must be recognised and learnt by the participant.

One way that an artist can anticipate how a participant will attend to a work is to act as a participant (2.7.4), however the artist is likely to soon reach a fairly skilled state: In motor performance, skill improves approximately logarithmically with practice, it does however continue to improve. i.e. the more you practice the better you get - it just takes a lot longer (Loftus & Loftus 83). Ultimately this skilled state can achieve a level of independence where the cognitive system cannot describe how the motor system does what it does (although at a learning stage it would be able to).

Identifying whether efficient feedback enables a participant to rapidly achieve competence, or whether the participant is likely to be kept in a state of learning must therefore be tested by artists at a stage when they are unskilled, or by an assistant behaving as a new user. How quickly responses become automatic is therefore identified as another characteristic of works.

Krueger remarked that:

> Dancers are strenuously involved in their work and feel aesthetic pleasure from their own performance (Krueger 83).

The sheer exuberance of sensing physical feedback when using a motor skill successfully in a participatory work, is clearly an important characteristic. The importance of a participants' abilities to measure their performance is a crucial component of works and is discussed in subsection (4.1.7).

### *2.7.7 Summary.*

*Feedback is part of the cycle of communication and can be used by participants to check that information has been transferred correctly.*

*Feedback can be positive or negative, it can also include unwanted or useless "noise".*

*Misinterpretation can lead to originality but it more often has a negative effect.*

*The speed of response in a work can vary and can be tailored to suit the intentions behind the work.*

*In human-human interaction, speed of response can be interpreted in a positive or negative sense depending on context.*

*The way in which feedback is used to direct the attention of participants can be characteristic of a work.*

*When developing participatory works it is important to assign time to using the work as a participant would.*

*It is valuable for the artist to monitor participants' responses to works.*

*Feedback to the artist from a work is a characteristic which will have an important effect on the direction followed by future works.*

*The routes of feedback are those discussed regarding the physical aspects of the interface.*

*The way feedback is communicated physically can be a characteristic of a work.*

*The significance of feedback in a work and the time it takes to learn that significance can be characteristic of a work.*

*The sheer exuberance of sensing physical feedback when using a motor skill successfully can be an important characteristic of a work.*

# *3 THE DEVELOPMENT OF SMALLWORLD; A SUITE OF COMPUTER PROGRAMS.*

In the introduction it was explained that a participatory work was developed in parallel to the critical review of existing work (1.4).

The fundamental programs of the Smallworld suite had been developed at the University of Kent at Canterbury (UKC), with the intention that they should form the core of a participatory work. At the start of this research the project was at a stage where possible ways of introducing participation were about to be investigated.

The original development of the Smallworld project is summarised in section (3.1).

Section (3.2) describes the state of Smallworld at the start of this research.

The central part of the chapter follows the pattern of exhibitions of the work in progress on Smallworld in 1986, 1987, 1988 and 1989. The exhibitions formed deadlines which were to influence decisions made during the course of the project and sections (3.3) to (3.6) each address the work pursued related to particular exhibitions.

Section (3.7) is a discussion of the theories that arose and were tested through practice, and how they support or contradict the experiences of other artists.

## *3.1 Smallworld at The University of Kent at Canterbury.*

### *3.1.1 The initial concept.*

The project that evolved into Smallworld was conceived as a work that people could voluntarily participate in, but it was not intended that participants would produce their own, individual work. The idea was not to make them into artists but to enhance the efficiency of communication between artist and audience by allowing the audience to share something of the experiences that had led the artist to make the work.

A general intuition had been held regarding the potential value of interactive computer technology in participatory works for some time (Bell 89). The equipment capable of high-quality real-time interactive 3D graphic animation needed to begin to pursue the ideas did not become available until 1985. Prior to 1985, however, preliminary investigations had been pursued in the belief that equipment would eventually become available.

### *3.1.2 Influences on Smallworld.*

The principle of Smallworld was based on an earlier "Space Exploration Game" program produced whilst a student in the Experimental and Electronic Department of The Slade School of Fine Art, London, in 1977-79. The program was influenced by the work of artists Christopher Briscoe, Christopher Crabtree, and Julian Sullivan, who were teaching at The Slade at that time. In their work these artists described in programmatic form the rules and parameters governing the interaction of autonomous agents. The programs then determined the outcome of the interactions of these agents; changing values associated with the agents were used to generate graphics on display devices and as plotted and printed drawings (A10).

The program was also influenced by the work of Peter Beyls (2.5.2) (A10) and Paul Brown (A10), who were students at The Slade at the same time.

The use of a game format in the "Space Game" was supported by reference to the work of Öyvind Fahlström (A11) and a paper in Leonardo by Ellen Dissanayake (Dissanayake 74). The game metaphor has been used to structure participatory works including those by Cornock & Edmonds (Cornock & Edmonds 73) (Edmonds 75), Krueger (Krueger 83) and Brown(A10).

The work at The Slade was also influenced by Conway's "Game of Life" (Gardner 70).

### *3.1.3 Combining a number of influences.*

When the idea of Smallworld began to take shape in 1984 it was the product of a synthesis of the influence of all the work mentioned above, with additional components from other sources which emerged in the course of practice. Although dimly conceived at the outset, it was intended to eventually consist of a simulation of an imaginary world that people could explore interactively.

One of the components in the synthesis was the desire to write a program that generated marks of a calligraphic character similar to those that had been produced by controlled randomness in an earlier program called “Ranstak” (figure 3.1.3.a) but which were generated by rules that, once understood, had significance.

Figure 3.1.3.a
Ranstack

The principle behind the “Space Exploration Game” (3.1.2) was that users would guide a spaceship around a representation of the nearest twenty star-systems to the sun, encountering friendly and unfriendly inhabitants in the course of a mission. After dealing with them in various ways, successful or unsuccessful, the user would be presented with a comic-book type print-out of the edited highlights of their explorations in narrative form. An example of the output of the partially complete program is shown in figure 3.1.3.b . The algorithms that were developed for testing the proximity of spaceships and determining the courses of interception and evasion were later modified for use in Smallworld.

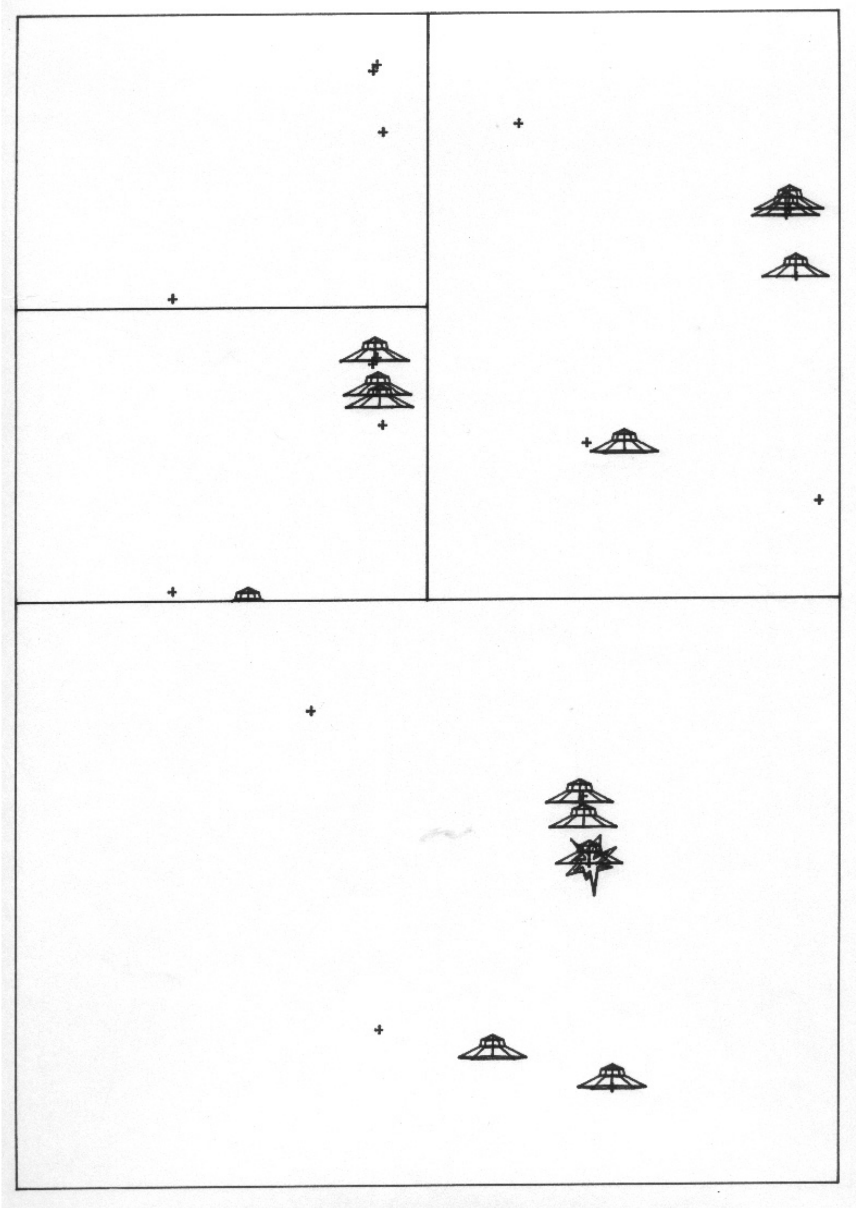


Figure 3.1.3.b
Space Exploration Game

The important thing to note is that the audience for the work was expected to play a leading role in the “Space Game”. This participation was used to introduce some unpredictability to the system, making it more open. J.Z.Young wrote that, given the complexity of human decision-making processes and the fact that all individuals have different genetic and past influences on their deliberations; although we can make forecasts about someone’s actions we can not anticipate the exact results of their brain actions (Young 78).

The human participants were to replace the pseudo-random element that had been used in “Ranstak”. It was intended that after playing the game a few times people would build a model in their mind of the relative positions of the sun and its nearest stellar neighbours in the same way that it was later found that users of the Silicon Graphics IRIS flight simulator would build up an imaginary picture of a programmed world (2.4.1).

Another component in the initial idea of Smallworld was the intention that the work should remain abstract, in the sense that it would not be a re-presentation of any actual observed phenomena or a simulation of fantastic events as in the “Space Game”, yet would take advantage of peoples’ ability to observe and interpret particular kinds of event in the actual world as a method of deducing the rules governing the generation of the images. This intent derived from learning of the work of artists in which it is important that the method and context of the generation of the work can be discovered by the audience through exhibition of the work and related materials; i.e. its “recoverability” (Bann 78); an example being the work of Kenneth Martin (Martin 79). Paradoxically this intent also reflected an interest in the work of artists who documented their exploration of actual places, like Richard Long and Hamish Fulton.

Another intention was that means could be included to enable a participant to examine events in the programmed world in apparently closer and closer detail just as is possible in the actual world.

It was intended that the generative system would not be recognized as a numerical or geometrical system, which would restrict the audience by making the content of the work accessible only to an audience who apprehend and appreciate the aesthetics of mathematical and geometrical phenomena (although in computing terms it would have to be represented as such), or in terms of physical phenomena like gravity or mass as in Briscoe's work (A10). Instead, a generative system was sought which would share certain characteristics with natural phenomena that all humans could be expected to apprehend and appreciate, without actually reproducing the natural phenomena. At this initial stage of the Smallworld project there was no clear picture of the system that would be used. This approach to the initialisation of work is significant in the light of Scrivener's observations regarding the practice of artists using more traditional media who retain and exploit perceptual ambiguity at the conceptual stage of the work (Scrivener 82).

Considering the origin of the interest in simulated environments, and keeping the work abstract, it was noted:

> This interest in simulated environments seems to stem from, among other things, environmental art, architecture etc. . Faced with the impracticality of changing the 'real' environment on a large scale, one can change an imaginary environment.
> As size becomes ... less relevant in the mind, the scale of an operation in a simulated environment may match, in its effect on the perceptions, a large event in the real world. Clearly what one is aiming for here is the type of response one gets from a literary novel; ... novels can stir the emotion ... there is no need for great detail - verisimilitude can be achieved using just a few signs that stimulate the imagination of the participant.

At this point it was decided that participants would be able to explore a progarmmed world and that the overall project could be named Smallworld. The initial working title chosen, with a direct reference to Swift's "Gulliver's Travels" (Swift 26), was Lilliput.

### *3.1.4 The inhabitants of Lilliput become more interesting than the geography.*

After initially considering the simulation of the geography of the imaginary world that was to be explored, the idea that the world should be inhabited by creatures that could be interacted with became more interesting. This was an extension of some of the ideas considered for the “Space Exploration Game”, but the creatures in Smallworld were to be less literal than the characters in the “Space Game” would have been. The data generated by the Lilliput programs would be used to draw lines; trails representing the routes that had been followed by the creatures as they pursued their activities. This retained the calligraphic, vector based approach of the “Ranstak” programs (3.1.3).

In the initial programs, written to test the principles, each individual only had a notional “mass” and their effects on each other were based on this value alone. The “mass” notion was used temporarily whilst working out other aspects of the program. It was anticipated that the program would have to be debugged, and considered sensible to start with a relatively simple version and gradually elaborate upon it.

At this early stage it was noted:

> Once the elementary ‘gravity’ program is working and drawings are being produced ... move on to give the objects more ‘life-like’ qualities so their interactions are more complex.
>
> Some objects may be plant-like (i.e. don’t move)
> " " " " " " " and yet ‘carnivorous’ etc.
> " " " " able to appeal to the programmer for aid!

An algorithm recorded in June 1984 is represented in figure 3.1.4.a.

It was noted at the time that there should be an option of displaying individual causes of movements in separate colours and recording “events” in a personal “history” file for each individual as well as recording a “general history” of events.

It was anticipated that once these programs were working, the next stage would be to develop an “... interpretive program to allow a 3D view of a particular event to be made - a kind of snapshot in an imaginary environment.”

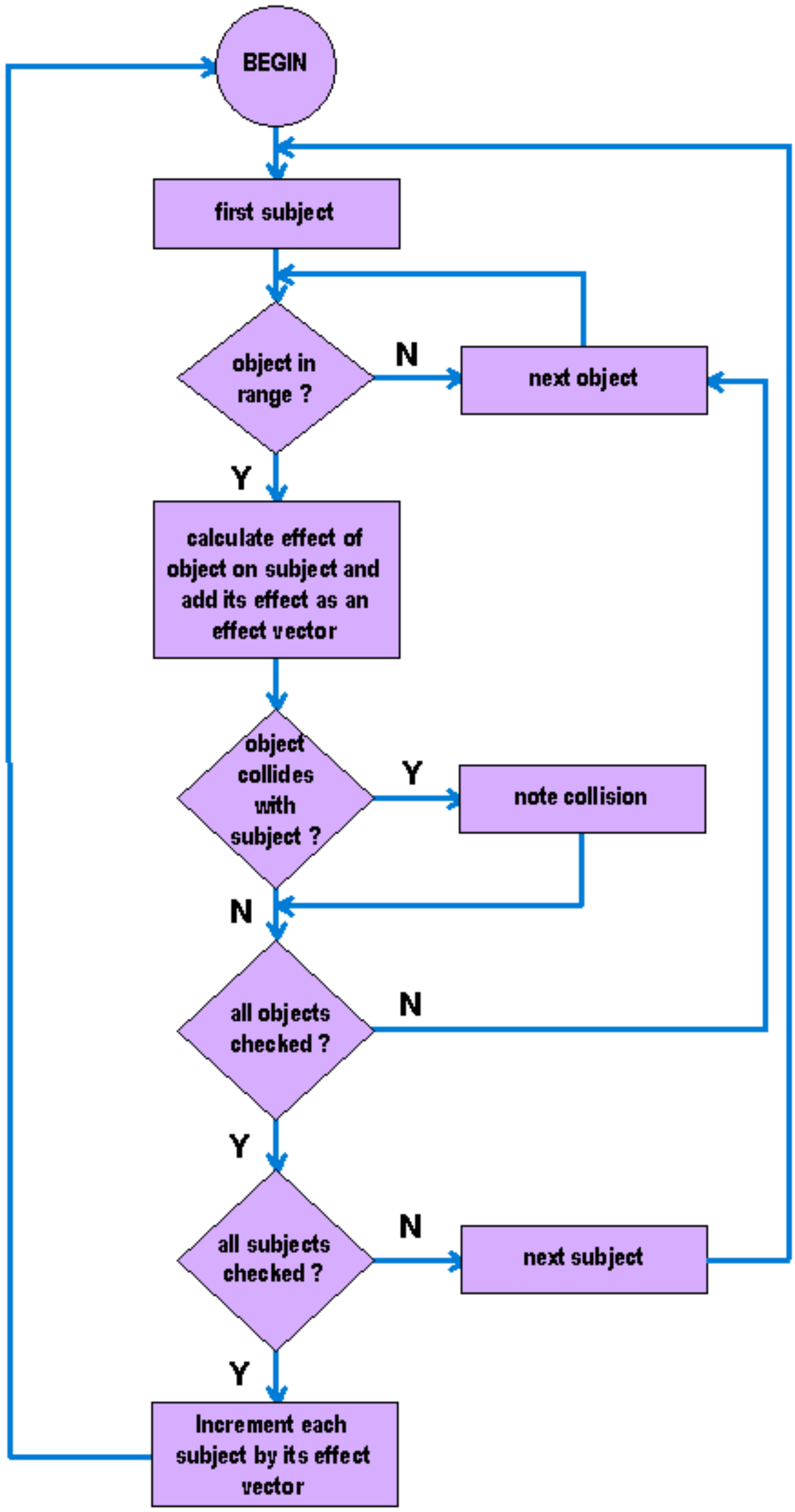

BEGIN
first subject
object in range ?
N
next object
Y
calculate effect of object on subject and add its effect as an effect vector
object collides with subject ?
Y
note collision
N
all objects checked ?
N
Y
all subjects checked ?
N
next subject
Y
Increment each subject by its effect vector

Figure 3.1.4.a

The possibility of animation was also considered:

> ... if animation is contemplated, remember ants' nests, 'creepy-crawly' side-effects. i.e. do not ignore the possible emotional involvement, rather encourage it. The human capacity for empathy is not to be sneered at. Anthropomorphism should be subtly encouraged to achieve this empathy. People should almost believe in the small world they are interacting with.

From the conceptual stage, therefore, it can be seen that Smallworld was intended to rely on the imaginative as well as the physical contribution of eventual participants to realize the work (2.4.1) (2.4.2).

### *3.1.5 The exhibition: "Computer Generated Images", 1985*

These investigations led to the work exhibited in 1985 under the title "Computer Generated Images" at: The Gulbenkian Theatre, Canterbury; The Draughting Design and Graphics Exhibition, Olympia, London; and the Ikon Gallery, Birmingham. The work exhibited consisted of colour photographs of static images taken from a computer graphic screen. The work was discussed in an interview for "Page", the bulletin of the Computer Arts Society (Mahoney 85) and in a broadsheet published to accompany the exhibition (Bell 85).

Some Images were printed as twenty-four inch square transparencies and displayed in back-lit light boxes, others were presented as glossy prints illuminated by directed spotlights. Slides (B1) to (B5) are examples of work exhibited.

A DEC Microvax I computer was used to run the programs on in the exhibition space during an open day held to mark the twentieth anniversary of UKC. Visitors were able to see how the images were generated but they were not able to interact with the programs.

All the shapes generated for the exhibition were the result of a search to find types of event or phenomena that could be investigated interactively at a later stage if the equipment became available. The aim at this stage in the development of Smallworld was to determine whether the images exhibited were interesting enough to attract and sustain the attention of visitors; whether the static images could be interpreted as being the result of movement and whether the rules generating the movement could be deduced.

### *3.1.6 The results of the initial investigations.*

The work exhibited in 1985 did, to an extent, achieve some of the goal set; the static images were interpreted as the consequence of a simulation of movement, and movement with purpose (Mahoney 85). Visitors to the exhibition likened the images to fireworks and time-exposures of traffic at night. A zoologist recognised the predator-prey relationship in “Grid Explosion No.1” (Figure 3.1.6.a), likening it to the movement of fish, before the generative procedure had even been hinted at.

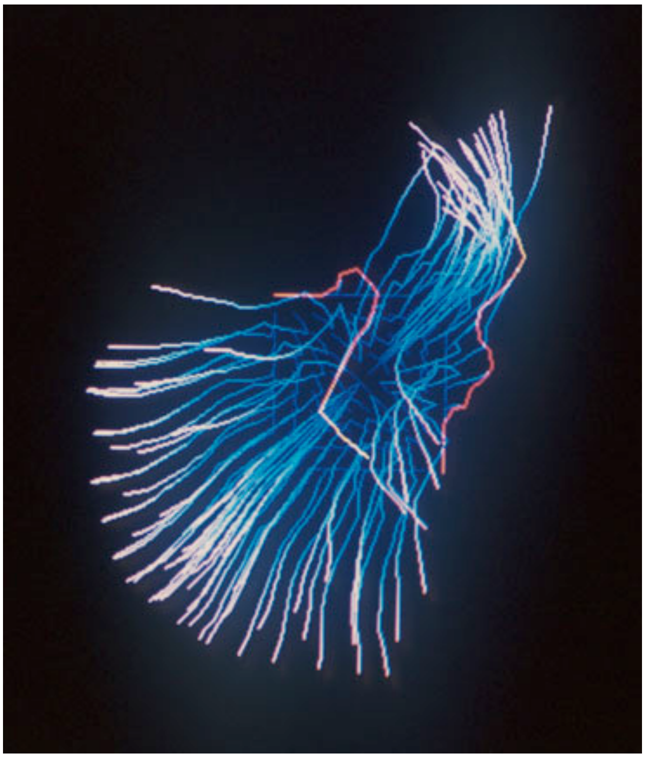


Figure 3.1.6.a
Grid Explosion No.1

The program satisfied the goal of generating marks that were the result of a deterministic system and that could be interpreted to reveal some of the principles that had generated them (3.1.3). It was, however, not possible for viewers to retrieve as much information about the system as it was considered ought to be possible. With regard to generating images that had calligraphic character and generated by rules which had significance, the type of information carrying achieved was similar to that in contour lines in geographical maps which, although they may be interpreted as representing a number of points of similar height can also be related to each other to reveal characteristics like the relative steepness of the gradient at any given point.

There were ambiguities in the work which the exhibition made some play with. For example: making two-dimensional shapes appear three-dimensional and vice-versa. It became evident though, that although some shapes could be interpreted relatively easily, the more complex three-dimensional shapes were not represented clearly enough. The display programs which are explained (3.2.1.vi) did not calculate perspective projection. This is an example of deciding to postpone learning a new programming technique to attend to other aspects of the work (2.7.4).

The firework analogy often used implied an assumption of the existence of a gravity-like effect and a physical rather than a behavioural model. This assumption is easily understood, but misleading if people were to be able to understand the actual generative procedure (1.3.1). Presenting a sequence of static images went only a little way towards solving this problem (Figure 3.1.6.b)

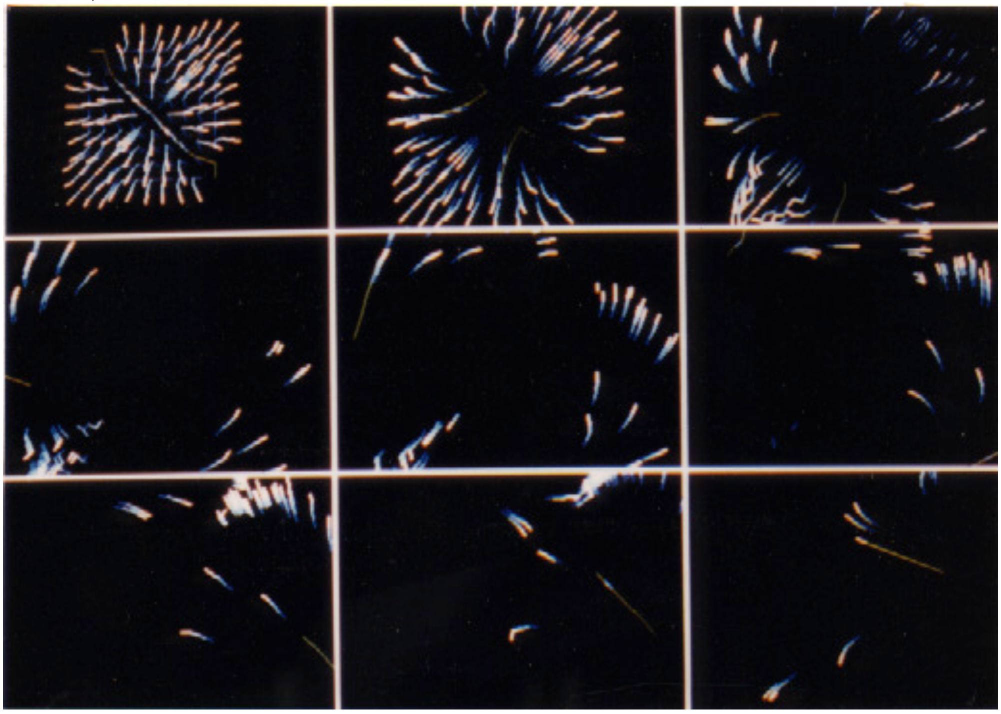


Figure 3.1.6.b

A way had been developed to generate both creatures and objects (the shapes generated by trails) to populate the small world that had been the original conception and the shapes and behaviours that generated them appeared to be complex enough to warrant their presentation in a participatory work which would allow people to investigate them interactively.

The Lilliput suite of programs are described in the next section;  first in summary and then in more detail.

## 3.2 *Smallworld at the start of this research.*

The Lilliput programs are described in this section; first in summary and then in more detail as much of the discussion in the sections that follow addresses changes made to the original programs to make the work more accessible to participants, reflecting the identification of the characteristics of such works.

The basic organisation of the programs developed from several considerations, one of which was that participants should be able to design animals and release them into the programmed world to observe their behaviour. Although, at the time of writing, the program has not been developed to a stage which makes this easy for participants to do, the principle contributed in large part to the design of the program.

### 3.2.1 *An overview of the Lilliput programs.*

Figure 3.2.1.a illustrates the relationships between the programs and data files used in the Lilliput system. It can be compared to similar diagrams later in the chapter to identify changes in the suite of programs as they evolved.

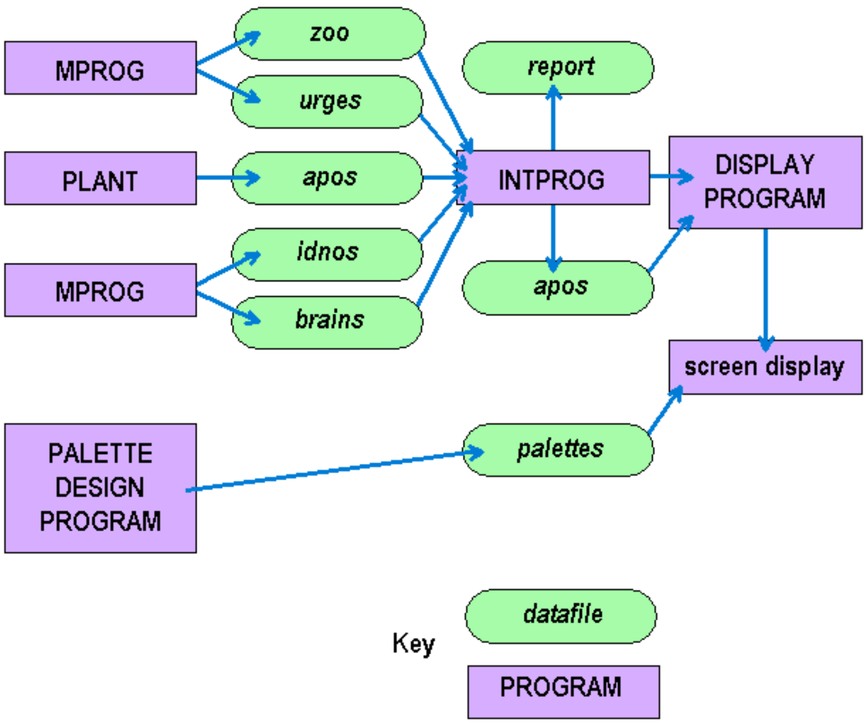



Figure 3.2.1.a

MPROG was used to design animal species behaviours; data describing these designs were stored in files named *zoo* and *urges*.

PLANT was used to determine animals' initial locations; data describing these positions were stored in a file named *apos.*

A TEXT EDITOR of the computer was used to build some files that described the species of each animal and how each species classed other species; data stored in files named *idnos* and *brains*.

The INTPROG program used the data in the files described above to determine how the animals would interact with each other; a text report of events was stored in a file named *report* and data needed by the display program were stored in a file named *piccy*.

The PALETTE DESIGN PROGRAM was used to determine which colours would be used in the screen display; a range of palette designs were saved in different files that could be used at the press of a single key.

The DISPLAY PROGRAM was used to determine how the data saved in the *piccy* file was presented on screen. It was also possible to monitor what was happening while the INTPROG program was being executed.

The images were presented on the SCREEN DISPLAY from which photographs were also taken.

### *3.2.2 A more detailed explanation of the Lilliput programs.*

#### *3.2.2.i The MPROG animal behaviour design program.*

The first approach to enabling the user to make decisions that would determine an animal's behaviour was to design a program that asked the user questions. By answering, the user would effectively describe the potential behaviour of an animal in given circumstances. The user was addressed as an animal. Typical questions were:

How do you react to perceiving an animal of your own sex in the distance?
How do you react to perceiving an animal of your own kind and of the* opposite sex in the distance?
(* It was also considered that more than two sexes might exist)
How do you react to perceiving a dangerous enemy at medium distance?

And so on.

This technique was found to be time-consuming, and therefore inappropriate if the work was to become participatory. The eventual aim was to have a totally graphic interface with no text. MPROG was designed as the first step in pursuing this goal.


Figure 3.2.2a.
MPROG screen

MPROG, short for “menu program”, was a program that would display a screen as seen in figure 3.2.2.a . The program read the data stored in the files named *zoo* and *urges*, which described the current characteristics of each species, and displayed the information graphically on screen.

Data in the files could then be changed by using the joy-stick built into the keyboard to move a cross-hair cursor to point at particular parts of the screen, clicking a key, then typing in new values using the keyboard.

To the bottom left of the screen five boxes were titled:

| species |
|---|
| code number |
| colour |
| speed |
| eyesight |

The current species name was displayed in the **species** box; the species being displayed could be changed by selecting the **code number** box, entering a new number by typing it on the keyboard and then pressing the return key.

The colour of the species could be changed by selecting the **colour** box and typing in a new value that corresponded to the colour look-up table used by the program: values ranging from 0 to 63 could be entered, giving a selection of 64 colours.

The speed of the species could be changed by selecting the **speed** box and typing in a new value. The value was used to determine the rate at which the position of a given individual of the species could be changed.

The eyesight of the species could be changed by selecting the **eyesight** box and typing in a new value. The value was used to determine the radius of a spherical volume of notional 3D space around an individual of the species within which it could detect other animals.

The main part of the screen consisted of a matrix displaying the ways in which individuals of the species would respond to given classifications of events.

The left column of titles listed the possible types of class to which an event could be assigned:

own kind same sex

own kind opposite sex

safe food

safe not food

safe untested

dangerous food

dangerous not food

dangerous enemy

unknown phenomenon

The next four columns were titled according to range and contained the responses of an individual of the current species when cross-referenced with classes of event.

The ranges were:

intimate range

close range

medium range

distant range

The possible behavioural responses were listed in the column of options at the left of the screen:

| |
|---|
| ignore |
| move toward |
| run toward |
| charge toward |
| try to eat |
| try to mate |

The **try to eat** and **try to mate** options were only displayed if the current response being changed was in the **intimate range** column of the main matrix;  i.e. the animals had to be close enough to each other to exhibit these behaviours.

The responses in the boxes in the main matrix could be changed by selecting the box displaying the current setting (by pointing using the joy-stick and clicking a key) then selecting the desired new action from the options column to the left (again by using joy-stick and cursor and pressing a key).

At the far right of the matrix a column titled **urgency** contained values denoting the relative urgency with which an individual of the species would treat the various classes of event, the higher the value, the more urgent the event.  The values could be changed by selecting the appropriate box in the urgency column and entering a new value from the keyboard.

Once the desired changes to the species behaviour characteristics had been made the user quit the program and the changed data would be saved in the *zoo* and *urges* files.  The *zoo* file recorded data describing the species eyesight,  colour and behaviour.  The *urges* file recorded data entered in the urgency column.

### *3.2.2.ii The PLANT program.*

After using MPROG to design species, the PLANT program could be used to enter two-dimensional cartesian coordinates describing the individual animals' locations by pointing to a location on screen using the cursor and joy-stick, then pressing a key. The data were stored in the file *apos* (animal positions).

If the user wanted to locate the animals in three dimensions they would then have to edit the *apos* file using the system's text editor to change a third coordinate for each position.

### *3.2.2.iii The idnos file.*

The species identity code of each individual was entered in a file named *idnos* (identity numbers) using the text editor. The first number in the file referred to the species code of individual number 1, the second to that of individual number 2, and so on.

### *3.2.2.iv The brains file.*

Using MPROG a user could design how a given species would respond to particular classes of event, but not how one species classified another. Each species could classify the other species according to one of the classes described in MPROG. The values 0 to 8 corresponding to the nine possible classifications. The user had to use the text editor to enter values in a file named *brains* which contained for each species in turn a list of values indicating how they classified each other species, and their own.

### *3.2.2.v The INTPROG program.*

Having set up the data in the files: *zoo*, *urges*, *apos*, *idnos* and *brains*, using MPROG, PLANT and the TEXT EDITOR, the user executed INTPROG (interaction program).

The diagram 3.1.4.a evolved into the diagram illustrated in figure 3.2.2.b which describes the INTPROG program;  the core of the Lilliput and Smallworld suites.

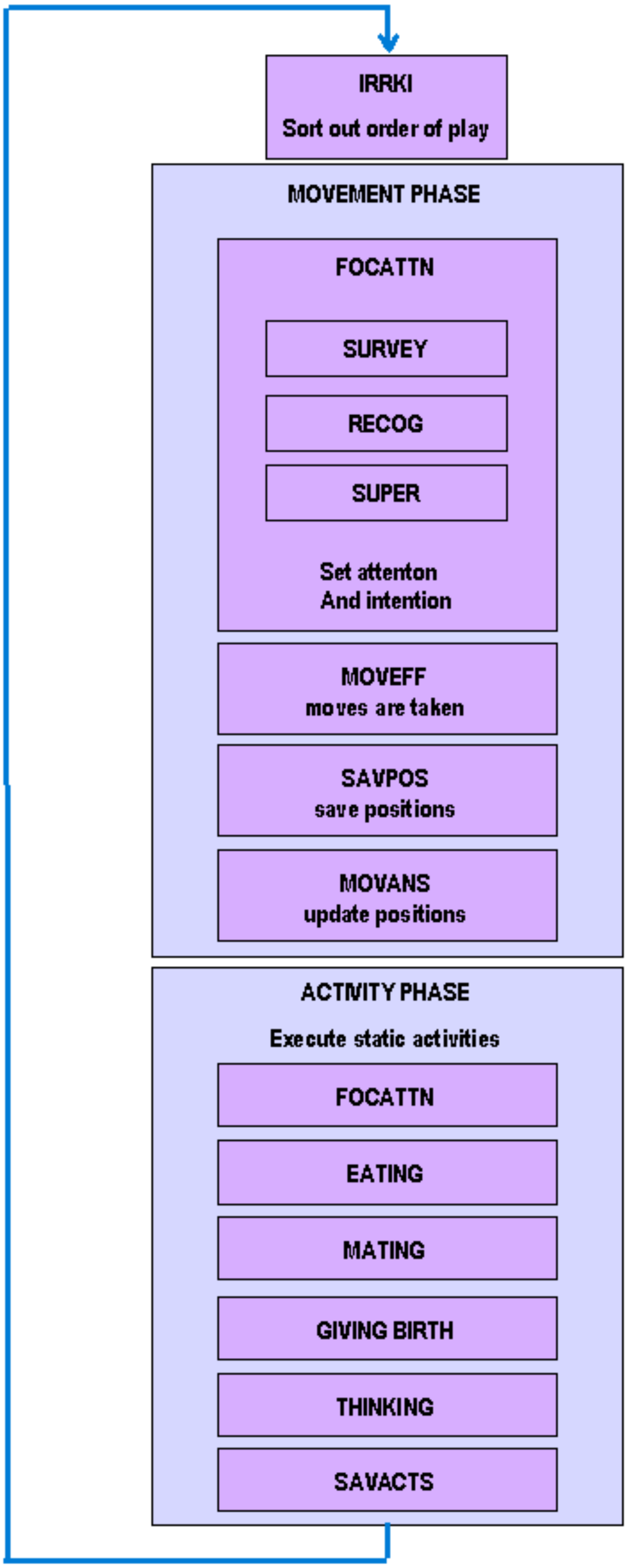



Figure 3.2.2.b

Using data provided by supporting programs in the suite INTPROG calculated the interactions and changing locations of the animals; other supporting programs could then be used to present this data graphically.

The program achieved a degree of symmetrical participation (2.1.3) among the animals by adopting the method of modelling the changes in a situation over a given period of time used in table-top wargaming; time is treated as a series of discrete “rounds” divided into distinct “phases” in which each player has a “turn”. One phase might consist of each player writing down orders. Later phases would include moving pieces representing army units into new positions and resolving combat according to appropriate rules. This treatment of events lends itself to the iterative techniques used in programming. The practice in the ‘C’ programming language of building a program out of “blocks” of code also contributed to the way the program was developed.

The program was written to treat each animal as if it were a participant in a game, leading to an arrangement similar to that represented in figure 2.5.2.f. In each round every animal had a movement phase in which the program determined if the position of other animals should cause it to move and effectively recorded its orders - i.e. whether it intended to move and, if so, how. When the program had checked and recorded the intentions of all the animals they were “moved”; i.e. the coordinates describing their relative positions were altered. There was then an activity phase in which the program determined whether any non-movement activities were appropriate for the animals in their changed positions. The program would determine the results of any activities and make any necessary adjustments to the data, then the next “round” would be started.

Figure 3.2.2.b refers to the central part of the program. The following paragraphs briefly explain each part of the diagram. There then follows a description of the program from the user’s point of view.

***IRRKI***

This routine determined order of play, i.e. which animal’s activities would be determined first.

Although all moves were considered simultaneous, sometimes priority had to be decided. Initially it would be decided on health; The healthier an animal the more advantageous would be its position in the hierarchy. If two animals had the same health, their original position in the idnos file was used as an arbitrary determinant.

***MOVEMENT PHASE***

Each animal in turn (in order of play) became **can** (**c**urrent **an**imal) (“subject” in fig. 3.1.4.a) and was related to the **oans** (**o**ther **an**imals) (“objects” in fig. 3.1.4.a) to determine how it would move in the MOVANS part of the program.

***FOCATTN***

Each **oan** was checked against the **can**’s criteria to see if any of them became its focus of attention; this was achieved by using SURVEY, RECOG and SUPER.

***SURVEY***

Checked the position of **oan** against **can** and if **oan** was in range of **can**’s eyesight, moved execution to RECOG.

***RECOG***

Checked if can recognized **oan** (i.e. whether animals of **can**’s species were programmed to react in any particular way to animals of **oan**’s species) if it did, execution moved to SUPER.

***SUPER***

Checked if **can** considered **oan** superior in importance to other animals in **can**’s range of vision by reference to data from the *urges* file. If so it was ranked as more important.

When all the **oans** had been checked against this **can** the events classed as most urgent that had been recognised were temporarily recorded for use in the next routine.

***MOVEFF***

The type of move that **can** would make was based on its response to the events that it classed as superior in importance. The data describing its next position were changed based on the positions of these events; an individual **can** might have, for example, an inclination to move from several threatening events. The program always moved an individual to another animal's next position and from another animal's current position. As the least healthy animals were always first to become **can** the healthier animals tended to have an advantage.

When the current **can** had been processed by MOVEFF, the next animal in the order of play hierarchy became **can** and had its movement phase computed.

When all animals had been control passed to the SAVPOS routine.

***SAVPOS***

Wrote the current positions of all animals into a plot file (i.e. a file of data that could be used to plot a drawing) plus other data if needed, for example an individual's current colour (3.2.2.vi) (this file was usually named *piccy*).

***MOVANS***

Changed all the animals' current positions to the next positions that had been worked out in the MOVEMENT PHASE.

### *ACTIVITY PHASE*

Each animal in turn (in order of play) became **can** and its current activity (**act**) was determined by checking the relative positions of it and all the other animals in turn and seeing whether the species that **can** belonged to should react in any particular way.

### *FOCATTN*

Worked as FOCATTN above to determine which other individuals would be attended to by **can**. Only static activities were allowed in response to **oan** positions; if movement was indicated it was ignored.

### *EATING (Fighting)*

If **can** was close enough to **oan**, and it had been determined that **can**'s species try to eat **oan**'s if they are close enough, any "fighting" took place: The health of an animal being attacked was reduced. The health of the attacker was increased by the same value. The changes in value were proportional to the relative healths of attacker and victim.

### *MATING*

If the **can** was close enough to **oan** and it had been determined that **can**'s species try to mate with **oan**'s if they are close enough, and the **can** and **oan** were mature enough (i.e. had sufficient age) mating was recorded.

### *GIVING BIRTH*

A record was kept of the age of the animal in role of **oan** at the time of an attempt at mating and at a given number of rounds after the mating a new animal of either the **oan**'s or **can**'s species was introduced into the environment near the one giving birth. The species of the offspring of a given species was designated at the species design stage. The offspring could be of another species; thus, for example: users could design a predator species to give birth to a prey species and vice-versa.

### *THINKING*

It was intended that if the **can** was not doing anything else it would "speculate" about possible outcomes of other strategies in previously experienced situations and could decide to modify its future behaviour; effectively changing its species data. Although planned for at an early stage, this routine has not yet been implemented. It would effectively consist of the animal prompting INTPROG to run a version of Smallworld as a sub-program, applying criteria to the events in the sub-program to determine the relative value of possible changes in behaviour. This would constitute the program generating a world model as discussed in (2.5.1) for each of the animals. If a human's behaviour could be represented in this world model the program could treat the human as if it were a program.

***SAVACTS***

When the program had determined all the static activities of animals and changed animal data accordingly, a record of significant changes was made in a documentation file named *report* which satisfied the role of the "general history" described in (3.1.4). Control then returned to the start of the program.

***Animal Data***

As it was executing, the program recorded and made use of the following information about each individual animal:

| | |
|---|---|
| Species | (A number used as a code ) |
| Age | (Measured in rounds) |
| Health | (The higher the number, the healthier the animal) |
| Current x position | (The position of the animal at the |
| Current y position | start of the round, represented |
| Current z position | as coordinates) |
| Next x position | (The position the animal is to |
| Next y position | move to during the movement |
| Next z position | phase of the round) |
| Focus of attention | (Identity code of other animal) |
| Urgency of focus of attention | (Importance of other animal) |
| Distance of focus of attention | (Distance from other animal) |
| Current activity | (Code representing response to focus of attention) |
| Rate of movement | (Static, slow, fast or very fast) |

***The INTPROG interface from the user's point of view.***

The program communicated with the user simply by printing text on the screen and waiting for the user to type a response. It would first prompt the user for some information:

Do you want to change parameters ?

If the user responded by typing:

y

and pressing the return key, the program would prompt the user to enter further information which would determine whether the changes in position of the individuals would be plotted and displayed in one graphic window covering the whole screen, or several, showing a number of steps (Figure 3.1.6.b).

The user could choose:

- the number of columns and rows of frames
- the dimensions of the windows
- the scale of the drawing within the window
- whether the centre of the plot was to be displaced from the centre of the windows
- the clipping of the plot in the third dimension
- the width of the lines to be plotted

If the user chose not to change the parameters, the default values would lead to the presentation of a single image filling the whole screen, centred in the middle of the screen.

The user would then be asked if they wanted the program to:

- record and display the shape generated

- just record it

- just display it

The final input prompted from the user was the number of rounds, i.e. how many cycles of the program would be executed.

***Watching the shape being generated***

The user could then sit back as data were generated and, if the display option had been chosen, watch an image being drawn on the screen.

The first vectors would start at the points on the screen corresponding to the positions entered in the *apos* file using the PLANT program (3.2.2.ii ). Subsequent lines were drawn according to the changes in position of the individuals determined in the INTPROG program, joining an individual's current position with its next position (figure 3.2.2.c).

Once INTPROG had completed the number of rounds specified, if the option to record had been chosen, the data describing the movements of the individuals would be recorded in a file named *piccy*. The *piccy* file could then be renamed if it was to be kept and re-displayed later using another program.

The information recorded consisted of a round by round record of:

- the colour code of each individual
- its last X, Y and Z position
- its current X, Y and Z position

The data could then be used to produce further images in a number of ways:

### *3.2.2.vi* ***Display programs.***

Within the INTPROG program an option could be included to increment the colour code of an individual every time a number of rounds had passed. This meant that when the trails were displayed the colour of each portion of an individual's trail would have a different colour according to the round it had been generated in.

The image in Figure 3.2.2.c and in Slide (B1) illustrate the effect of incrementing the colour code each round.

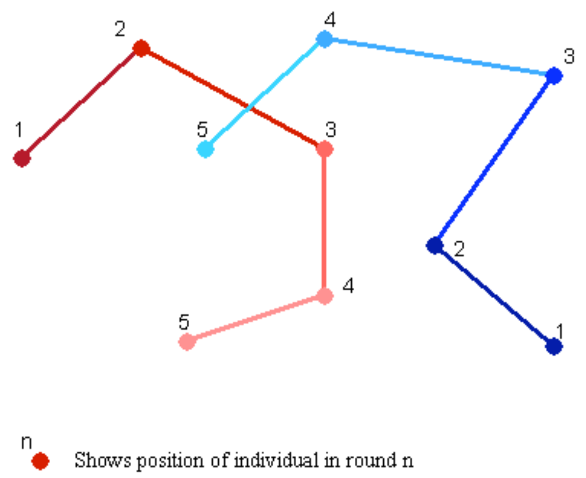



Figure 3.2.2.c
Drawing trails of individuals

None of the display programs calculated a perspective projection; the points on the screen were drawn in the same X, Y location no matter what Z value the point had.

Using a program named DEPTHSORT the data in a file of *piccy* format could be sorted according to its Z coordinates and the image could then be drawn so that the nearest lines were effectively drawn over more distant ones. This “painter’s algorithm” approach to presenting an illusion of three-dimensional depth could be further enhanced by changing the width and the colour of a section of a trail according to its Z value. Examples produced using these techniques are illustrated in Slides (B2) (B3) and (B6).

The numbers in the colour table, or palette, corresponded to values representing the intensity of the red, green and blue guns of the display screen. These values could be changed using a program named PALETTE which displayed the complete colour palette in a column to the left of the screen. The user could use the cursor and joy-stick to select the colour in the palette to be changed and then by selecting one of three boxes labelled red, green or blue use the keyboard to enter a new value varying from 0 to 63, thus changing the intensity of the respective colour.

Once designed, palettes could be saved and associated with particular special function keys built into the keyboard; the palette of colours being used to display an image could then be changed at the press of a single function key.

## *3.3 Introducing animation.*

It was considered that it should be determined whether the shapes generated by Lilliput would be sufficiently interesting when animated before investigating ways of enabling people to participate in the work.

Computers may be used to produce animations but to do so requires powerful technology. When the Silicon Graphics IRIS series of interactive three-dimensional graphics workstations were introduced in 1985 they set new standards in real-time interactive animation. The series has since continued to be developed to include technical improvements and continue to hold a significant part of the market.

Not long after moving to Loughborough University of Technology (LUT) in 1985, to pursue this research, it was learnt that the Human Computer Interface Research Unit (HCIRU) (Soon to become LUT Computer-Human Interface Research Centre - LUTCHI ) were about to take delivery of two IRISs. It was decided to use them in pursuit of the project even though such a technology was at the time costly, and therefore not within reach of most artists, as was anticipated that trends in the development and manufacture of technology would eventually lead the costs to fall and equipment of a similar performance would become more widely available* .

The equipment was ideally suited to test the hypotheses developed as a result of the work at the University of Kent at Canterbury, being specifically designed to produce animated displays of three-dimensional computer-graphical objects that could be interacted with in real-time.

### *3.3.1 Animation on the Silicon Graphics IRIS Workstation.*

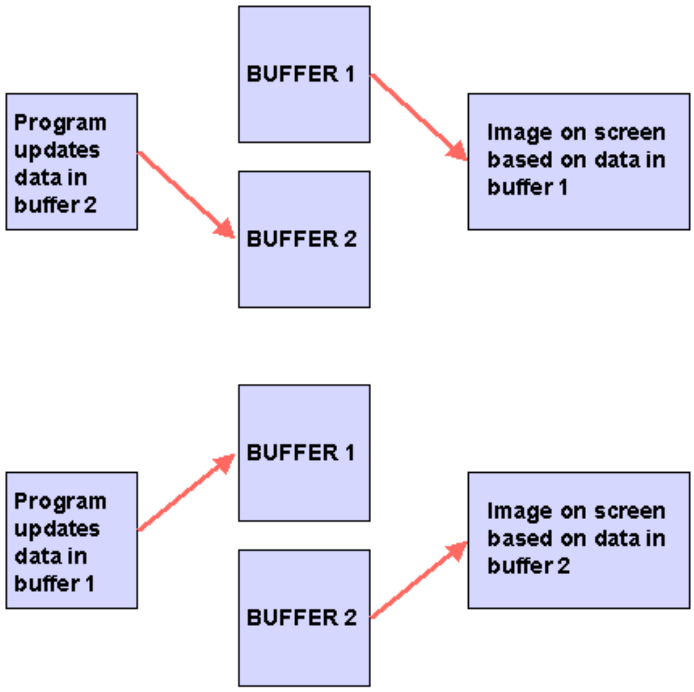
Animation was produced on the IRIS using a “frame buffering” technique: The data used to determine what to display on screen was read from either of

* To illustrate that the cost has indeed reduced: the insurance value of the IRIS used at the exhibition “Art and Computers” in 1988 (3.5) was £65,000. In that same year Silicon Graphics launched a new series of improved IRIS workstations called “Personal” IRISs which were marketed at from £15,000. In 1991 the IRIS INDIGO was introduced, marketing at under $10,000.

two areas of memory. Display of sequences of changing images was achieved by causing the display management system to display an image described by data from first one memory "buffer" and then the other, changing the data in each buffer during the period that it was not being used to determine the image displayed. The rapid alternative display of updated frames enabled the production of an illusion of movement similar to that achieved using cine-film.

The system had to be managed so that the data in a given buffer was not used for the display while its contents are being changed.

Figure 3.3.1.a shows the state of the system for alternate frames.




Double-buffering to produce animation

Figure 3.3.1.a

### 3.3.2 *Deciding how to animate the images.*

The equipment that had been used to develop Smallworld at UKC were DEC VAX 11/730 and 11/750 computers connected to a Sigmex colour graphics terminal that could display static images of up to 64 colours. The programs were written in the 'C' programming language, including the special instructions necessary to produce images on the display screen.

At LUTCHI the programs were transferred to a Silicon Graphics IRIS 2400 Turbo 3D graphics workstation. This machine could run programs written in 'C' thus it was only necessary to change those portions of the programs that dealt with sending instructions to control the graphic display to produce static images similar to those produced at UKC.

New programs had to be written to take advantage of the special capabilities of the IRIS.

If figure 3.3.2.a is compared with figure 3.2.1.a it can be seen that the input programs MPROG and PLANT were not implemented immediately on the IRIS. This was because it differed significantly from the Sigma/VAX combination in the way it dealt with input and output.

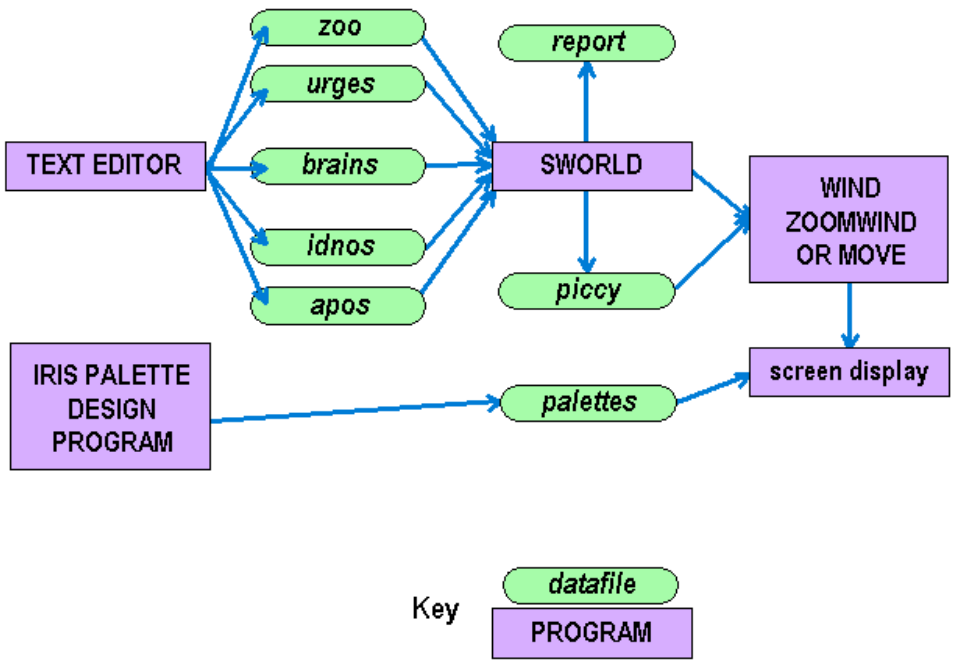



Figure 3.3.2.a

It was considered more important in the short term to make use of the special facilities of the IRIS to produce real-time animation and to add the modified input programs later.

Some useful programs for changing colour palettes were provided on the IRIS so these were used rather than rewriting the palette design program (3.2.2.vi) that had been used at UKC.

Although some of the shapes that had been generated at UKC were described in data three-dimensionally, the images of them had not used perspective projection (3.2.2.vi). Using the IRIS it was relatively easy to produce perspective projections of three-dimensional shapes and facilities were built in to use "depth cueing" (3.5.2.iii). Among the many transformation functions built in to the IRIS were means of rotating and translating the projected shape. A number of example programs were provided by Silicon Graphics to demonstrate the use of the IRIS's. The principles described in these programs provided models for the first programs written to animate shapes in Smallworld, described below

### *3.3.2.i The WIND and ZOOMWIND programs.*

One of the first animation programs developed was called WIND after the canal navigation term "winding", used to describe turning a Narrow Boat around (a more-or-less laborious task depending on the skill of the boatman). This program enabled the user to display a shape generated by the SWORLD program and change the image on screen by pressing keys so the shape appeared to rotate about its centre point.

A few modifications to the program enabled the user to change the position of the shape relative to the viewpoint of the perspective projection, causing the effect of zooming the shape towards and away from the viewer, hence the program called ZOOMWIND.

ZOOMWIND can be seen in use on the accompanying videotape.

### 3.3.2.ii The MOVIE program.

One of the aspects of the use of INTPROG that it was considered had been poorly expressed by the UKC programs were the catastrophic changes that could be caused by slightly altering just one parameter governing the generation of a shape.

For example: the effect of the changing the speed of one of the species in a predator-prey relationship could make animals of either species move farther in a given round. The compound effect of a simple change in the behaviour of one species could thus lead to more, less, and even different animals being pursued and caught. (See Slides (B2) and (B3) “Panic 1” and “Panic 2” and (B5) “Impact: Two Versions” ).

The MOVIE program was written early in the LUTCHI part of the project as it had long been considered that to display a number of *piccy* files that had been generated using species with slightly varying parameters one after another, fast enough to produce an animated image, would reveal more about the incidence of catastrophic changes in the generative procedure than simply displaying a sequence of still images simultaneously.

Using MOVIE a sequence of piccy format files could be displayed at varying rates. Each of the different files would be generated using the same start positions and animals, but changing, for example, the speed or eyesight of one of the species from one frame to the next. An example from the MOVIE program is included on the accompanying videotape.

Although MOVIE showed the effects of changes in species behaviour parameters it did not make sufficiently clear to a viewer of the animation what was causing the changes. It is considered that this will not be possible until the programs can generate full, multi-round images quickly enough to produce the effect of MOVIE in real-time. The user could then actually change parameters that would effect the animation in real-time and could determine what changes of species behaviour were causing the changes in the animation.

The SWORLD program could not be made fast enough at generating the new *piccy* files for this to be implemented. It remains an intention should fast enough computing power become available.

When animation was first considered at UKC it was noted that “creepy crawly” side-effects and anthropomorphism should be encouraged. The non-interactive results of MOVIE were considered to be too much like computer-game animation and consequentially likely to be misread; trivialising by association the experiences that the research was concentrating on in other parts of the suite.

### *3.3.2.iii The PLANT program.*

A rudimentary new version of Plant (3.2.2.ii) was developed to use on the IRIS which enabled the user to point at a part of the screen using a mouse (in place of the joy-stick) to move the cursor and locate a point by pressing the leftmost of the three mouse buttons (Figure 3.3.2.b).

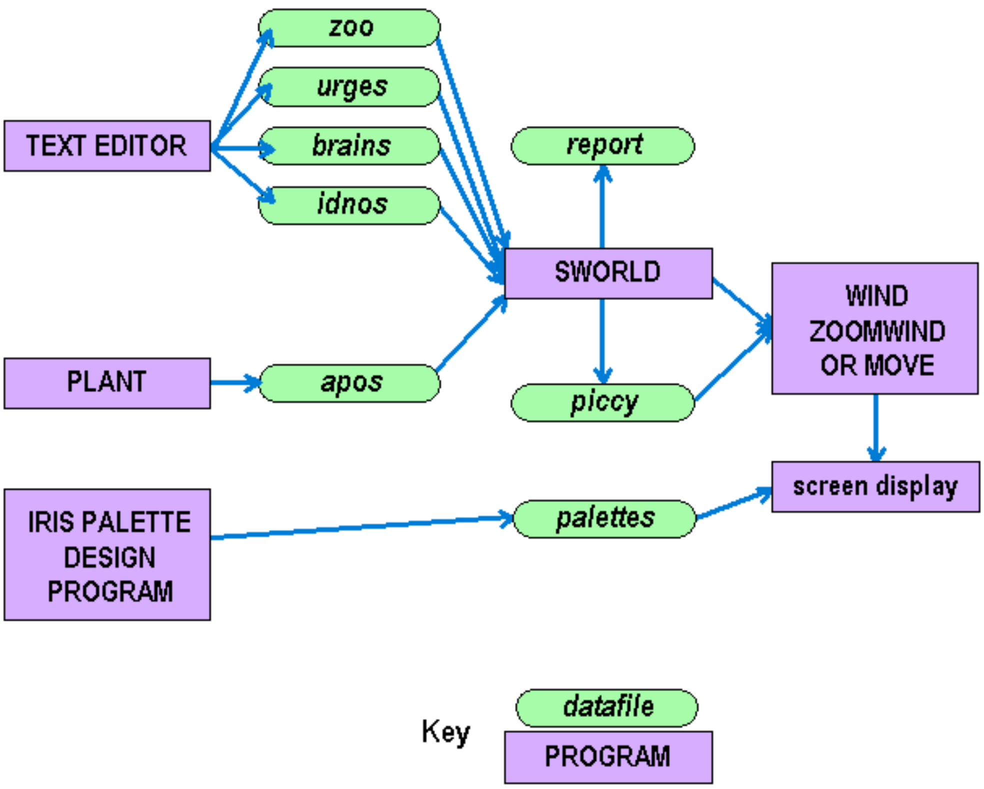



Figure 3.3.2.b

The locations could still only be made in two-dimensions, however, and the third coordinate of each point still had to be either a default value (i.e. a value that would be allocated to it by the PLANT program automatically) or changed using the text editor.

The *idnos* file was constructed using the text editor.

### *3.3.2.iv The SWORLD program.*

The INTPROG program was renamed SWORLD (Smallworld) but initially remained fundamentally the same as described in (3.2.2.v).

### *3.3.3 Exhibition of photographs and video at Imperial College London, 1986.*

An opportunity arose to exhibit in the exhibition, “Art and Industry”, at the Concourse Gallery of Imperial College in 1986. It was decided that this exhibition would be a good opportunity to show, and gauge people’s reactions to, recordings of the real-time generation of images.

A selection of the photographs that had been produced at UKC were exhibited along with the first video recording of Smallworld.

The video sequence was titled “Images Generated by Programs that simulate Predator-Prey Interaction”. The title was intended to direct viewers’ attentions to identifying how the predator-prey relationship manifested itself in the work (2.6.1). Extracts are included on the accompanying videotape.

At the start of the recording a shape was shown being rotated using ZOOMWIND.

Following this it showed some individuals being located using PLANT.

When the SWORLD program was run the individuals to the left of the screen exhibited predatory behaviour with regard to those to the right.

SWORLD was run a further three times, using the same starting locations but with the parameters governing the rate at which individuals could move varied each time.

All four of the shapes were then shown closer to illustrate the difference changing this one parameter could make to the images generated.

The next sequence showed a three-dimensional matrix of twenty-seven start points. The centre individual was a predator. The shape was rotated slowly using ZOOMWIND to show the shape from different points of view. The shape itself was static; no lines were seen being generated.

Four versions were shown, each one with more the predator's trail generated.

The four versions were then shown together. Each one was rotated in turn for comparison and to show how the final shape was arrived at.

### *3.3.4 General conclusions drawn from the exhibition.*

Observations and discussions with visitors and other exhibitors supported the hypothesis that animations would help people to interpret the images.

Any doubts that existed regarding the possibility that the images would be too abstract to interest people were also quelled by the amount of time visitors spent watching the video.

There was a strong indication that visitors to an exhibition might actually be sufficiently interested to use a participatory version of the program so it was decided to test this at the art exhibition of the World Science Fiction Convention in Brighton in 1987 for which an invitation to exhibit had been received in 1985.

It was also decided that a questionnaire should be prepared, to be completed voluntarily by those visitors who used the participatory program, to gauge more clearly their responses to it (2.7.4).

### 3.3.5 *Observations made once the shapes were animated.*

Having developed the ZOOMWIND program to enable shapes to be rotated and examined at will, it became clear that just showing recordings of animations would not allow people looking at the work sufficient control over how the shapes were presented. The animations made the three-dimensional shapes more obvious, but did not allow the viewer the freedom they would have to attend to those aspects of the work and build a coherent mental model (2.4.2), as they would in the actual world with a three-dimensional object like a sculpture. It was considered that access to the ZOOMWIND program might at least allow people the freedom to control how the shapes were presented to them.

### *3.4 Development of ways for visitors to access program.*

The invitation to exhibit in the art show of the World Science Fiction Convention in Brighton in 1987 formed a venue for which to prepare the first version of Smallworld that visitors could interact with.

### *3.4.1 What the participant should be able to do.*

Theoretically there were many parts of the Smallworld system that could be made accessible to a participant. It was considered likely that some aspects of the system would be easier for new users to understand than others and that this part of the research should begin to test these assumptions and determine the relative ease with which participants could understand different aspects of the system.

As the work was to be exhibited alongside the work of other artists it was considered that potential participants should be able to achieve initial results with a minimum of exploration and then be free to explore the system further if they desired.

To test the effectiveness of the work's ability to enable participants to recognise and recover the generative system it was considered important that anyone participating in Smallworld should interpret the way the individual animals affected each other's behaviour by watching the shape being generated rather than being told in advance what was likely to happen. For this reason it was determined that the individuals should not be referred to as "animals", as the expectation of seeing animals would prejudice participant interpretations. The intention was to determine whether the abstract shapes generated would be interpreted as the product of animal-like behaviour, as opposed to the product of effects like gravity that had led to the firework analogy (3.1.6).

Although it was intended that eventually people would be enabled to design animals, the idea of enabling participants to use a species design program along the lines of MPROG (3.2.2.i) was dismissed; it was intended that as many people as possible should be given the chance to use the program and species design would take a lot of time. It was also considered that participants introduced to Smallworld by first using a species design program would be afforded too much foreknowledge of the possible events in the shape generation part of the system.

The PLANT program seemed an appropriate candidate for inclusion as it was anticipated that participants would soon learn how to use a mouse to select species from a pop-up menu and locate start-points for individual release. The main drawback was that participants would only be able to locate points in two-dimensions as an easy interface for releasing individuals in three-dimensional locations had yet to be developed. Participants would also not be able to see the results of their “planting” until the SWORLD image generation program was executed.

The SWORLD image generation program would have to be run as a non-interactive stage to show the effects of the participants choice of species and release locations. The user could at most choose when to start running SWORLD and when to stop it.

The ZOOMWIND program promised to be the easiest program in the suite for participants to use as the feedback was so direct (2.1.1) (2.7.2); the movement of the image changed almost immediately after the appropriate key had been pressed.

### *3.4.2 Smallworld exhibited in Brighton, 1987.*

The programs were exhibited using a Silicon Graphics IRIS workstation which was installed alongside a static exhibit of photographs, the video made for the “Art, Science and Industry” exhibition in 1986 (3.3.3), and a video of the graphics produced using a program called TRACK (3.4.2.i).

Visitors who participated in Smallworld completed questionnaires. Their answers were discussed in an intermediate report (Bell 87). A summary of which follows in (3.4.3).

Figure 3.4.2.a shows a general view of the exhibit and figures 3.4.2.b, c and d show visitors at the exhibit.

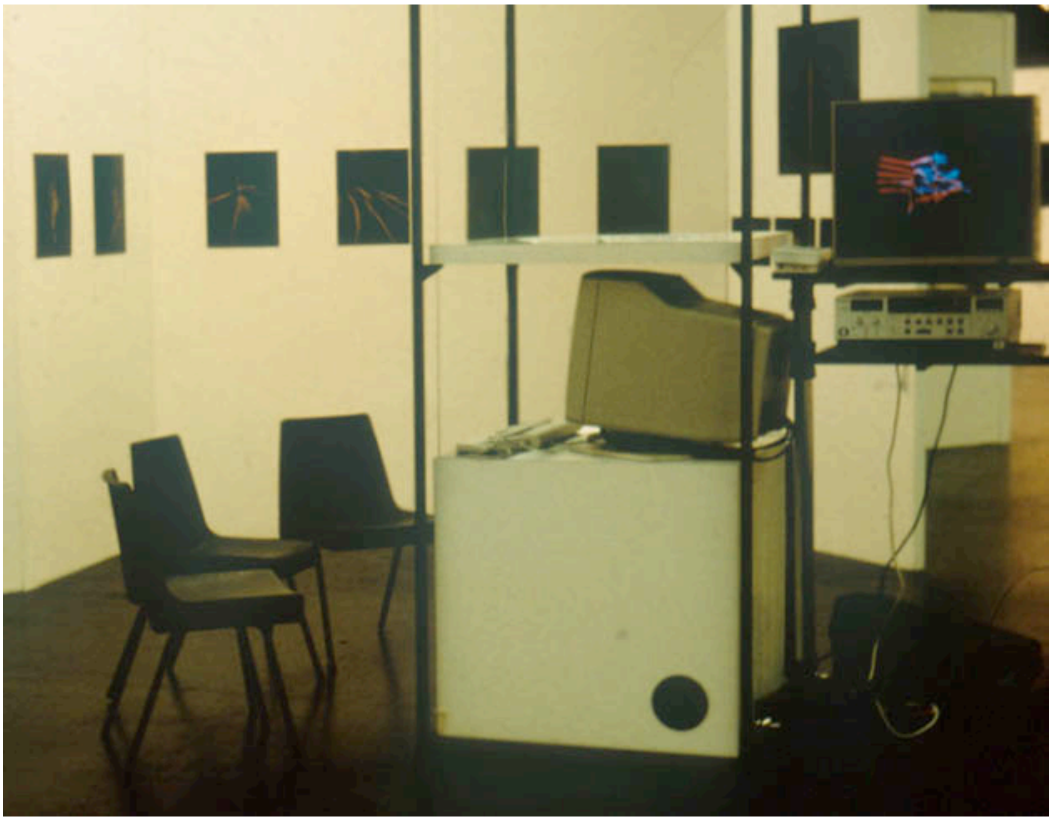


Figure 3.4.2.a

Figure 3.4.2.b

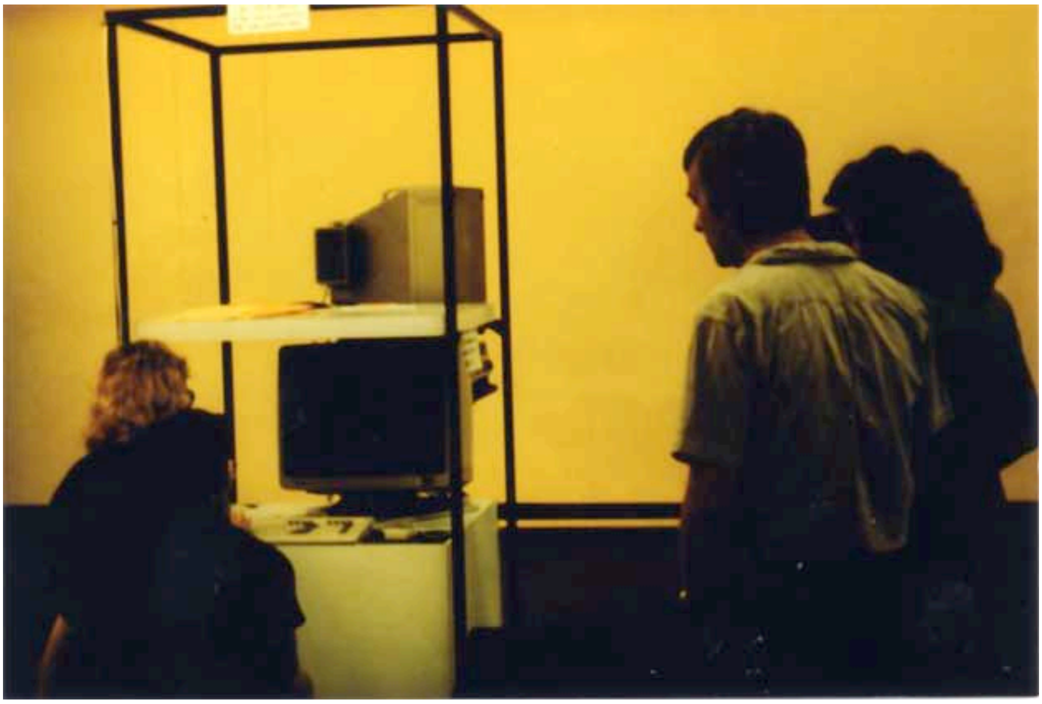


Figure 3.4.2.c

Figure 3.4.2.d

Some of the photographic prints exhibited the inadequacy of attempting to show movement in a still image and contrasted with the positive way in which the volumes of space traced by the moving shapes could be exploited to explore spatial organisation and colour effects.

The time exposures, examples of which are shown in Slides (B7) and (B8) were not considered very satisfactory at the time as they appeared rather dated. In retrospect they served a useful purpose as they indicated, however poorly, that shapes of more solid appearance with translucent layers of surfaces could be generated using Smallworld, and briefly allowed a glimpse into another path of investigation that could be pursued in future. At the time they were exhibited as a contrast to the video and participatory piece.

Slides (B9) and (B10) were considered a little more successful. The effects were achieved by making the colours of trails oscillate darker and lighter over time, instead of simply becoming lighter (3.2.2.vi). The accidentally vaguely figure-like image titled “Prospero” (B9) indicated how in a future version of Smallworld each animal could perhaps be represented by vaguely figurative shapes.

The relationship between the version of Smallworld exhibited and the previous version can be seen by comparing figure 3.4.2.e (ii) with figures 3.4.2.e (i) and 3.3.2.b.

The configuration eventually exhibited consisted of three programs which could be started by pressing keys 1, 2 or 3 followed by the “return” or “enter” key.

***PROGRAM 1***

The program started by pressing key 1 was a version of PLANT developed from the one described in 3.3.2.iii. The participant was not able to choose the Z location of the released individuals - this was predetermined according to species; each species would be introduced at a different value of Z (all individuals of the same species starting with the same Z value).

The pop-up menu is one of a number of now conventional ways of enabling users to make selections (Foley et al 90). It is a relatively easily mastered technique and was used in PLANT as it fulfilled a role in which the interface was intended to provide access to the program rather than being a subject of attention (2.3.1).

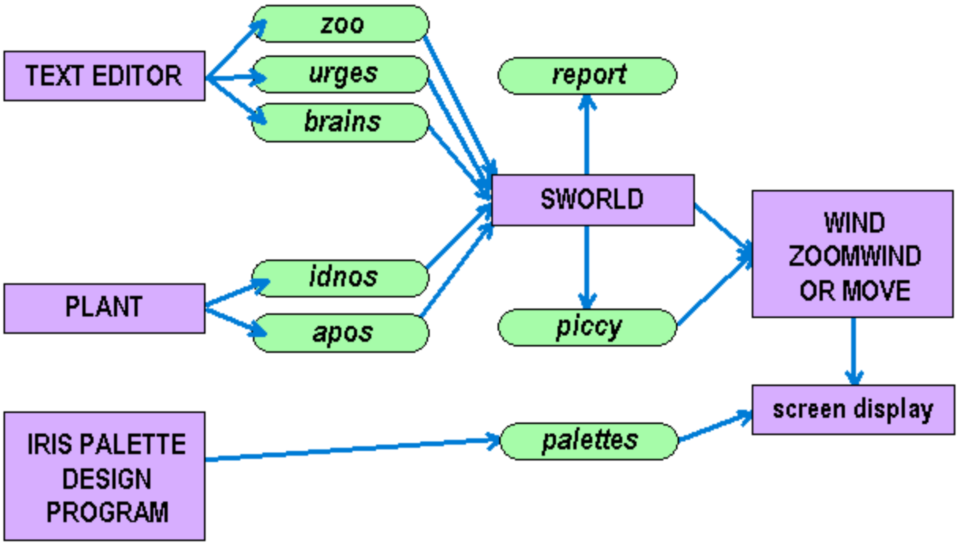



Figure 3.4.2.e (i)

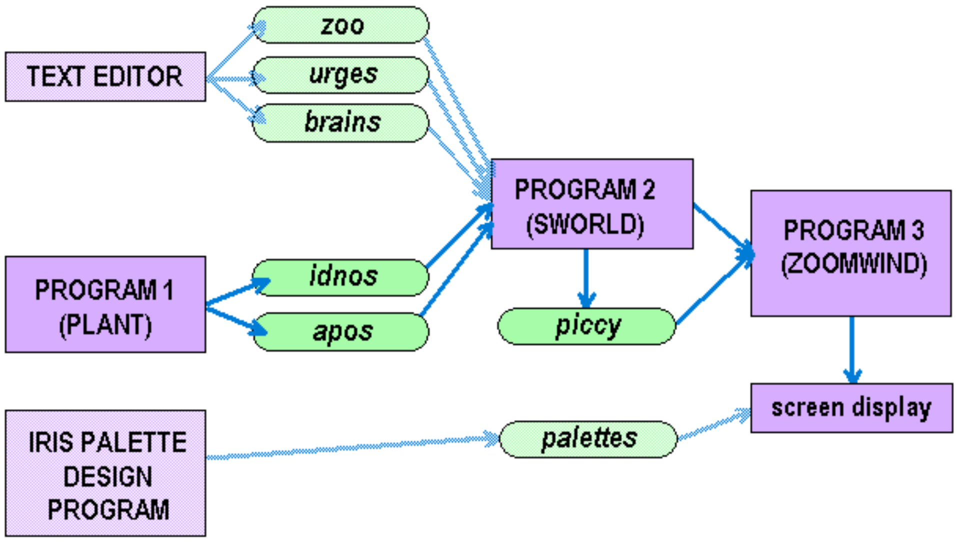



Figure 3.4.2.e (ii)
Version exhibited at Brighton

The IRIS system was delivered with pre-written functions to be used in programs that included ones to make “menus” of options “pop-up” on screen if the rightmost mousebutton was pressed. This feature was used to introduce pop-up menus into PLANT. By pressing the right mousebutton a selection of species could be made to appear. If the button was held down and the mouse moved different options on the menu would then be highlighted. If the button was released while a particular option was highlighted, that option would be selected and executed by the program (figures 3.4.2.f & g). This enabled the user to enter values indirectly in the *idnos* file without recourse to the text editor.

Above the options in the pop-up menu the title “Line Generators” was displayed to avoid the animal analogy.

Figures 3.4.2.f to 3.4.2.i show this version of PLANT being used. It can also be seen on the accompanying video.

Participants could locate up to one hundred individuals. Once this limit had been reached, the PLANT program would automatically stop.

Participants could quit the program voluntarily before having located one hundred individuals by pressing the right mousebutton.

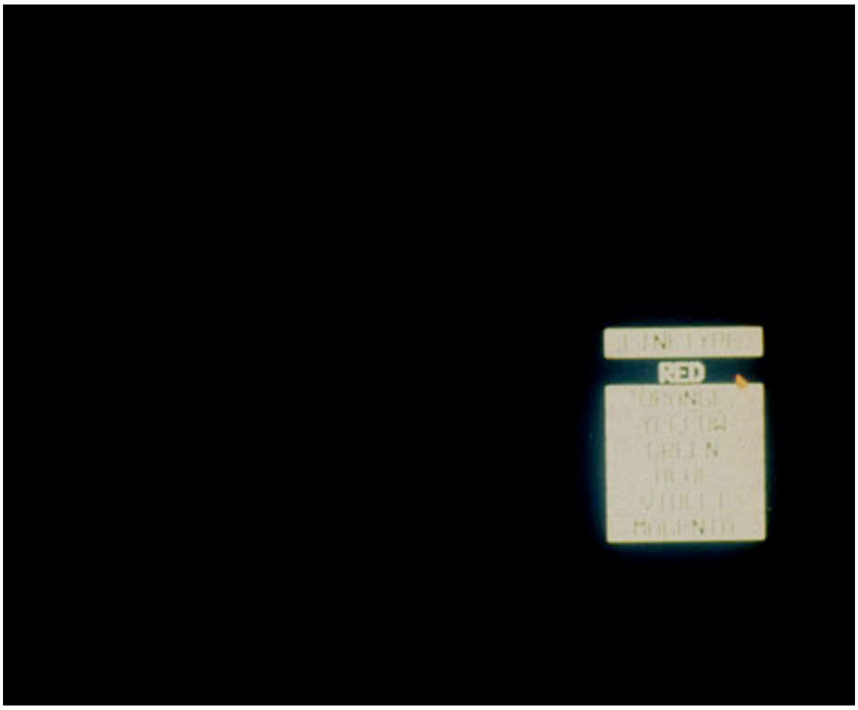



Figure 3.4.2.f

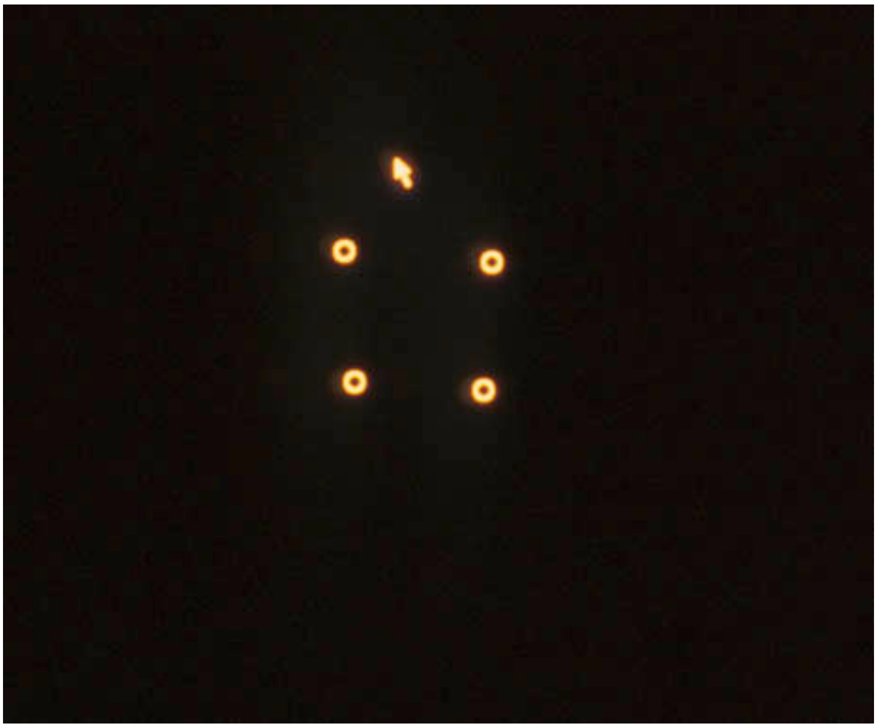


Figure 3.4.2.g


Figure 3.4.2.h

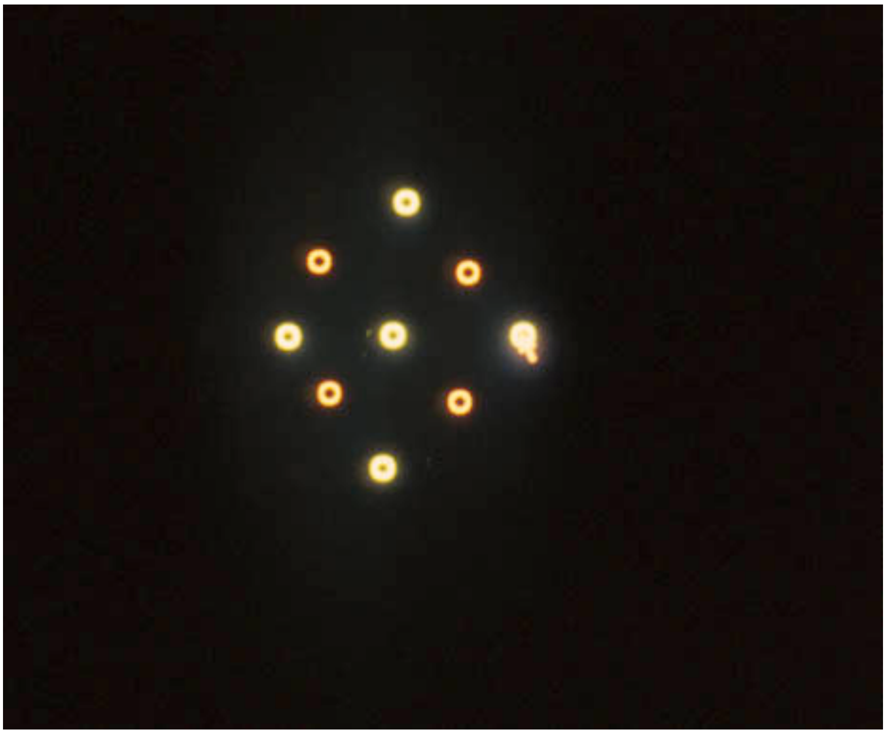


Figure 3.4.2.i

***PROGRAM 2***

The program started by pressing key 2 was SWORLD (3.3.2.iv). Users could watch the shape being generated and the consequences of their choices in program 1. The shape drawn on screen would at this stage give the appearance of being two-dimensional. The participant could quit the program by pressing 1 or 2.

***PROGRAM 3***

The program started by pressing key 3 was a version of ZOOMWIND (3.3.2.i). Participants could move the image's centre on the screen by moving the mouse, rotate the shape by pressing the A, S, E and D keys and zoom in and out by using Z and X keys on the keyboard. It was through use of the ZOOMWIND program that users could see that the shape was actually three-dimensional.

Examples of all three programs in use can be seen on the accompanying videotape.

### *3.4.2.i The TRACK program.*

In the development of Smallworld it was noted that the point of view of participants could influence their logical and affective interpretations of observations made during interaction (2.1.4) (Bell 90). The TRACK program was an experiment pursued to explore this idea. In the program the viewpoint used to determine the image drawn on the screen was made to move along the tracks generated by SWORLD.

The character of the movement of the viewpoint reflected the behaviour of the individual it was tracking. The intention was to eventually incorporate TRACK into the Smallworld suite to enable users to experience the feeling of being pursued when the viewpoint followed the trail of a prey species, and of pursuing when it was following the trail of a predator species.

The animation seemed promising but it seemed likely that it did not indicate clearly enough what was happening. The only evidence that the viewpoint was notionally moving was the change of parallax of other features: if, for example, a predator was being pursued (and therefore remaining “in front” of the viewer), as the only record of its presence was a trail and the only features of the trail that could signify movement were where it changed direction, there was insufficient change of parallax to imply movement.

There was also a technical programming problem in getting the viewpoint to change neatly as the path followed by the viewpoint changed direction: the view would often invert unpredictably, which made the animation confusing. This was another situation where a decision was made to abandon learning a new programming technique in order to concentrate on other aspects of the work (2.7.4).

The video was exhibited to determine by talking to visitors whether the assumption regarding the ambiguity of the animation was correct. Replies confirmed this to be the case, and development of the program was halted until time was available to learn the necessary techniques to improve it.

Visitors who used Smallworld filled in questionnaires. Their answers were discussed in (Bell 87). A summary of their responses follows in sub-section (3.4.3).

An example of TRACK is included in the accompanying videotape.

### *3.4.3 Summary of report and questionnaire.*

The responses to the questionnaire indicated that nearly all of the 45 participants who completed the questionnaire were already to some degree familiar with computer graphics through seeing it on television or home computers. 16 had produced some computer graphics themselves on a painting type program and 13 claimed to have had experience of writing computer graphics programs. All those who answered indicated that they had enjoyed participating.

Some people were reminded by the work of other uses of computer graphics including Jeff Minter's "Colour Space" program (Also called "Trip-a-Tron"; an interactive abstract graphic program produced by the "Llamasoft" company), but others were reminded of other things that did not involve computers: a mechanical device that spun a piece of paper that had wet paint on it, time-lapse photography , fireworks, Conway's Game of Life (3.1.2) (Gardner 70), kinetic and light sculpture, and Paul Klee's "Taking a line for a walk".

Eighteen of the Forty-Five participants indicated that they thought they had made mistakes when using the programs. Five with using the keyboard and mouse, and ten with design decisions when using PLANT that led to unsatisfactory shapes being generated (4.1.2).

Many responses pointed to the need for more information about how to use the program and suggested that such information should be available interactively as an option within the program, demonstrating in their suggestions a knowledge of current approaches to software design. They seemed to want programs to be designed according to these current conventions (2.3.1).

The following comments are a selection from the section of the questionnaire set aside for further comments:

- There should be more types of line generator that can be chosen during the initial location program.

- There should be a clearer explanation of the line generator's likely behaviours.

- The program should have a 'undo' option to see what you did to produce a certain effect, so you can repeat it if you want to.

- There should be a way that wrongly placed start points can be erased.

- 3D location could be indicated when entering start points by arrow-key controls and indicated by size of circle and/or number displayed at edge of screen.

- Some people might prefer the option of a numerical X, Y, Z representation of position.

- The places where ‘predator’ and ‘prey’ meet could be highlighted further and perhaps made the site of ‘scavenger’ activity (to continue the ecological theme)

- Colour changes indicating mood might also enhance the image, particularly while it is being plotted.

The way these comments were responded to when considering changes to the program is discussed in (3.5.1).

Several images made by visitors to the exhibit were saved on disk. Slides (B11) and (B12) show views of one of these shapes, named “Sirior” by its creator, who unfortunately remains anonymous. The combination of 2D and 3D elements and the directional symmetry of his shape was considered particularly interesting and is discussed further in section (3.7.4) and (4.1.5). It also appears on the accompanying videotape.

### *3.4.4 General conclusions drawn from exhibition.*

The exhibit attracted the attention of at least 45 participants during the course of the three-day exhibition. Many lessons were learnt by observing visitors to the exhibit and from the answers given to the questionnaire. In the following section attention is drawn to those occasions where these observations affected later design decisions. The exhibit proved that the images generated and the process involved interested a sufficient number of visitors to warrant development of an improved interface; people were interested in the generative procedures, it was now necessary to find ways to make the interaction more extensive.

## *3.5 Improving ways for participants to access the programs.*

An invitation to exhibit Smallworld at the “Art and Computers” exhibition being organised by the Cleveland Gallery in Middlesbrough formed the next opportunity to test the programs in the context of an art exhibition. After the comments of people at the Brighton exhibition, satisfied that for the moment the content of the work was adequate to reward participant attention, it was decided to concentrate on improving the human-computer interface.

It was also decided to determine whether the work could stand alone by exhibiting the interactive program without any accompanying video-recording or static photographs.

### *3.5.1 How the interface was to be improved.*

At Brighton there had always been an instructor present to advise participants about the use of the programs. The circumstances of the “Art and Computers” exhibition were such that a similar arrangement would not be possible. Participants would have to be able to use the exhibit unsupervised. This demanded that there should be sufficient instructions available for visitors to the exhibition to enable them to access Smallworld without assistance.

It was determined that these instructions should be available on screen; some of the participants at the Brighton exhibition had expected it and it was considered that the fact that people could access the help information optionally, rather than have it displayed permanently as printed notices, would be less likely to distract attention from the work itself.

The use of the keyboard as well as the mouse at Brighton had meant that participants had to learn to use several input techniques and could make errors by pressing the wrong keys. They had learnt quickly how to use the pop-up menu however, so it was determined that the participants’ input to the programs should be via the mouse alone, using pop-up menus rather than the keyboard to select the various program options.

To make the user more immediately involved in Smallworld it was determined that the PLANT and SWORLD programs should be combined so that as soon as new individuals were introduced into the 3D space they would start interacting with those individuals already there.

The list of suggestions made by participants at Brighton noted in (3.4.2) were considered and acted upon as follows:

That there should be more types or species of line generator was considered to run counter to the intentions of the project at this stage; it was considered that in the time available to a user it was more important for them to become familiar with the varied effects of a limited number of species on each others' behaviour, rather than to have an extensive selection of species that it would take a long time to become familiar with.

As one of the main intentions behind Smallworld was that users should find out that the lines are generated by animal-like behaviour through observation of the computer graphics, it was considered that rather than the line-generators' likely behaviour being explained more clearly in advance, it should actually be even less clear than it had been at Brighton. The animal behaviour analogy had often been resorted to in explanations by the instructor at Brighton. This analogy was avoided in the on-screen help texts developed for exhibition at Middlesbrough.

An "undo" option of sorts was considered a good idea as it would enable correction due to dynamic feedback of the kind discussed in (2.5.1), but it was also felt that users should be encouraged to remember what they had done to achieve a particular effect, rather than be provided with an automatic way of repeating what they had done before. It was considered that repeating a sequence of inputs to generate a similar result should be achieved through practice rather than by use of templates or re-run facilities which could encourage participants to believe that the programs were designed as a tool for them to design shapes.

Considering how the "undo" option would give the user a greater or lesser degree of control led to extensive consideration of just how much control participants should have and added to the realisation that varying degree of control constituted an important characteristic of participatory work. This characteristic is discussed further in (4.1) but at this stage of the research its full significance had not been identified. This was demonstrated in the fact that there was only one question in the Brighton questionnaire about how much control participants felt they had .

The possibility of a serendipitous outcome from a supposed error, that could be missed if the participant had complete control over the PLANT program, was ensured by redesigning the program to allow users to stop lines that were already being generated, but with some difficulty. In the modified program, so it would be an available option yet take practice to master, moving the cursor close enough to the moving end-point of a line to identify that it was to be stopped was made a difficult task. “Errors” of placement could thus not be negated completely (3.5.2.ii). The intention was to communicate the idea that the programmed world had a momentum of its own; that, as in the actual world, the participant is not always in complete control over events. Considering these issues led to the development of ideas about the different manners of intervention possible in participatory works discussed in (2.1.4) and (Bell 90).

A crude means of 3D location was introduced by enabling participants to change the Z value of a start-point by holding down the middle mousebutton and moving the mouse: If a participant moved the mouse towards themselves the Z value was incremented. If a participant moved the mouse away from themselves the Z value was decremented. The position of the cursor on screen did not, however, take perspective into account, so although the X and Y position of a point could be roughly identified visually, the Z position could not be, and when the user pressed the left mousebutton to release a line-generator it would appear on screen in a position more or less displaced from the cursor, depending on the difference between the Z value of the start point, chosen in the method described above, and the Z=0 plane. This is illustrated in diagram 3.5.1.a and demonstrated on the accompanying video.

This confusing effect was not intentional; it was considered a compromise in the program that needed improvement. As the deadline of the exhibition approached it had not been improved but it was decided to include it as, however inelegant the implementation was, it still gave the user more freedom in placing the start-points than had been the case with the Brighton version.

The further development of PLANT and why it took so long to adopt a conventional approach is discussed in 3.6.1.ii.

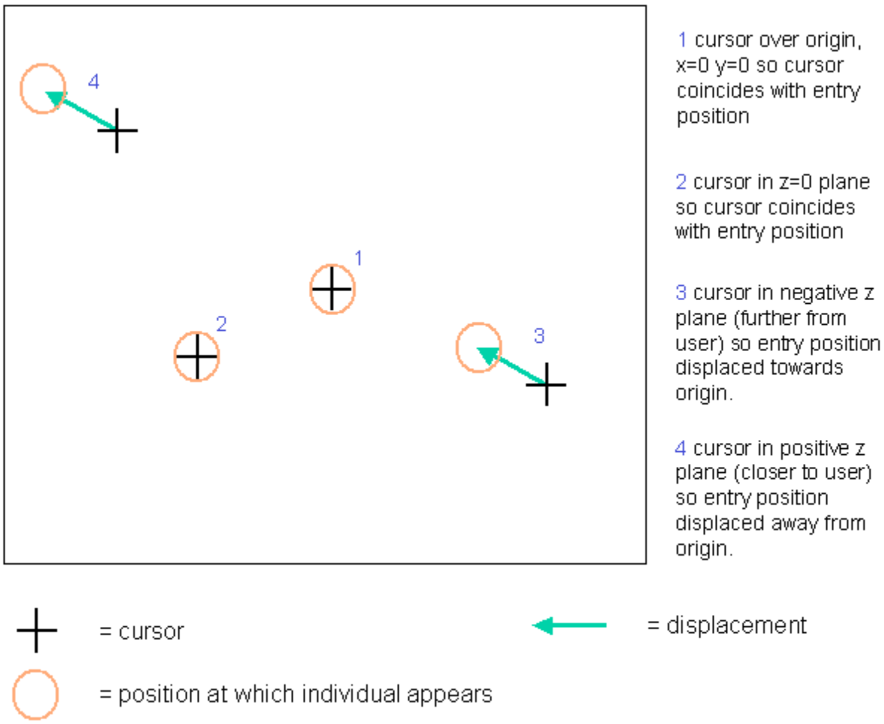



Figure 3.5.1.a

The notion of using numerical coordinates as feedback ran contrary to the philosophy that peoples' understanding of Smallworld should be achieved as much as possible through observation of computer graphics and getting a *feel* for the interface through physical movement of the mouse in the manner of described by Norman Baumann writing about the work of Nam June Paik in the catalogue of the “Cybernetic Serendipity” exhibition (Baumann 68) (A9) and in the spirit of the initial insight when constructing sculptures out of wooden beams (Bell 89). The suggestion that an option of a numerical display of X, Y, Z coordinates should be available to those who preferred it was therefore not implemented.

Marking the places where predators and prey meet also ran counter to another of the principles that had emerged through the development of the programs and was being applied at the time; that the changing direction indicating the behaviour of the individuals should become the focus of attention. The suggestion did, however, reflect an understanding and enthusiasm for the project and confirmed that the ecological references in the work had been recognised.

The suggestion that colour changes could indicate mood also indicated that a participant had understanding and enthusiasm for the project; changing colour was already being used to indicate the age of an individual (3.2.2.vi) so changing it also to represent mood, e.g. attacking or resting, would be possible. The idea was noted but not implemented as it was considered that the "mood" of an individual could theoretically be deduced from its movements.

These last two suggestions matched in some degree ideas that had acted as guide-lines during the development of Smallworld and ideas about possible future implementations. It had been considered throughout the project that as much information as possible about the individuals' behaviour should be retrievable. The suggestions were therefore noted as possible options to include. A plan to represent the internal state of the individual by a shape was considered, an idea which Julian Sullivan pursued in his work (3.1.2) (A10)

### *3.5.2 A description of the exhibit at the "Art and Computers" exhibition, 1988.*

As planned, Smallworld was exhibited without supporting photographs and videos. To encourage people to move the mouse an introduction to the program was posted near the exhibit as, if the Silicon Graphics IRIS had not detected any input for a while it would switch off the graphic display to conserve the phosphors on the screen. On discovering a blank screen an inquisitive visitor might move the mouse to see if anything would happen, but a more cautious visitor might well assume that the machine was not working.

Figure 3.5.2.a can be used to compare the version of Smallworld exhibited with previous versions.

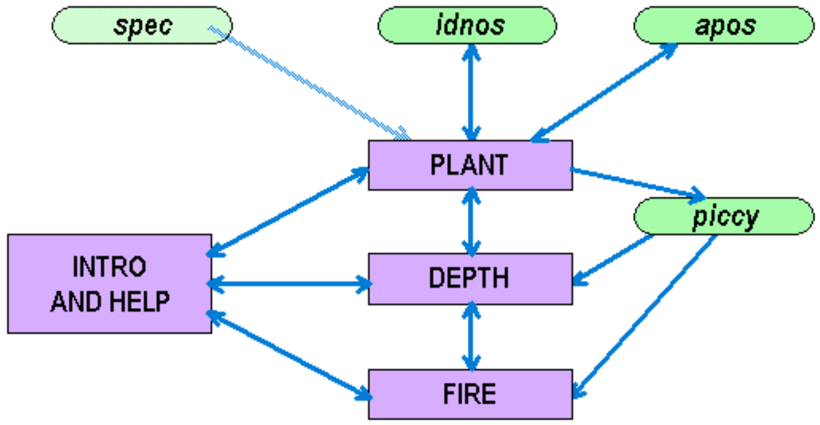



Figure 3.5.2.a

### *3.5.2.i On screen introduction.*

By holding down the right mousebutton users could cause a menu to pop up on screen. Moving the mouse while holding the button down they could then select INTRO from the available alternatives, causing an introductory screen of text to appear. The text read:

| |
|---|
| SMALLWORLD<br>a suite of interactive computer programs<br>by Stephen Bell<br><br>GENERAL HELP:<br>You can always get back to this screen by pressing the RIGHT mousebutton, holding the button down, moving mouse until INTRO is highlighted then releasing the button.<br><br>There are HELP screens for the three programs PLANT, DEPTH and FIRE. Select and read them before trying the different programs.<br><br>Use PLANT to generate an image before using DEPTH or FIRE to look at the image in different ways. |

If the user pressed the right mousebutton at this stage a menu would pop up with the choice:

| |
|---|
| PLANT |
| DEPTH |
| FIRE |

Selecting PLANT would cause the screen to clear and start the PLANT/SWORLD program, selecting DEPTH would start the DEPTH program and selecting FIRE would start the FIRE program. All three are described below.

### *3.5.2.ii The PLANT program.*

Pressing the right mousebutton while PLANT was running would cause a menu to pop up with the following options:

| |
|---|
| RED |
| ORANGE |
| YELLOW |
| GREEN |
| BLUE |
| VIOLET |
| MAGENTA |
| STOPLINE |
| RESTART |
| DEPTH |
| FIRE |
| HELP |
| INTRO |

Selecting one of the colours would determine the species of the line generator to be released when the left button was used to locate start points.

Selecting STOPLINE would change the function of the left mousebutton so that pressing it would cause the nearest individual to the cursor to be stopped as described in (3.5.1).

Selecting RESTART would re-start PLANT with a clear screen so a new shape could be generated.

Selecting DEPTH or FIRE would quit PLANT and start the selected program.

Selecting HELP would cause the HELP IN PLANT screen to appear. This is shown in figure 3.5.2.b.

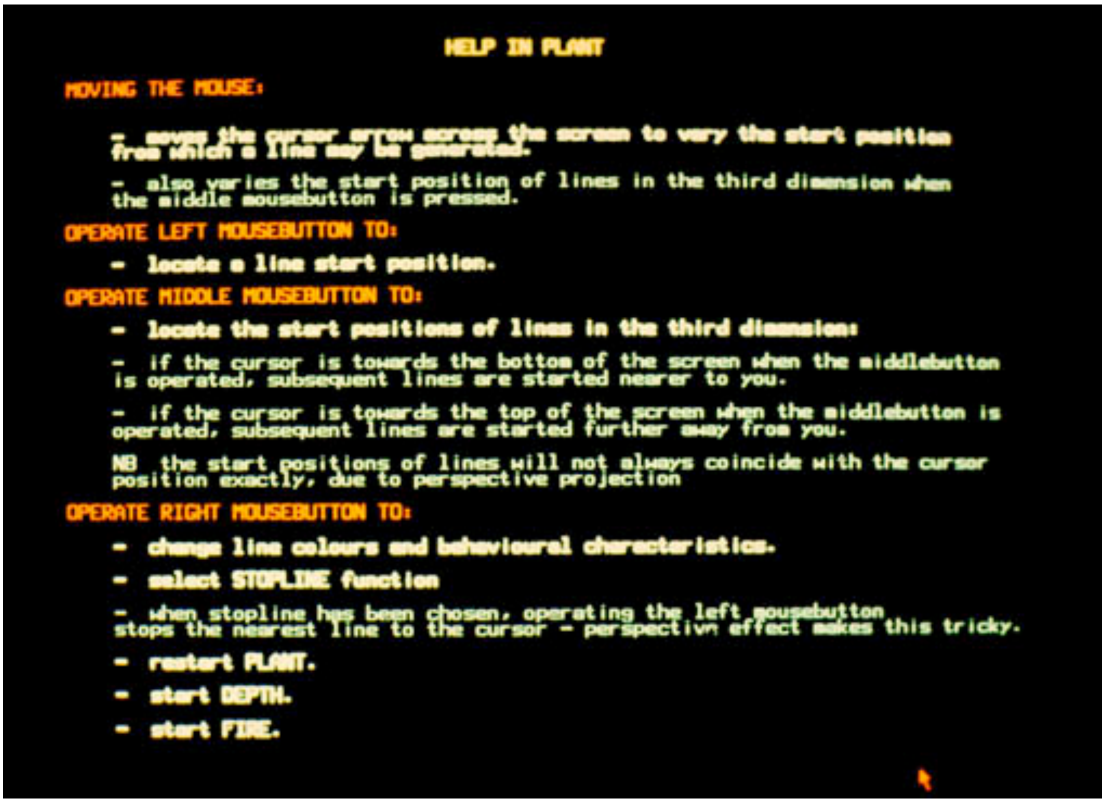



Figure 3.5.2.b

The guidance in the help screen explained how:

- moving the mouse moved the cursor across the screen to vary the start positions of lines

- operating the left mousebutton would locate a start position

- operating the middle mousebutton would change the start positions of lines in the third dimension

It also explained how the right mousebutton could be used to select line colours, STOPLINE, restart PLANT, and start DEPTH and FIRE.

Selecting INTRO would cause the GENERAL HELP screen to appear.

Figure 3.5.2.c shows the pop-up menu in PLANT being used to select GREEN.

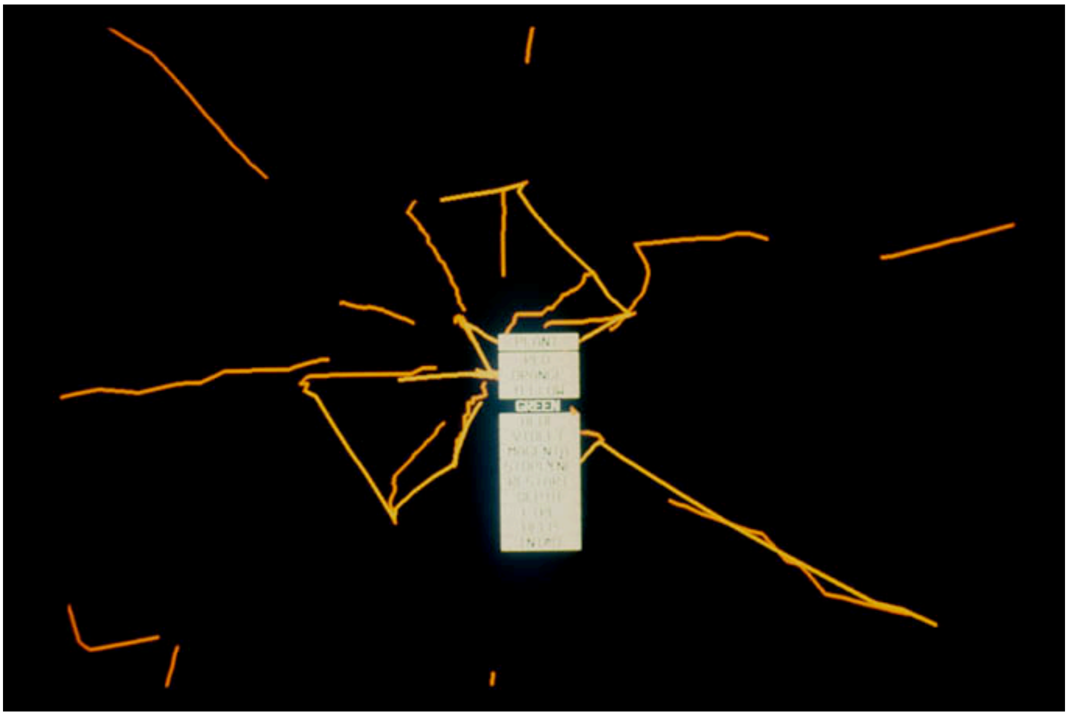


Figure 3.5.2.c

Figure 3.5.2.d shows the shape grown with the green line-generators and some blues introduced.

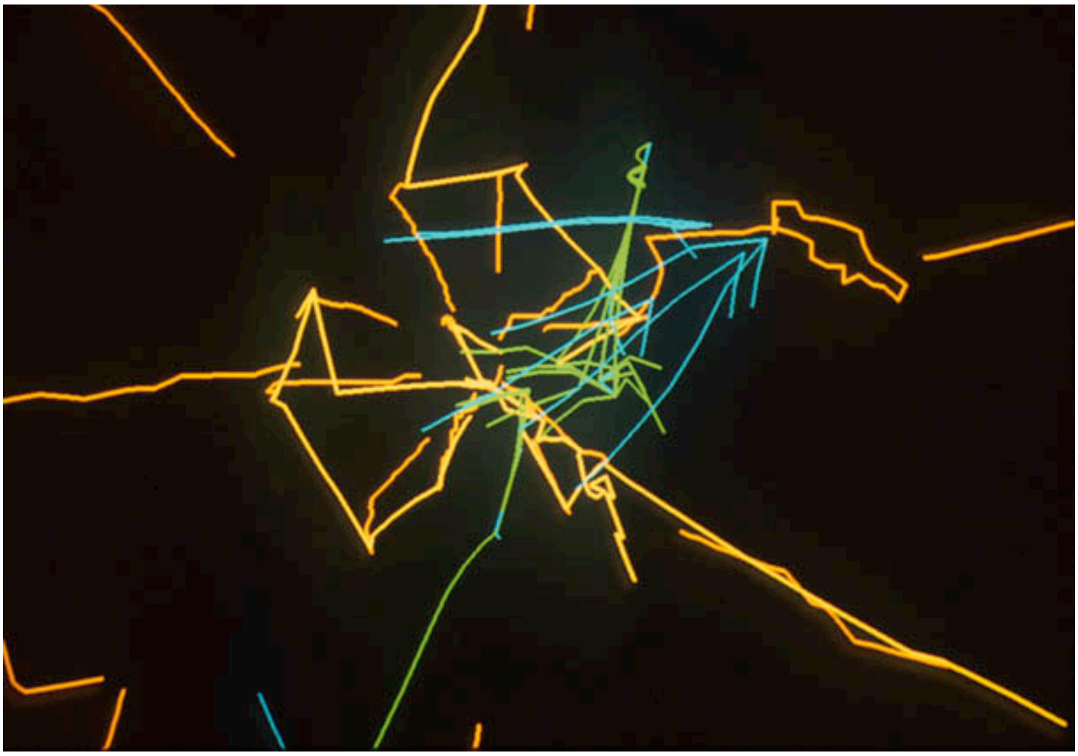


Figure 3.5.2.d

### *3.5.2.iii The DEPTH program.*

DEPTH was a variation on the ZOOMWIND program (3.3.2.i) and (3.4.1). Figure 3.5.2.e shows the same shape after it has been rotated using the DEPTH program.

The DEPTH program made use of the IRIS's built-in facility to produce depth-cued images, i.e. images where the intensity of an object drawn in three-dimensions depends on its theoretical distance from the viewer; the lines became darker as they receded into the screen, away from the viewer. A similar effect had been achieved in some of the images produced at the UKC . On the IRIS, however, the depth-cued shape could be manipulated, e.g. rotated or scaled, as in the ZOOMWIND program.

Figure 3.5.2.e barely illustrates the effect of depth-cueing which is most effective if the shape is seen to disappear by degrees as it is apparently moved away from the viewer into gloomy depths.

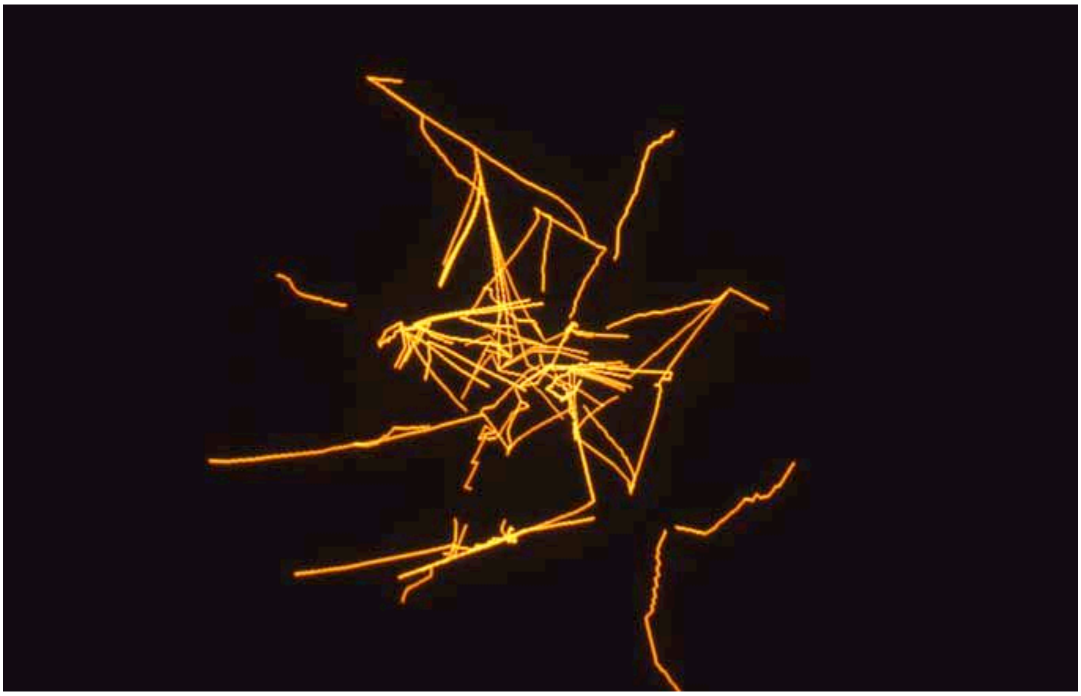


Figure 3.5.2.e

This use of depth-cueing came closest to making the shapes appear to be emerging from the depths of a pool of liquid, and at one stage it was considered that the screen might be mounted horizontally and viewed by looking down on it to enhance the pool metaphor, it was, however, thought too literal and approach and the screen was kept vertical.

The “HELP IN DEPTH” screen explained that:

- moving the mouse rotated the image
- operating the left mouse button moved the image closer
- operating the middle mousebutton moved the image away
- operating the right mousebutton could restart DEPTH, start PLANT or start FIRE.

### *3.5.2.iv The FIRE program.*

Figure 3.5.2.f shows the FIRE program being selected.

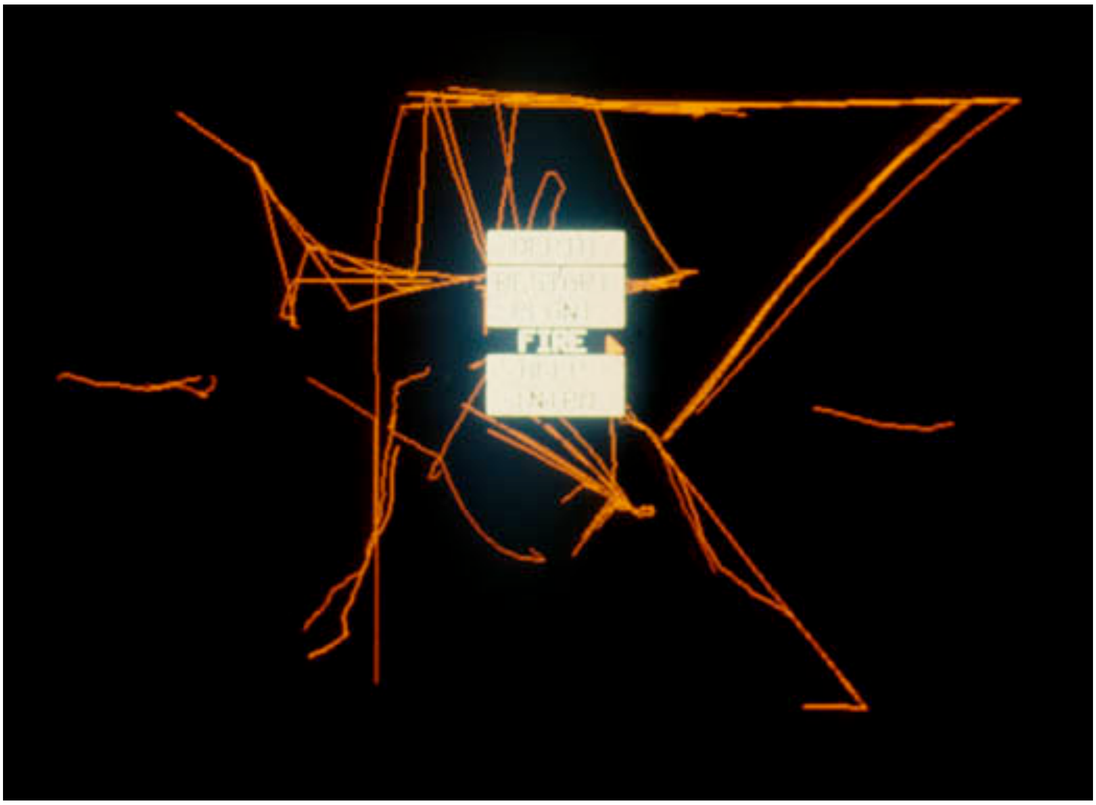



Figure 3.5.2.f

Instead of displaying the complete trails of animals, FIRE displayed all the vectors that had been generated in PLANT in one round, then all those that had been generated in the next, and so on, as frames in an animation. This presented the behaviour of the various individuals dynamically; the change of length of the vectors indicating how an individual's movement rate could change from round to round depending on circumstances.

Static images can not do justice to the effects achieved in FIRE. Time-exposures only produce images similar to trails seen in ZOOMWIND. There are sequences of FIRE on the accompanying videotape.

Crude versions of effects like those seen in FIRE had been experimented with before this, the first experiment, sponsored by the Arts Council of Great Britain, was made at UKC by saving each frame in turn using a video-camera focussed on the screen, then replaying them to produce a very short animation. The experiment indicated the value of developing a program like FIRE when the equipment became available.

A version of FIRE that was developed but not included in the participatory exhibit drew small shapes, generated by INTPROG, to represent individuals instead of using vectors. There are examples of this visually recursive version of FIRE on the videotape exhibited in the touring version of “Art and Computers” excerpts of which are included on the accompanying videotape.

### 3.5.3 *Responses to questionnaire at the Art and Computers exhibition.*

The exhibit at the Cleveland Gallery in Middlesbrough attracted a range of visitors aged from seven to seventy-two. Only thirty-two questionnaires were filled in and it is not known what percentage of the users of Smallworld at the exhibition this represented.

The responses confirmed that a considerable amount of work still had to be pursued to develop the interface to the extent where new users could feel confident in their ability to use it.

As with the questionnaire at the Brighton exhibition, the participants at Middlesbrough were asked if they had any suggestions for improvements. They suggested:

- bigger screen
- more colours
- more detail
- colour in Depth
- easier instructions
- improved user friendliness
- hierarchy of instructions
- more help on the creation of Plant image
- demonstration modes
- explain the idea of growing shapes rather than start-finish system
- ability to control lines drawn in Plant - e.g. drawing ability
- more control in Plant
- control should be more direct
- hold menu open until selection made
- print out

The range of peoples' ages and experience with computers indicated that, if a work is to be exhibited in art exhibitions, it needs to satisfy a participants of all ages who may be experienced computer users or using computers for the first time.

Degree of control began to emerge as an important aspect of the work; particularly the difference between the degree of control users want and the degree of control the artist intends them to have.

The expression of a desire for more colours and for more functions built into the suite underlined the need to make it clear in the program that, just as every element of the work should be considered to be intentional, those things that have been left out should be considered to have been left out intentionally. It was determined that compromises would eventually have to be eliminated so that no part of the work could be considered to be unintentional before Smallworld could be considered completed.

The questionnaire asked which of the three programs people preferred. DEPTH appeared to be most popular, a selection of the reasons given being: "the element of control", "the 3D effects", "faster movement" and "most immediate effect".

FIRE was almost as popular as DEPTH: "you can spin it and it grows", "it looked really good with the lines moving about", "it moved", "it looks like a firework" and "most dynamic".

Some of the reasons given by those who liked PLANT were: "Interaction drawing lines", "The unexpected results", "You could create a more interesting pattern".

The negative criticism of PLANT was that "its less fun because its just making the lines".

Of Smallworld in general it was mentioned that primary colours were too limiting and mouse response could be slow, also that it seemed slow to get started.

### *3.5.4 Exhibition at the First International Symposium on Electronic Art, Utrecht, 1988.*

The “Art and Computers” exhibition was included at the above symposium in The Netherlands in the autumn of 1988.

By attending and presenting a paper at the symposium (Bell 89) an opportunity became available to gather further feedback from people with a specific interest in the field of Electronic Art. Responses were encouraging, and it was particularly useful to exchange views with other people with a professional interest in the field.

Figures 3.5.4.a and b show visitors to the symposium exploring Smallworld.

Figure 3.5.4.a

Edward R. Pope of the University of Wisconsin, Madison, presented a paper significant to this research on, “Creativity, Art and Computers” (Pope 88), in which he argued that some adventure games written for microcomputers by established artists are not superficial play but, more profoundly, stem from a recognition that the computer has an intrinsic interactive capacity and of its capabilities for symbolic transformation. No other medium, he argued, has this interactive capacity as such a definitive aspect of it.

Fantasy, as demonstrated in these computer games, he argued, is a limited interpretation of the term; fantasy is not necessarily figurative and narrative.

The works of Victor Vasarely, Jean Arp and Bridget Riley were all fantastic, he argued, in the sense that they opposed and challenged reality.

Pope described the progression: painting to photography to cinema to video to interactive video, and suggested that computer game arcades were a projection of a more fully developed interactive art form. Some of the findings in chapter 4 support Pope's suggestion (4.1.9).

Figure 3.5.4.b

Harold Cohen argued in a paper that he presented that the philosophy of the "expert systems" approach to computers that has developed from the discipline of Knowledge Engineering are inappropriate for use in art as they try to be general. Artists goals are fuzzy; they try to break rules, not discover them and tend to get bored with known problems. Cohen argued that machines designed to be general satisfy only the lowest common denominator. “User Friendliness” is actually making the user less important. Cohen disparaged the value of “idiot-proof” technology, arguing that artists are not idiots and do not share a need for a generalism. Artists need “difficult-to-use” technologies and only they can know what they need a technology to be like. He concluded, using his own practice as an example, that artists should develop the technology themselves and write their own programs; developing “expert’s systems”, tailored specifically to their own practice rather than using general “expert systems” designed to satisfy a lowest common denominator idea of art practice (Cohen 88). His presentation extended views expressed in (Cohen 82).

Although he did not address participatory or interactive works, Cohen’s ideas are significant when participant skill is considered: If an artist has chosen to play the role of enabler; making participatory work that participants are intended to use to make their own products and, in effect, to become artists, how “user friendly” should the work be? His arguments brought into focus an idea that had been emerging through observations of people using Smallworld: if participants were to be able to apprehend the subtleties of the work how closely did their experience of using the program need to be to the artist’s, and how skilful did their use of the program need to be? “User friendliness” refers to how difficult a technology is to use; a characteristic typical of participatory works of art. It can be included in the characteristic of “degree and manner of control” discussed in (4.1.6).

### *3.5.5 Conclusions drawn from the “Art and Computers” Exhibition.*

Involvement in the exhibition had been very useful as it proved a tough testing ground. Getting the equipment to work after it had been moved around and out of the country was particularly tricky due to a sensitive hard disk drive. Notes made at the time reflected the lessons being learnt about the sensitivity of computer technology.

This experience of technical problems indicated that, if it was shared by other makers of participatory works, it could lead to a lack of interactive computer installations at exhibitions. Robust equipment is essential if artists and exhibitions are going to take interactive works seriously.

It was noted that some people have difficulty using a mouse for more than simple selection tasks; they know how to open books and turn over pages automatically. Similar automatic skills in using a computer's input/output techniques appeared to be needed to see beyond the interface.
It was also noted that more time should be allocated to tuning the controls as it is a way to make the interaction more, or less, smooth.

Notes taken over this period revealed a growing awareness of the limitations of using a technology that had not been developed with fine artists in mind, balanced by a realization that the possibilities of Smallworld, which used this limiting technology, had still not been completely explored.

Control emerged as possibly the most important characteristic of an interactive work. From this came the fundamental realisation that the effectiveness of participatory interactive works depended not only on the technology and how the artist sets it up but on the degree of ability of the participant. Degree of control and participant skill are discussed further in (4.1).

A parallel between of participatory interactive work with music became apparent and a clearer insight was gained into Krueger's observation that his works were composable (Krueger 83). The interactive technology could be likened to a musical instrument that could be played to greater or lesser effect depending on the skill of the player. The program, which limits and directs how the user should use the technology could be seen as analogous to a musical score (4.2.2).

When this fundamental characteristic was recognised it constituted both a challenge and turning point in the project. It was realised that to fully experience the possibilities of an interactive work participants would either have to be experienced users of it; they should be able to master it very quickly, or, if the work was difficult to master, they should be able to spend a considerable amount of time doing so. The second option would necessitate that participants be afforded longer and perhaps repeated access to a work.

A problem arose as it was realised that the work could be addressed to expert computer users and incorporate HCI conventions because users would be familiar with them, or could flout these conventions to cause participants to question their assumptions about them. This led to the recognition of the ideas discussed in (2.3.1). It was considered that ideally both courses should be explored and the results compared. For the purposes of completion of this research, however, it was determined to pursue the first course, pursuing the second after completion as it promised to be a long-term task and new skills would have to be learnt to achieve it. Approaches to modifying the human-computer interface of Smallworld after this decision tended to a more conventional solution in order to exploit I/O abilities experienced computer users have already developed.

This led to the development of the final version of Smallworld to be considered in this research, which is discussed in the following section.

### 3.6 *1989 version of Smallworld and exhibition at Loughborough University of Technology.*

After the experiences of the Art and Computers exhibition it was considered that the research could develop along two fundamentally different paths:

i) it could continue to use existing technology and I/O devices and software.

ii) it could generate research into new forms of I/O device and software.

As (ii) would constitute a new series of research tasks it was decided to follow approach (i) until the completion of this research.

#### 3.6.1 *Modifying the interface in response to lessons learnt with previous exhibitions.*

It was becoming clear that one of the functions of the interface of an exhibited version of Smallworld should be to stand in for the skills that had been acquired by its designer.

It was considered that this goal could be achieved if the work:

i) encouraged users to repeat the experiments and exercises that had been tried in the course of Smallworld's development

ii) at the same time allowed the participants the freedom to discover these experiences and exercises in their own way, thus retaining the exploratory idea conceived at the start of the project (3.1.3)

It was considered that the most important skill that the designer had learnt was that of anticipating where individuals would be introduced into the 3D space in PLANT.

It was determined, therefore, to develop software that would help the learning of this skill and refine the other aspects of the interface so that they were less distracting.

The suggestion that demonstration modes should be available was rejected as it was considered that they could encourage users to become imitators rather than inventors in their own right; satisfying aim (i) above, but not (ii).

Instead, the revised introduction screen, shown in figure 3.6.1.a, encouraged participants to play with the programs to get a feel for what they could do. There was no need to encourage participants to attend to the work as art as this expectation was implicit in the context of the exhibition.

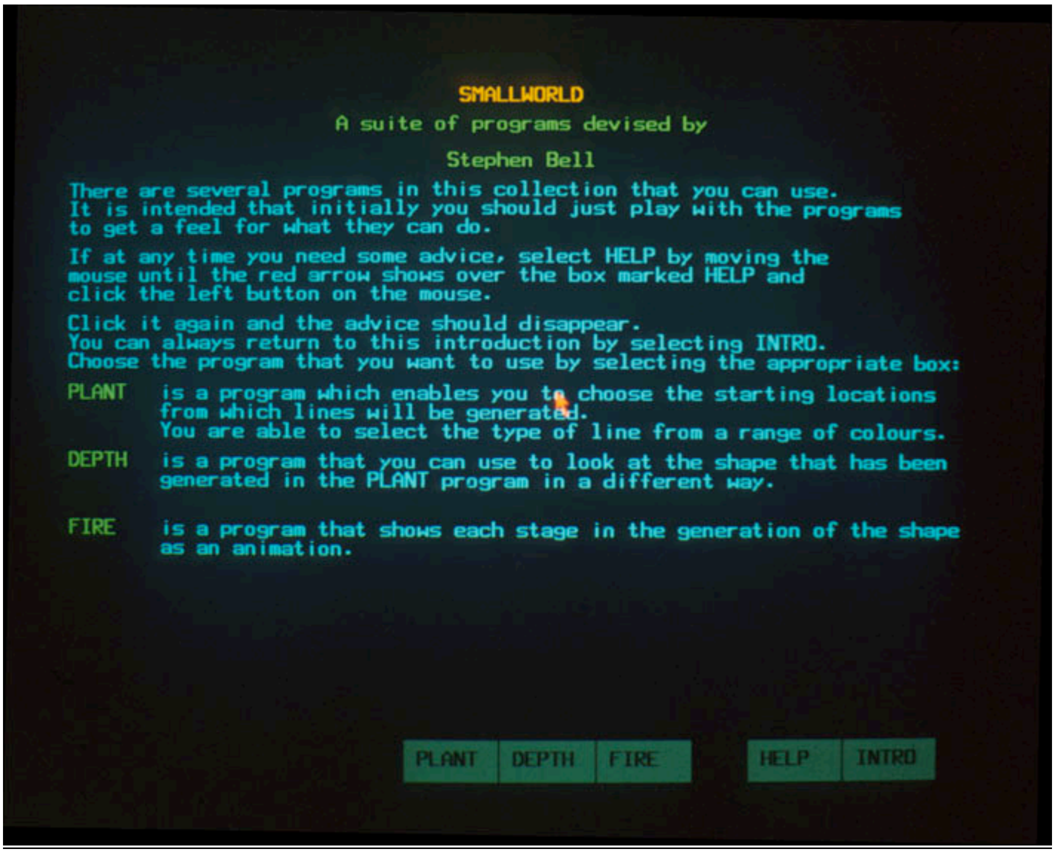



Figure 3.6.1.a

### 3.6.1.i *Replacing the pop-up menus with on-screen "buttons".*

One of the suggestions that had been made by a Middlesbrough participant was that one should not have to hold down the mousebutton to keep the pop-up menu on screen until a selection had been made. There had also been a dissatisfaction, noted during development, with the visual interference that the menu caused when it popped-up, obscuring an image being generated.

Mastering the use of pop-up menus was considered a distraction, so they were replaced using the convention of a number of graphic control boxes or buttons on screen. These could be activated by pointing to them with the mouse and clicking the left mousebutton. The computer sounded a beep to confirm when a box had been selected. Control boxes with similar functions were always in the same position on screen so that, with practice, the physical act of selection could become automatic. It also allowed options to be selected without the main image being obscured. The boxes were arranged at the bottom of the screen to associate them with the input functionality of the keyboard and were kept simple in appearance so that they did not distract the participants attention from the other graphics on the screen.

### *3.6.1.ii The PLANT program.*

The graphic interface of PLANT was modified to include the control boxes. It also incorporated a new tool to provide the participant with more feedback to help them anticipate where individuals would be introduced into the 3D space.

One of the skills that had been acquired by the designer during the development of Smallworld was the ability to imagine where the entry point of a new individual would be when using PLANT.

The exhibit at Brighton proved that it was relatively easy to introduce participants to the concept of locating start-points in two dimensions, with the third dimensional coordinate pre-determined (3.4.2). Providing an interface that helped them to anticipate where an individual they were trying to place would appear on screen had proved less easy.

It was intended that participants should eventually have this freedom, and some participants had expressed irritation with the restriction of having the third coordinate pre-determined. A significant amount of time had therefore been spent considering ways to achieve this goal.

The method introduced in the Middlesbrough version enabled participants to change the third coordinate of a start-point by moving the mouse whilst holding down the middle button,  but still did not indicate clearly where an individual would appear (3.5.1).

The revised version of the 3D planting interface made use of a 3D cursor which replaces the standard IRIS arrow pointer:

The cursor appeared as a small cube in the centre of the screen when plant was run.  This is shown in figure 3.6.1.b. As the mouse was moved the small cube moved in the plane on screen parallel to the mouse:

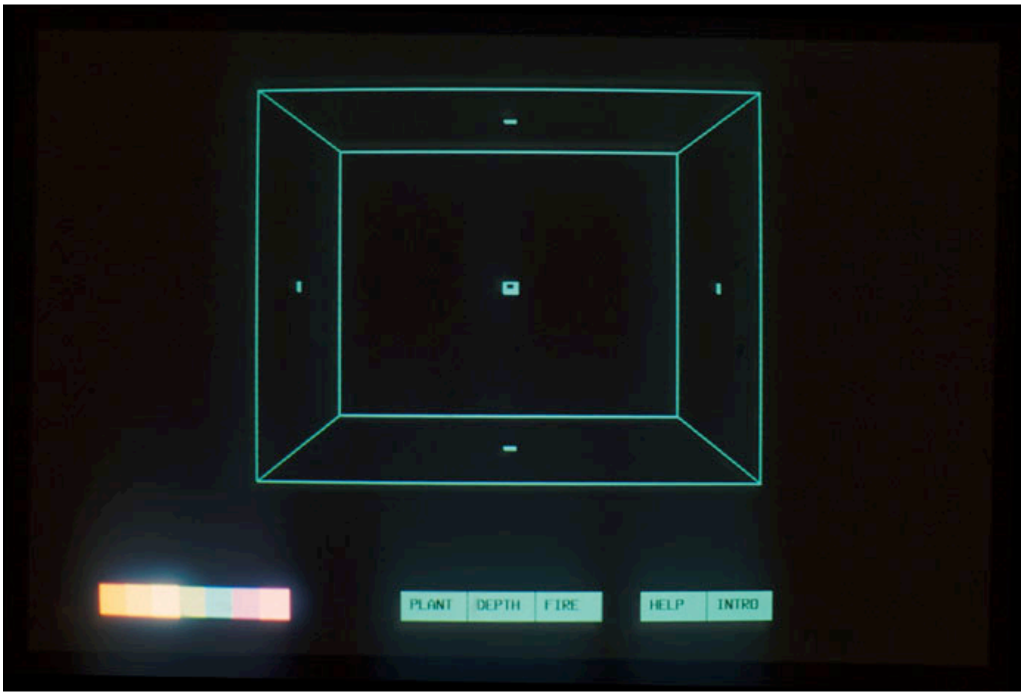



Figure 3.6.1.b

- when the mouse was moved from side to side, the cursor-cube also moved from side to side. (figure 3.6.1.c)

- when the mouse was moved away from the participant the effect of perspective projection made the cursor-cube appear to move away from the participant too.

- If the participant held the middle mousebutton down the cursor-cube could only be moved up and down in the plane parallel to the computer screen; moving the mouse away from the participant would move the cursor-cube up; moving the mouse towards the participant would move the cursor-cube down. (figure 3.1.6.d)

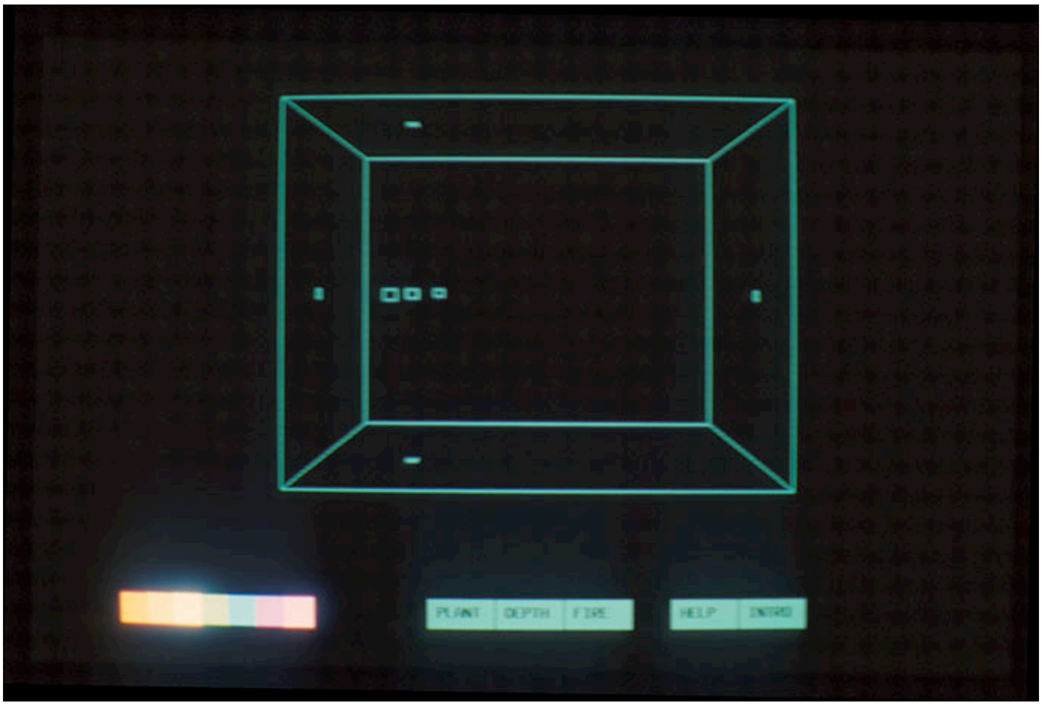



Figure 3.6.1.c

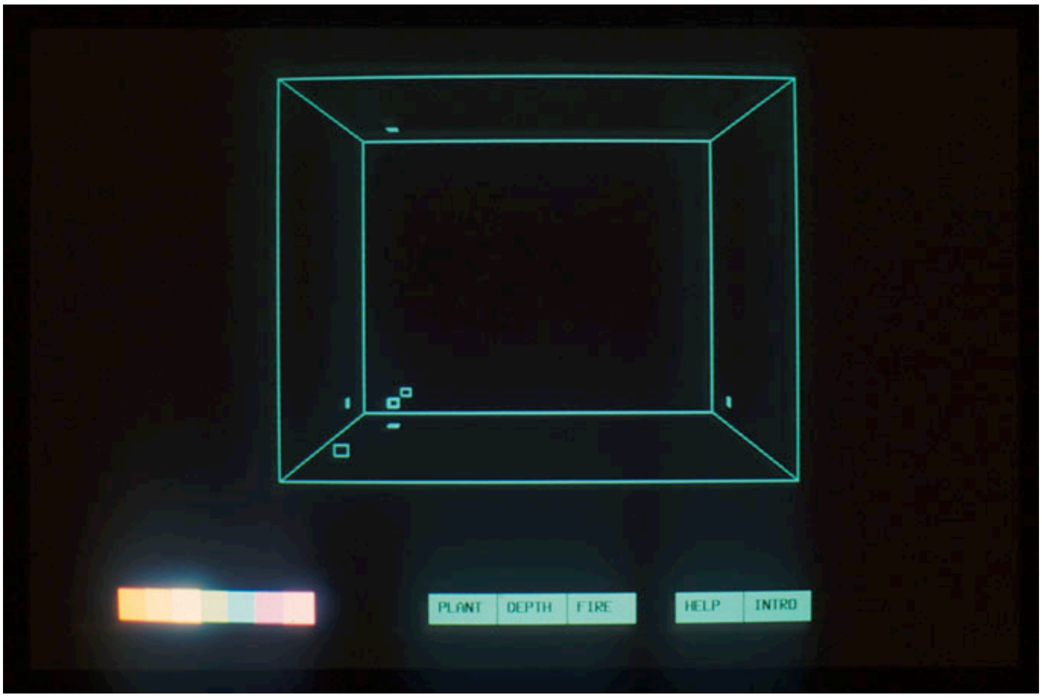



Figure 3.6.1.d

The cursor-cube moved within a large wire-frame drawing of another cube, which was used as a reference. To assist this further square “shadow” of the cursor-cube was projected onto each face of the reference cube.

The use of a reference cube to help participants visualise 3D space represented on screen is a convention that had been observed in work at The Slade in 1977 (3.1.2). Its use had been avoided, however, because of interest in the way that 3D projections could also be read as 2D shapes. The possibility of this interpretation was retained in the revised version by making the reference cube disappear if the cursor was moved down to select control boxes at the bottom of the screen; shown in figure 3.6.1.f.

To the bottom left of the screen a line of coloured control boxes represented a selection of species. To choose a species of line the mouse was moved towards the participant until the cursor-cube changed into the normal IRIS arrow cursor. The participant could then point at the desired colour and click the left mousebutton to make a selection.

An individual of the currently selected species was released by moving the cursor-cube to the desired position in the 3D space and clicking the left mousebutton. The individual was introduced at the centre of the cursor-cube (figure 3.6.1.e).

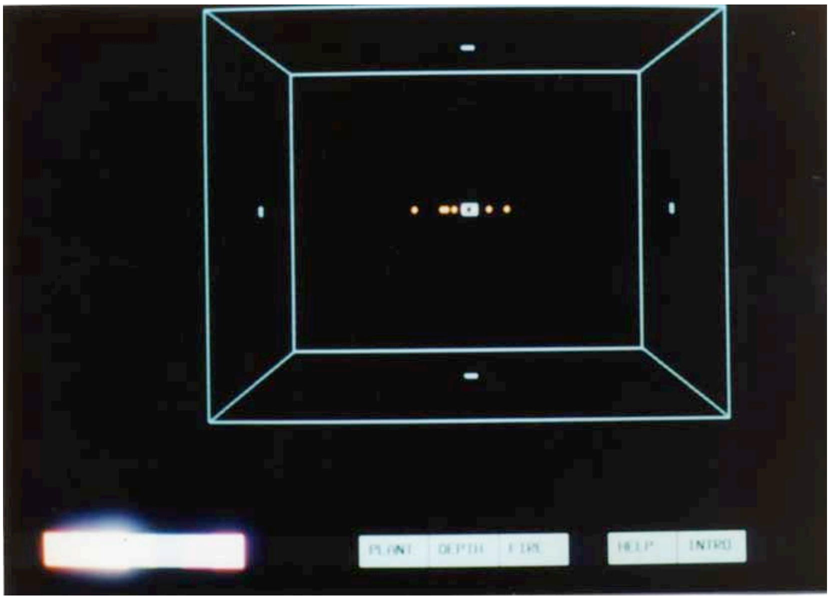
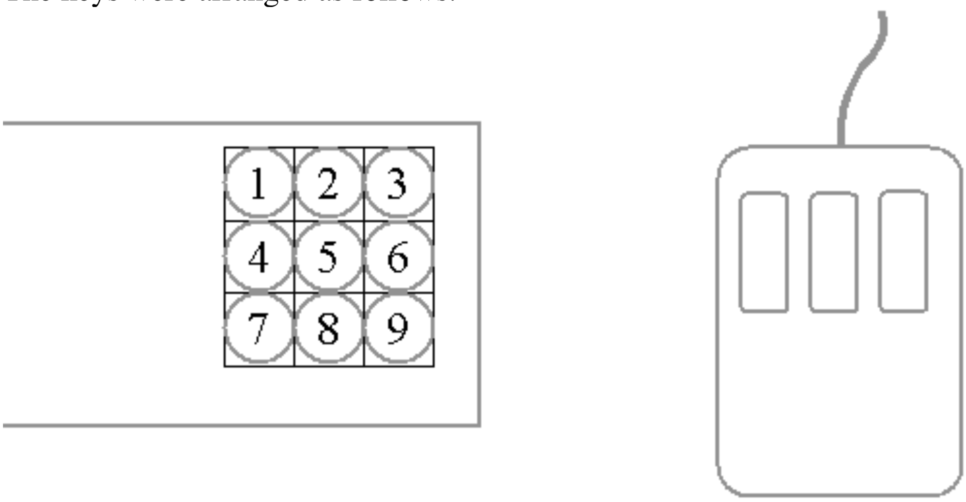



Figure 3.6.1.e


Figure 3.6.1.f

To get a better idea of where the cursor-cube was in relation to the reference cube the whole 3D space could be made to appear to rotate.  The enhanced 3D effect of this rotation could be achieved by using the numerical keypad on the right of the keyboard.

The keys were arranged as follows:



- Pressing the 4 or 6 keys caused the space to rotate about the Y=0 axis. (The origin was at the centre of the reference cube and the Y=0 axis was initially vertical).

- Pressing the 2 or 8 keys caused the space to rotate about the X=0 axis.

The rotations would continue until the **5** key was pressed which would halt the space at the orientation that had been attained (figures 3.6.1.g and h).

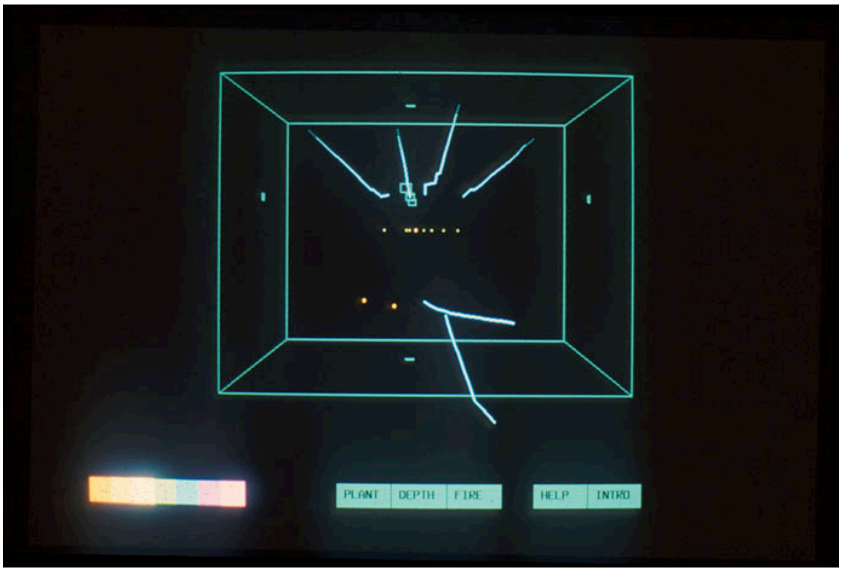



Figure 3.6.1.g

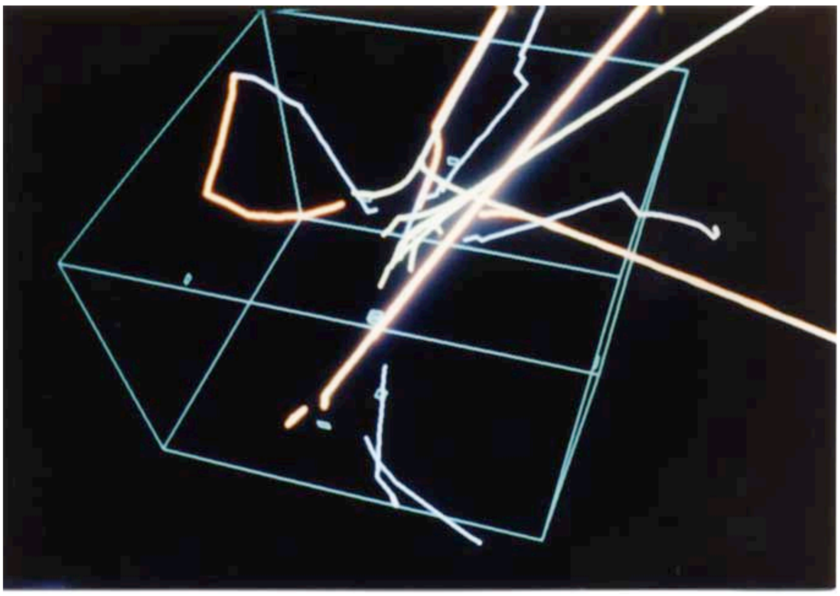


Figure 3.6.1.h

Rotation of the axes altered the relationship between the mouse and the cube-cursor's movement on screen described above but, used with discretion, could improve control.

The placement of the start-point was further assisted by being able to zoom in and out of the image by pressing the **0** and **.** keys.

With a little practice the user could use one hand to control the mouse and their other to use the keypad.

An example of this version of PLANT in use is included in the accompanying videotape.

A further aid to start-point location was the addition of a PAUSE control box. This allowed the user to pause the SWORLD part of the program whilst locating several individuals and then, by selecting the PAUSE control again let SWORLD continue execution.

### *3.6.1.iii The DEPTH and FIRE programs.*

The DEPTH and FIRE programs in this version were controlled using the same techniques as in the “Art and Computers” version (3.5.2.iii) (3.5.2.iv). The only change was that the pop-up menus were replaced by control boxes.

### *3.6.1.iv On-screen HELP.*

Rather than clearing the graphics on screen and replacing it with a screen of text the programs were revised so that help advice appeared on the screen at the same time as the graphics but without obscuring it. The HELP box acted as a “toggle” switch, alternately showing or hiding the help advice when pressed. This allowed the user to continue using the programs whilst reading the advice.

## 3.6.2 *Smallworld Vistas exhibition at Pilkington Library, Loughborough University of Technology, 1989.*

An exhibition was arranged in 1989 to show the work that had been pursued to other members of LUT. The exhibit documented the developments in the project, and included images from UKC through to new ones produced especially for the show. The show included a videotape and rather than having the computer installed in the exhibit, a notice invited visitors to visit LUTCHI to try the Smallworld programs. Figure 3.6.2.a shows a view of the exhibition.

3.6.2.a

A selection of the new photographs exhibited are illustrated in Slides (B13) (B14) and (B15). They were made using a version of DEPTH and a large number of individuals.

The videotape included ZOOMWIND and FIRE versions of the shape used in the photographs.

The photographs were exhibited to show that a single shape could be explored and recorded rather like a geographical or architectural location. They anticipate the next stage of the work described in 5.2.

### 3.6.3 *Responses to the interface and further developments to Smallworld.*

The following comments were made in a visitors book provided at the exhibition:

> I think a few captions on the video might help. I like the independent “animals” that shoot off on singular tracks! The visuals are attractive in their own right; don’t think one needs to know what is going on to enjoy them as images.
>
> Very interesting mobile images. Is it necessary to give it a title related to animals? People at LUT will appreciate it more if these are realistic animals instead of abstract, although it is unfortunate.
>
> This is great stuff: will you ever be marketing some software for it? i.e. so I can have all the fun with none of the programming hassle!
>
> Some beautiful stuff here. What about:
> 1) Landscape - your animals are moving in an empty universe.
> 2) Randomness - presumably if you re-run the program with the same initial conditions you'll get identical results - what happens if you introduce chance?
> 3) When looking along an animal trail (tracks) on the video it is confusing when turning right angles as the viewpoint suddenly jumps - wouldn’t enforcing a curving turn be more realistic/visually pleasing?

To balance these responses there were others of a different opinion:

> Very pretty I’m sure - but really I just don’t get it, seen better pictures at a firework display.
>
> ---
>
> Can’t understand what is going on!
>
> ---
>
> Where are the animals? Please explain more ... too abstract.

Some who wrote comments followed the animal behaviour metaphor and others did not, suggesting that the metaphor did not fail but that it was not universally recognised. This indicated that the intention of using a system that would take advantage of people's ability to observe and interpret particular kinds of event in the actual world as a method of deducing the generative system, (3.1.3) had only been partly successful.

The comments indicated that once people had grasped the metaphor their interpretations of the work were in a similar spirit to that intended.

Due to the exhibition coinciding with start of the main university vacation only a few colleagues and students responded to the invitation at the Pilkington Library to visit LUTCHI and try Smallworld. Therefore, rather than using a questionnaire, people were observed as they participated and their comments were noted.

Among those who did respond to the invitation, the 3D location interface attracted particular comment, and the sensation that the "little creatures" in Smallworld seemed to actually exist, to the degree that they could evoke emotional responses, was also remarked upon.

### *3.6.4 Continuing responses to Smallworld.*

Copies of the Smallworld programs have since been installed at The National Centre for Computer Animation, at Bournemouth Polytechnic (5.2). Some students following the M.A. course in Computer Visualisation and Animation have been introduced to the work and have responded by suggesting ways in which it could be used in computer animation production.

It has also been remarked several times that the animals in Smallworld animations, although represented only by vectors, appear more "alive" than animated characters or creatures in computer animations that use more sophisticated rendering techniques. This supports the decision to follow the approach of symbolic rather than photo-realistic representation discussed in (3.1.3). It also supports the identification of non-visual similarity to the actual world as a characteristic (2.4.2).

Possible future developments of Smallworld are discussed in (5.2).

## 3.7 *Characteristics identified through making Smallworld into an interactive participatory work.*

Many of the characteristics discussed in chapter 2 and to be discussed in chapters 4 and 5 were identified through the development of Smallworld. Where this is the case it is mentioned in those chapters. Some of the characteristics identified had a more direct effect on the development of the work. These characteristics and their effects are discussed in this section.

### 3.7.1 *The changing reasons for using interaction.*

The initial intentions for making participatory work were based on the assumption that by doing so participants could be brought closer to the artist's experience of the medium, by ensuring that they had experienced aspects of the work that had affected decisions made about its composition (3.1.1). During the course of this research that fundamental intention did not change, but it became clear that more had to be done than simply making the work participatory ; the work needed to take account of the fact that a new participant would need to develop a certain amount of participatory skill. This realisation supported the findings of Krueger, who had found that a certain amount of time should be allocated for people to learn how to use an installation (Krueger 83).

The importance of participant skill, discussed further in (4.1.6) to (4.1.9), became particularly significant as during the course of the project, the formal model of the participants being like players in a game (3.1.3) (an approach used by Cornock and Edmonds (A12) and Krueger (A1), and discussed by Thomas (A11) ), changed to their being more like players of musical instruments, as described by Baumann (A9) and interpreters of compositions, as discussed by Krueger (4.1.5) (4.1.6). This led eventually to the invention of the method of composing and analysing works proposed in (4.2). The metaphor of the physical exploration of an environment was in this way generalised to the exploration of different interpretations of a composition; possible elements of the composition being the characteristics identified in the thesis.

### 3.7.2 *Changing approaches to the programming.*

The initial approach to realising Smallworld, described in (3.1.4) was of a single program simulating a world that people would eventually be able to explore in some way. The use of the 'C' programming language encouraged a modular approach, which when combined with the table-top wargame model led the work to be treated as a suite of several programs rather than a single piece (3.2.2).

The concept of the suite of programs supported the emerging musical analogy described in (3.7.1), it also contributed to the emergence of the method of organising the characteristics of participatory works identified in this research described in (4.2).

The extensive use of the Prolog programming language (Clocksin & Melish 84) (Bratko 86) at LUTCHI Research Centre led to some considerable time being spent exploring the value of using this language to implement part or all of Smallworld. The fundamentally different approach between Prolog and the procedural model that had been adopted in the initial implementation of the programs in 'C' could not, however, be reconciled. It did, however, raise other issues:

The realisation that the implementation of Smallworld had come to be so procedurally based, when other types of language were being developed, indicated that Cohen's argument against the value to artists of lowest common denominator systems (3.5.4) could be expanded to argue against the value of lowest common denominator languages. The use of different input devices (keyboard, joystick, mouse, keypad) supported the inclusion of hardware in the argument and fostered the belief that artists using computer technology should be able to design, develop and interface I/O hardware as well as software. This realisation grew into the idea that it would be desirable to design a language specifically for use in the programming of Smallworld-like interactive participatory works.

The plan to represent the internal state of an individual by its shape (3.5.1), which was planned but not implemented, could be incorporated into a Smallworld-based programming language.

The possibility of developing a language from Smallworld was encouraged by a report on the development at Xerox's Palo Alto Research Centre (Parc) of "Ark" (Alternative Reality Kit); an operating system which made use of a display of computer graphic objects such as buttons and menus that you can "pick up and throw around." (Durham 87). "Ark" was an interface where the icons and graphic devices could have attributes like "mass" and "gravity" which could be turned on and off, affecting how the graphic shapes behaved on screen.

The concept of the Smallworld language is that it would be used by participants who would participate not only through exploring the imaginary world, but by programming it.

A comment by Dr. Randall Smith who built the "Ark" system was of particular relevance as it supported the part of the philosophy of Smallworld that favoured an abstract representation of phenomena (3.1.3):

> "There are some interesting questions in following a metaphor .... In a computer based system there is a real trade-off. When you follow a metaphor too slavishly, you end up duplicating the metaphorical domain, in this case the real world, which we have already got." (Durham 87)

One of the motives behind avoiding photo-realism in Smallworld was that the actual world already exists and may be explored without being duplicated.

Durham wrote:

> Smith believes that a good metaphor gives people a quick way to get their bearings in a computer-created world. But a little magic will be needed sooner or later. He himself finds it is quicker to program an Ark button in text, rather than relying entirely on programming methods within the physical metaphor. (Durham 87)

If adopted by an artist executing a similar task, Smith's choice to program using text rather than using the physical metaphor of "Ark" would run counter to the recommendation in (2.7.4) that an artist developing a participatory work should use the same interface as future participants in order that they can more easily embody the attitude of the participant. The value of adopting this approach was recognised while applying it during the development of Smallworld when, whilst controlling one version of ZOOMWIND it was felt that the degree of control (and type of control) was similar to that when flying a “Peter Powell” stunt kite. The similarity was between controlling the spinning kite and a spinning object on screen by the use of two strings or two buttons. The experience was common to both events and prompted the consideration of what other comparisons of sensations could be considered and incorporated into works, like, for example: moving a mouse. This was identified as feeling more like sliding something across a plane surface, grinding, polishing, or wiping than moving an object, as when a mouse is picked up and moved nothing happens on screen.

The tendency of this conclusion of the research is to reiterate and support Krueger’s recommendation that “... it is desirable to think in terms of inventing a tool for exploring the medium”. It is considered, however, that this does not preclude the production of discrete “pieces” of work.

### *3.7.3 Changing the audience.*

In the initial conception of the work it was intended that people should to some extent be able to design animals. The MPROG behavioural design program was, however, considered to be too time-consuming in use to be part of an exhibit (3.4.1).

The time limitations of public exhibition in galleries prevents the development of time-based works of a long duration, which would have demanded the kind of attention usually applied in musical and dramatic performances, or reading a book. This problem could be countered by producing versions of Smallworld that could be implemented on small computer systems of the kind used at home and office, allowing participants to get involved in Smallworld over a longer period of time. MPROG could also be extended to constitute a more complex graphic programming language (3.7.2). This approach would, however, address a different audience to those who attend art exhibitions. The implications of this are discussed further in chapter (4.1.9).

### *3.7.4 From manipulating object to moving through object.*

The pictures of the shape named “Sirior” (Slides (B11) and (B12)) and the sequence on the accompanying videotape illustrate the visual side of a phenomenon identified very soon after writing ZOOMWIND that relates to Baumann’s description of “feeling” magnetic fields in Paik’s work (A9):

When a shape was rotated and viewed on screen as a small shape surrounded by space, the relationship felt between the control being used and the movement of the shape was as if an object was being manipulated.

If the zooming option was used to move the viewpoint closer to the shape, and then sufficiently close that the viewpoint was apparently inside the shape, the feel of the same key-presses or mouse movements changed to that of flying in the space described by the shape, as if a vehicle being piloted by the user was rotating in the space described by the object, rather than the object being made to rotate around the viewpoint.

When the shape seemed to be an object, and rotation was controlled by two keys, the degree and feel of control was very like flying a two-stringed aerobatic kite (3.7.2).

The transformation between one type of relationship and the other also had an effect of the perception of the scale of the shape being manipulated, as did the amount of response of the object to the input from mouse or keyboard: In the first case described above a sluggish response implied that a massive object was being manipulated, a fast response implied a light object. In the second case, a sluggish response implied that the space the viewer “occupied” was vast, a fast response that it was quite small.

These changes of contributed to the degree to which a participant felt part of the events depicted on screen, characteristics discussed in (2.4.3).

### 3.7.5 Communication, feedback and types of intervention in participation.

In Smallworld, communication was perceived first as human-machine; when learning to use the interface, then as human-animal/alien when communicating with the “animals” (1.5.2).

There was no attempt to lead the programs to “know” anything about the participant in Smallworld. Instead, the approach was to limit the participants’ means of accessing the programs. There was as much or as little “knowledge” built into the system as in the controls of a car. The shapes were “turned” in space by remote control, the participant could relate cause and effect, but there was no communication other than in the sense of one-way transfer of very simple information.

In an experimental version of the PLANT program, in which the participant could control a pointer which was responded to by the animals in Smallworld as if it was another Smallworld animal, the kind of communication began to change. The animals’ responses to the moving pointer depended on their species’ characteristics, which determined how they classified the participant’s intrusion into their environment. To get the animals to behave in a particular way (for example: to move to the bottom of the screen) the participant had to communicate this to them through the behaviour and positioning of the cursor. At this stage the communication felt much closer to that between humans and animals in the actual world than to interaction with a machine; the participant had to see things from the animals’ points of view and change the pointer’s behaviour accordingly.

In Smallworld the communication was always initiated by the participant, though as a consequence of the research there are plans to develop ways that animal may initiate interactions (1.5.2). The behaviour will still, however, be within the confines of the Smallworld environment.

The nature of Smallworld; the concept of a participant exploring and interacting with a programmed world populated by automata led to the realization of the degrees of influence a participant could have on the events in that world. A large proportion of time was spent observing representations of the interactions of the programmed “animals”. It was noted in doing so that the viewpoint from which the representation of the interactions were seen could change the affective as well as the logical interpretation of them. This led to a realisation that the way participants are able to observe interaction in a work (including any interaction they are involved in) can effect their interpretation of it (2.1.4).

The TRACK program (3.4.2.i), which placed the observer's viewpoint at the location of one of the animals, was developed to explore this effect. The intention being to lead participants to believe that they were observing events from the point of view of the animal.

Although not all the options were implemented, it was realised that the relationship between the participant and the animals could theoretically be any of the following:

- Affecting the starting positions of the animals (Using PLANT for example)

- Interceding directly in events while they continued (Using an erase option, destroying existing animals)

- Pausing the action to make the above and following interventions more extensive (Pause option in plant)

- Releasing specially designed individuals to cause particular effects

- Having the cursor recognised by animals as if it was one of the species, with the capabilities of the users intervention limited to those of an individual animal

- With the cursor recognised as if it was one of the species but with unlimited or special capabilities available to the user

These manners of intervention were generalised and discussed further in (2.1.5), and, combined with the musical analogy mentioned in (3.7.1), led to the identification of varying degree of control as the most significant general characteristic of works and the realisation that degree of control could be composed (4.2).

Suggestions were made by people who have participated in Smallworld that could make errors less likely by making the participant more aware of the way the program works in advance and to provide ways of correcting mistakes; particularly “undo” options and demonstration modes. A decision was made, however, that participants should not know too much in advance; participants were not intended to have total control over events in the “world”, and some of the events that could be perceived as errors were considered positive components of the work (3.5.1).

Thus the use of numerical output describing X, Y and Z coordinates, which could have provided more explicit feedback, was rejected as it would have made locating the start-points depend more on cognitive skill and less on motor skill. Figures would also have added a specific measure of scale in the works. The ambiguity of scale was considered essential to some of the events the participants were intended to experience. For example: the transition from the sensation of “flying through” a shape as if it were an environment to “manipulating” the same shape as if it were an object (3.7.5).

It was apparent from participants’ responses that the speed of response could be particularly impressive in the DEPTH program where the shape could be rotated almost instantaneously by use of the mouse. It was considered that this impressiveness was related to the degree of control afforded to the participant by such immediate feedback.

Where control was considered important, fast and unambiguous feedback was favoured so the interface was changed to improve this (1.7.2). The control buttons introduced to replace the pop-up menus were an example of this, as was the reference cube introduced to give the participant more immediate feedback regarding the position of the 3D cursor.

These examples illustrate how degree and manner of control was changed in Smallworld. The following chapter generalises from this and proposes how degree and manner of control in works can be composed and used to analyse works.

# 4 CONTROL AND COMPOSITION.

## 4.1 Degree and manner of control.

The combination of all the characteristics identified and discussed in chapters 2 and 3 contribute to the degree and manner of control a participant has over the work they are participating in.

This compound characteristic of participatory works that use computer technology has emerged as the most significant as it is common to all such works and addresses the central philosophy that in making such works artists relinquish a degree of control to the participants.

### 4.1.1 The desire for control.

The central importance of this quality of interaction emerged in the development of Smallworld when it became clear that, given the chance to participate, people may desire more control over events than the artist intends them to have. At Middlesbrough for example a drawing ability was requested to be included in Smallworld and at Brighton options to undo mistakes were also requested (3.4.3) (3.5.3).

Participants generally have some immediate control over the duration of their attention to works of art: The audience at a concert or play usually attend for a given duration in order to see it completed; Visitors to a gallery control the length of their stay and the amount of time, sometimes only a matter of seconds, that they attend to a work. The amount of control participants may have over the duration of their experience of participatory works can vary.

Participation is not always voluntary, or even conscious (2.5.1); if a person does not know that they are part of a work, the control they have over it will be, at most, indirect.

In participatory works that use computer technology, to some extent the ambiguity of whether a program is a tool or a medium (and the fact that one program may fulfil both roles) can lead participants to *expect* considerable freedom of action and hence a large degree of control over events.

If the participation is intended to satisfy a democratizing principle (when the work is seen as an enabling device) participants will expect and should be afforded a large degree of control, but as has been noted in (2.5.2), participation does not automatically lead to democratization.

As there have been relatively few works exhibited it is likely that participants will have no established ideas as to how long they are expected to participate for and what degree of control they should expect during participation. This can be catered for if participants are provided with implicit or explicit goals.

### *4.1.2 Making control the goal.*

One response to a participant's desire for increased control is to make the participant's goal achievement of control through understanding the work. An example of how this might be realised is illustrated in Reffin Smith's comparison of White's Facing out, laying low, with Ihnatowicz's Senster.

White described his work as:

> ... a kinetic sculpture, interacting with its environment via its perception of the light patterns around it. (Reffin Smith 84)

Reffin Smith noted:

> The piece is essentially about the spectator performing little cognitive experiments, and questioning his or her approach to it. The Senster, I think, was more to do with different questions about inquiry and artificial intelligence in art.
>
> People adopted a slightly 'caring' approach to Facing out, laying low, and far from 'teasing' it, most visitors would perform small experiments on it, testing its response, trying to work out the logic, and in the process considering their own responses to it. (Reffin Smith 84)

In Smallworld it was confirmed that some participants established goals as they expressed dissatisfaction with some of the resulting shapes (3.4.3).

Gaining control was in this sense an intermediate task necessary to achieve the goal of generating a shape that satisfied participants' own criteria.

The importance of goals for participants is discussed further in (4.1.7).

### *4.1.3 Freedom to rewrite the program.*

A characteristic that has been identified is whether the program is re-set after a participant has finished participating in the work. The discussion in (2.6.3) was about changes through interaction with the work rather than through rewriting the program directly.

The nature of computer technology, however, is such that programs may be rewritten or edited. Ultimately the maximum degree of control over a work that a participant may be offered is the freedom to edit and rewrite the program.

Roger Malina has proposed that interactive works are those in which the participants are changed by the interaction, implying that both participant and program should be changed if the work is to be called interactive (Malina 88).

Ernest Edmonds in his inaugural lecture as Professor of Computer Studies at Loughborough University of Technology argued that:

> The significant factor of an interactive computing machine is not the particular numbers that it can compute but the very fact that it interacts. Its behaviour is not fully determined in its definition, rather it is formed by its exchanges with the world outside it. (Edmonds 87)

In this light it can be argued that, as being able to change the behaviour of an interactive computer is its fundamental characteristic, a work can not be considered to exploit the technology fully unless this characteristic of the interactive computer has been exploited. An essential characteristic of a work can then be identified as the degree to which the program can be changed during participation.

Participants may be intended to change the program in a work intentionally or coincidentally. They may, for example, be given the facility to write programs within the work, leading them to make intentional changes. Alternatively, they may be able to “teach” the work new terms or behaviours, coincidentally changing the program or database indirectly.

Cornock proposed that “Interactive Art Systems ... should exhibit the properties of a learning system.” (1.1.1), but, although learning is a form of change, change during participation does not necessarily imply learning.

The more freedom the participant has to change the program the less control the artist may have over the kind of experience the participant will have and consequently the interpretation they will place on the work. If the work is seen as the product of a cooperation between artists and participant this freedom may have to be limited.

It was mentioned in (2.6.4) that research into human-computer cooperation pursued at LUTCHI indicated that, in a system where a program simulates the behaviour of a cooperative partner in a task, continued modification of the program’s database could tend to lead the program to become closer in its behaviour to the user. The system developed in the LUTCHI research enabled the user to try and complete a design task. The program was able to tackle the same task, offering similar, yet slightly different solutions to those of the user. The user could choose to reject or accept the program’s offerings and include them in the solution. To control the program’s contribution the system used a programmed model which shared information about how the design task being pursued by both program and user could be completed, but used different criteria to the user when making design decisions. This model was referred to as the “partner model”. As the very advantage of cooperation is that both participants contribute differently, the advantages of cooperation between user and partner are compromised if the partner model becomes a “yes man” (COM 89).

If works are made that will allow only one participant considerable freedom to re-program the work, the implications of this research into human-computer cooperation becomes significant. The tendency for changes in a program to begin reflecting the preferences of a given participant will be countered if a work is available for many different people to interact with, as they are likely to make different changes.

The extent to which a participant can change the program is therefore identified as a significant characteristic contributing to the participant's degree of control.

### *4.1.4 The artist's degree of control.*

It could appear that as the participant's degree of control increases the artist's degree of control decreases.

Cornock and Edmonds suggested that in such a situation the artist's role changes to that of a catalyst (Cornock & Edmonds 73). Krueger proposed the making of a tool to explore the medium of responsive environments rather than specific works (1.1.2).

It was found that through the improvement of the interface to increase the participant's degree of control in the development of Smallworld the designer also attained a greater degree of control. In particular, the introduction of the 3D cursor led to the production of new kinds of shape. This indicated that affording the participant greater degree of control over certain aspects of a given work did not necessarily mean that the artist had less control; the degrees of control of both artist and participant can be increased simultaneously. This realisation was an unexpected consequence of adopting the practice, recommended in (2.7.4), that artists should use the same interface as the participants.

### *4.1.5 Artist as composer.*

The degree to which an artist wishes to keep control over a work and thus retain a degree of responsibility for authorship can vary.

Krueger referred to the importance of the composition of the relationships between action and response and among the ways that a Responsive Environment may be considered included the idea of, "An experiential parable where the theme is illustrated by things that happen to the protagonist - the participant." (Krueger 83).

He gave as an example the Sisyphian maze version of Psychic Space (A1.3) where the manner in which the maze altered to make the task impossible to solve could be frustrating or exciting:

> Such poetic composition of experience is one of the most promising lines of development to be pursued within Responsive Environments. (Krueger 83)

Krueger wrote that:

> The computer perceives and interprets the participant's actions and responds intelligently. The art form is the composed interaction between human and machine, mediated by the artist. (Krueger 83)

The use of a musical metaphor when describing an interactive system was not new; it was made by W.J.Hansen in 1969:

> The "feel" of an interactive system can be compared to the impression generated by a piece of music. Both can only be experienced over a period of time. With either, the user must abstract the structure of the system from a sequence of details. Each may have a quality of "naturalness" because successive actions follow a logically consistent pattern. (Hansen 69)

Krueger took the use of the metaphor further, however, suggesting that the computer acts like an orchestra conductor, controlling the broad relationships. The artist provides the score to which the performer and conductor are bound. He wrote that the artist's responsibilities are broader than those of a composer, as an artist making an "artificial reality" composes a network of possibilities which may not all be realised by each participant.

Krueger's "network of possibilities" is not, however, unique to works of "artificial reality" except in its character. It can be compared with the different ways more traditional works of art may be interpreted, particularly those rich in allegory and symbolism, as they also depend on the viewer "following the correct route" of interpretation. The score of a composer is also open to interpretation by the player and conductor, particularly in works of art that encourage extemporisation.

The analogy with musical composition has also been identified in this research, however an important difference has also been identified; in participatory art the audience become performers (4.1.6). This has led to a different use of the metaphor than Krueger's as it has been more useful to imagine the role of the artist as analogous to a synthesis of the roles of musical composer and musical instrument maker (3.7.1).

The program can then be understood to be more like a score than a conductor in that it provides the guidelines for how the computer and I/O technology may be used. The interface can be seen to be like the controls and output of a musical instrument. Any constraints placed on the effects of using the interface are again like a musical score. The participant can then be seen to be free to interpret the work in the same way that a musician playing without a conductor is free to interpret a musical score.

There is no reason why a participant could not interpret a work and produce a "performance" equal or superior to one by the artist/composer. An example of this from Smallworld is illustrated by the shape "Sirior" (Slides (B11) and (B12)) which was generated by an anonymous visitor to the exhibition at Brighton (3.4).

That the feel of a work can be compared to the impression generated by a piece of music is explored further in (4.2) where the metaphor is extended to draw the various characteristics identified in this research together.

### *4.1.6 Participant skill.*

Degree of control may be hard for the participant to master. If mastery is necessary to apprehend the work the quality of the participant's experience will depend on the participant's skill .

Krueger wrote that having experience of trying to "create" can enhance an audiences' appreciation of work:

> ... a painter can identify with the sensuality of another artist's painting experience as revealed by the brushstrokes.
>
> The graceful movements of a dancer take on a new meaning to a member of the audience who has tried to dance ... (Krueger 83)

Extending this analogy to interactive participatory works in general indicates that the quality of experience of a participant will depend on their quality of "performance". It is not unique to participatory works that apprehending a work of art depends on an audiences interpretive ability, but participatory works make demands on an audience that many other forms of art do not; the participant not only has to interpret the work, but before or while doing so must perform - there is no other way of apprehending such a work.

What is the interactive equivalent of being able to appreciate another artist's brushstrokes? If, as has been discussed, the artist uses the same interface to create the work as the participant will use to experience it, it is anticipated that the identification will be more likely. If however the artist makes a work using a technique that the participant may not have shared; programming for example, the likelihood of such identification is lessened.

An interactive work may therefore be interpreted differently by a person who has some experience of making interactive works. Just as someone who has tried to dance may be more able to appreciate dance. Making a work interactive or participatory does not counter this tendency.

The significant difference between both the examples given by Krueger (of watching a dancer and looking at a painting) and interactive participatory work is that the responsibility for the execution of the physically skilled part of the work is with the dancer and painter, not the audience or viewer. It has become clear in this research that this is one of the most overlooked aspects of participatory works and to a large extent explains their apparent lack of continuing success as a major form of art beyond their initial novelty and political significance in the 1960s.

Reffin Smith described Gordon Pask's "Musicolor", produced in the mid 1950s, which was a work some way between participatory and non-participatory (Reffin Smith 84). The description indicates that the need for participant skill is not unique to participatory works that use computer technology: the work depended on the musicians' improvisational abilities as well as the machines capabilities; the work *relied* on the musician's skill for its success.

It is significant with reference to (3.1.4) and (4.1.2) that the musicians were learning about a complex system by playing with it.

Gerstner wrote that the 1960s group "Nouvelle Tendance" did not aim for perfection (A13). Their approach to participatory art is, however, not the only one; the degree of physical and interpretive skill that a participant needs to be able to experience a work can still be identified as a characteristic, even if it is not intended that the skill should be outstanding.

A common term used with reference to computer technology is that it should be "user friendly". Harold Cohen has, however, argued that artists need "difficult-to-use" technologies (3.5.4). If participants are to contribute physically and intellectually to works as artists, do they also need difficult-to-use technologies? This research indicates that, if artists design and use the same interfaces as the participants (2.7.4) it will ensure that the level of difficulty of use is in the control of the artist. Further, the concept of "degree and manner of control" has been found more appropriate than the general term "user friendliness".

### *4.1.7 The need to measure performance.*

Participants may need to practice to achieve the skill they need, particularly if an interface is unconventional (2.3.1). Krueger specifically planned for this in some of his work (A1) as did Cornock and Edmonds (A12). Smallworld participants were encouraged to play with the programs to get used to them.

Gombrich wrote that when using a musical instrument, bicycle etc., we need to master the basics before being free to plan and direct the use of these skills (Gombrich 79).

Unless it is the specific intention of the artist that users should concentrate their attention on aspects of using the I/O devices of an interface (soft and hard), participants need to be sufficiently aware that they have achieved the necessary degree of skill to attend to other aspects of the work.

Participants may therefore need a means of consciously measuring their attainment of skill so that they can register when to change the balance of their attention from learning to more active interpretive participation. The transition may be obvious, as it is when learning to play a musical instrument or ride a bicycle, but the experience may be so novel that participants have no way of confidently assessing their level of mastery.

To some degree the participant is challenged to participate in the work without any assurance that the outcome will be satisfactory. This may, in some respects, be an advantage as Malone argued that:

> For an activity to be challenging it needs to have a goal whose outcome is uncertain. (Malone 82)

When first confronting a work, however, a potential participant has no certain way of anticipating their degree of success. Participatory work can be challenging at least in this sense. It is also likely to be challenging in a further sense as the participant's *goal* may also be uncertain (4.1.1).

In works of the enabling kind, where the participant is granted a considerable degree of freedom, it may be hard to act on Malone's advice that:

> ... users need some form of performance feedback to know how well they are achieving their goals. (Malone 82)

His advice may be more readily implemented in works where participants enjoy a limited degree of freedom.

Artists who choose to produce work according to a practice as rigorous as, for example, those followed by artists for whom it is important that the system that generates the work is recoverable by means of analysis of the work, (Bann 78) may find it easier to anticipate the participant's goals. Tebby explained that such art:

> ... is generally abstract because of decisions taken by those artists who practice it. Such decisions relate to the intentions and purposes within, and of, a work, that they should not be deflected or diffused by subjective connotations and emotive factors. (Tebby 83)

In a participatory work that fits into this canon of art practice the goal of recovering the system that generated the work can be anticipated and planned for by both artist and participant; the nature of the performance can therefore also be more readily anticipated and appropriate feedback planned.

At a certain level in Smallworld the recoverability of the system that generated the shapes was crucial to a full experience of the work. Various programs within Smallworld can be seen as means of enabling the participant to visualise and experiment with the generative system, consequently learning about and identifying it (2.1.3).

In Wilson's "Responsive Linking Piece No 1" (A2.1) an important part of the work consisted of loss of control and apparent consistency. The idea of a goal, in the sense of a task to achieve, may thus be inappropriate in some works.

Bolt, when discussing "Dataland", a data retrieval system with a graphic output, pointed out that:

> Without visual continuity the system may degenerate into a muddle of imagery. Data must always make sense in their special framework. (Bolt 84)

If data-retrieval is the goal of a work this argument for consistency may be supported, and it is relatively easy for a participant to measure their performance, but efficient data-retrieval may not be a priority in a work; a discursive route may be more appropriate (A6).

In the opening chapter of “Art as Experience”, Dewey referred to Coleridge’s assertion that the reader of poetry should be carried forward by the pleasurable activity of the journey, not merely or chiefly by curiosity or the desire to arrive at a solution. Dewey added that:

> ... it is true in a way of all of us who are happily absorbed in their activities of mind and body. (Dewey 34)

Bearing in mind that this happy absorption does not necessarily constitute art, Coleridge’s observation on the reader of poetry can be generalised to support an open-ended approach to participatory work in which the participant is not necessarily given a task to achieve. A participant’s assessment of their performance must then be measured against goals they have set themselves.

To be able to experience a participatory work in this manner the act of participation assumes a primary role, endorsing Krueger’s assertion that, “ The quality of the interactive relationships is paramount ...” (1.1.2)

It can be seen that participants’ measures of their degree of control and their performance depend on their goals. The participants’ goals can in turn be seen to depend on the type of work they are confronted with; the more intrinsically ordered a work is the easier it is likely to be for the artist to to anticipate participants goals and plan for them.

Gombrich wrote that in aesthetics, “Delight lies somewhere between boredom and confusion.” (Gombrich 79) Regarding order, he wrote that:

> ... we could never have gathered any experience of the world if we lacked that sense of order which allows us to categorize our surroundings according to degrees of regularity, and its obverse. (Gombrich 79)

Sensing order can be classed with a whole range of perceptual activities, and was discussed in (2.3.3). Failing to recognise the order in a work may be due to a poor performance or a poor work.

In some computer games performance is measured explicitly and failing to recognise order and achieve goals leads to consequences that result in a low score being registered by the program. In a work of art there is no such scoring system; the participant has to develop and apply their own criteria to measure their performance and assess how satisfactory their participation has been.

Another characteristic of a work that can therefore be identified is whether participants are presented with a set goal or not.

The degree to which order is used to encourage the generation of particular goals is another characteristic that can be identified in works.

The amount of practice needed to achieve sufficient mastery of the interactive procedures of a work to apprehend its qualities at a meta-level can also be identified as another characteristic.

The combined effect of the characteristics discussed in this sub-section points to the fact that works may be characterised by how difficult they are to participate in, which equates with the characteristic of "ease of use" (3.5.4), but that this ultimately depends on the skill of the participant.

### *4.1.8 The participant's contribution.*

Cornock and Edmonds wrote:

> The burden of the exercise lays with the individual ... (Cornock & Edmonds 73)

Krueger also recognised this, remarking that a participant in a Responsive Environment has to act in a creative manner to complete a work and that, "... the viewers actions complete the piece." (Krueger 83).

The importance of the participant is not unique to participatory work. Nelson Goodman drew attention in "Languages of Art" to:

> ... the Kantian dictum: the innocent eye is blind, the virgin mind empty. (Goodman 69)

Laszlo Moholy-Nagy, wrote in 1922 that a spectator is no longer a passive or receptive observer when confronting a kinetic work but becomes an active partner (Moholy-Nagy & Kemeny 22). The spectator is not given a complete work but must extrapolate from the given information the complete range of possibilities of the work (Popper 75).

It has been argued in this thesis that participatory work, as well as relying on the participants' perceptual skills also relies on their skill in active participation (4.1.6).

The significance of participant skill in a work will depend on the relative degree of control afforded to the participant.

In non participatory work the observer is relied on to mentally "fill in the gaps" or construct interpretations of works. In participatory works the participant is further relied on to physically realise interpretations.

Techniques used in non-participatory works to ensure that the audience of a work can fulfil their role can also be appropriate to participatory work.

Gombrich stated:

> Much of what has been said about the rational and aesthetic aspects of geometrical orders also applies to temporal events. (Gombrich 79)

It can be argued that much of what has been said about these subjects also applies to participatory works.

As an example, Gombrich wrote of the rarity of regular forms in nature, hence the fact that they stand out, and also how:

> When the expected happens in our field of vision we cease to attend and the arrangement sinks below the threshold of our awareness. (Gombrich 79)

This observation can also be applied to interacting with a human-computer interface, particularly when familiar with it; only when something unexpected happens does attention turn to the interface.

It is possible to consider that using the interface in a work might be made as easy as reading a book, yet reading a book relies on conventions and the creative reading ability of the reader (1.2.4) (4.1.7). The contribution of the audience in completing a work is also evident in cinema; every cinema-goer must at some time have sat next to somebody who did not understand the plot. A person reading a book or listening to a concert may not consider themselves to be performing, yet their performance in the sense of their success or otherwise in interpreting, or in popular terms "understanding", a work is significant. The disappointment and puzzlement at having been unable to appreciate a highly regarded work of art is a common experience.

The physical contribution of a participant in a work of interactive participatory art that uses computer technology is clearly an important characteristic of such works, but is the audiences' contribution of a different order than in non-participatory works? The answer has to be that it depends on the characteristics of the work in question. In those works where a considerable degree of physical skill is needed it may be seen to be of a different order, just as any work of art can that demands more of its audience. In both cases the artist addresses a limited audience. This was recognised in the development of Smallworld (3.7.3) and is discussed further in (5.3).

### *4.1.9 The example of computer entertainments.*

The people who are currently most able to apprehend many of the subtleties of interactive computer systems are those who play interactive computer games. Bearing in mind that criteria are developed based on what is being assessed and why, and that the criteria applied to games are different than those applied to art, a short survey of the characteristics that have been identified by reviewers of these games is enlightening.

"ACE Advanced Computer Entertainment" used a rating system that included a Predicted Interest Curve (PIC), a graphical curve relating interest to passage of time. They described their system as follows:

> Brilliant arcade games start high on the curve, and then steadily tail off as you lose interest; powerful puzzle games may ride the crest of the curve for months but the moment you solve them they'll come tumbling down; complex strategy games may stump you at first but climb up the scale as you begin to appreciate the scope of the gameplay. And as for the Turkeys - they start low, stay low, and have nowhere to go but down, down, down.
>
> Once you've seen how long the game can hold your attention, all you need to glance at is the renowned ACE RATING. This is calculated according to the area under the PIC. The bigger it is, the better the game. Add to that our definitive ratings for IQ factor (will it give your brain a work out?) and Fun Factor - a measure of instant appeal and exhilaration as you dive into the game. Then there's the ARCADE ACCURACY rating, where appropriate, to report on how good a job on a game that began life in the coin-op arcade ... Of course we rate the Graphics and Audio effects too ...
> (ACE 89)

"The One" explained their criteria as follows:

> GRAPHICS: Not necessarily how colourful or well drawn they are but how well they fit into the overall effect.
>
> SOUND: Again, not necessarily quantity or indeed quality of sound, but how well it is used.
>
> PLAYABILITY: How does the game feel? Is it addictive or plain uninteresting?
>
> VALUE: Essentially a reflection of lasting interest - how much game do you get for your money.
>
> OVERALL PERCENTAGE: A useful point of reference - essentially a summary of the preceding ratings.

(ONE 90)

"CU Amiga", another EMAP publication, used a similar system.

"Amiga Format" rated each of the following characteristics from 1 to 10:

> GRAPHICS: Good graphics are an important part of any game: if the power is there, it should be used to the full. Both static and moving graphics come under scrutiny in this rating, but remember, graphic wonders do not a great game make ...
>
> SOUND: With stereo capabilities the last thing you want to hear is Spectrumesque beeps, right? Title tunes and effects all add to the atmosphere of a game and good sound can greatly increase your enjoyment.
>
> INTELLECT: How much real thought do you have to put in to play the game? Just because a game is mindless doesn't necessarily mean its bad, but a game with a high intellect rating says immediately that you'll need to think to gain maximum enjoyment.
>
> ADDICTION: How easy is the game to pick up and play? How much sheer fun would you get from it? Will you keep coming back?
>
> OVERALL: A percentage mark that takes into account all the ratings, plus lasting interest, documentation and packing.
> (AF 89)

Games are not art and art is not a game, yet Thomas argued that the game can and has been used as an art form (A11). Pope also referred to the area of computer games (3.5.4). The fact that criteria have been developed to assess games that share many of the characteristics identified in this research is significant; Prince argued that one of the reasons for the slow response of the "art world" to art produced using computers might be the fact that it "... intrigues the masses" (Prince 86). Whether this is the case or not, it is a fact that an increasing number of people who will participate in the kind of work described in this research will have played computer games. This becomes significant when considering the role of convention discussed in (2.3.1); the conventional criteria that game-players bring to bear as participants, whether conscious or not, are sure to have an effect on their interpretations of works.

It is interesting that it is acknowledged that some games, for example: puzzles, are less interesting once solved. Strategic games, on the other hand, become more interesting once the player begins to understand the game and form their own stratagems.

In exhibitions of Smallworld the ability of individuals in Smallworld to “mate” and produce offspring was not introduced explicitly; the appearance of new individuals in the 3D space of Smallworld which had not been located by the participant introduced the mating ability as a surprise; a puzzle to be solved.

Although the game criteria do not explicitly discuss degree of control they do relate to the players’ degree of mastery of the games. It is also indicated that it is expected that some considerable time should be spent playing the game before interest wanes if the purchaser is to get “value for money”.

The implications of this for artists considering making interactive work of similar complexity to some of these games is clear; exhibition in a traditional art venue does not allow people as much time as game-players have to master a complex strategic game, but may afford enough time for participants to solve puzzles or sample some of the characteristics of a work that shares the immediacy of arcade games.

Exhibitions are not the only venues which art can be found; more complex works that demand that participants make regular visits to the exhibit could be located in workplaces. Some works could also be explored at home.

David Rokeby has said of his work "Very Nervous System" (A15) that it is better if experienced in private; participants in public installations seem to retain a degree of self-consciousness even when very absorbed in the work.

## *4.2 A method of describing the possible combinations of characteristics of interactive participatory works of art that use computer technology.*

The initial goal of this research was to identify the characteristics of participatory works of art that use computer technology. Having done so it also became necessary to develop a method of describing and analysing the possible combinations of these characteristics.

### *4.2.1 The composition of control.*

The role of the artist in the realisation of works is similar to that of a composer of music (4.1.5). It is clear from the characteristics identified in previous sections that it is possible to describe and analyse *what* an artist has available as elements of the composition. The following section describes *how* the composition of these elements can be represented.

In (4.1) it was argued that the characteristics identified all contribute to the *degree and manner of control* that participants have in a work. It is a relatively simple step to realise that as the characteristics change so also do the degrees and manners of control of the various participants. In Smallworld, for example, the degree and manner of control offered to participants differed from one program to another.

The artist can be considered as a participant who has a considerable degree of control when a work is initiated and through its initial development: determining the degree and manner of control to retain in the final realisation of the work, how much will be delegated to the computer program, how much to other participants and how these degrees and manners of control may vary during participation.

Taking into consideration the combined effect of the various changing characteristics in a work, a picture emerges of the artist as the composer of the degree and manner of control afforded to the various participants. Whether the artist is conscious of this role or not, considering work in this light can be a valuable means of relating different works and the various elements in a work to each other.

The ways in which participants' degrees of control may vary during participation can be compared with the way this happens in other participatory activities:

- musical performance
- sport
- games
- drama
- dance
- play
- social intercourse (including political and religious)
- economics

These models for organising the degree of control participants have in an activity are potential subjects that may be, and in some cases have already been, interpreted and explored in participatory works by artists using allegory, metaphor and the vast range of other tools available to them.

All of these models exist within the actual world. In a work they may be combined; elements of one may be combined with elements of another. This points to the metaphor that is the most useful, yet the hardest to analyse: the actual world.

Section (2.4) discussed programmed worlds, identifying characteristics associated with works that use this metaphor. The participant in a work can, however, be seen in any work to be free to make decisions and choose paths of action just as they are able to in any other activity in the actual world. The choices and the routes chosen can vary with each participant, therefore, analysing the realisation of a work must, perforce, include analysis of the behaviour of the participant and, depending on the freedom afforded, each participant's behaviour will differ from every other.

This thesis proposes a means of identifying, analysing and composing the characteristics of works in a similar way to that in which characteristic features of the actual world, like hills, lakes, forests etc. can be identified, are analysed and, to some extent, composed. As the works are only complete during participation - it is necessary to map out the routes taken by individual participants to identify, analyse and compose the characteristics of complete works

In works that allow participants more freedom, their behaviours can be expected to be more idiosyncratic (they may ramble all over the countryside). In works that effectively have routes restricting participants' options their behaviours will conform more with each other (they have to keep to the paths).

The metaphor of musical composition discussed in (4.1.3) can fit within the programmed worlds metaphor as the performance can be seen to take place in a programmed world.

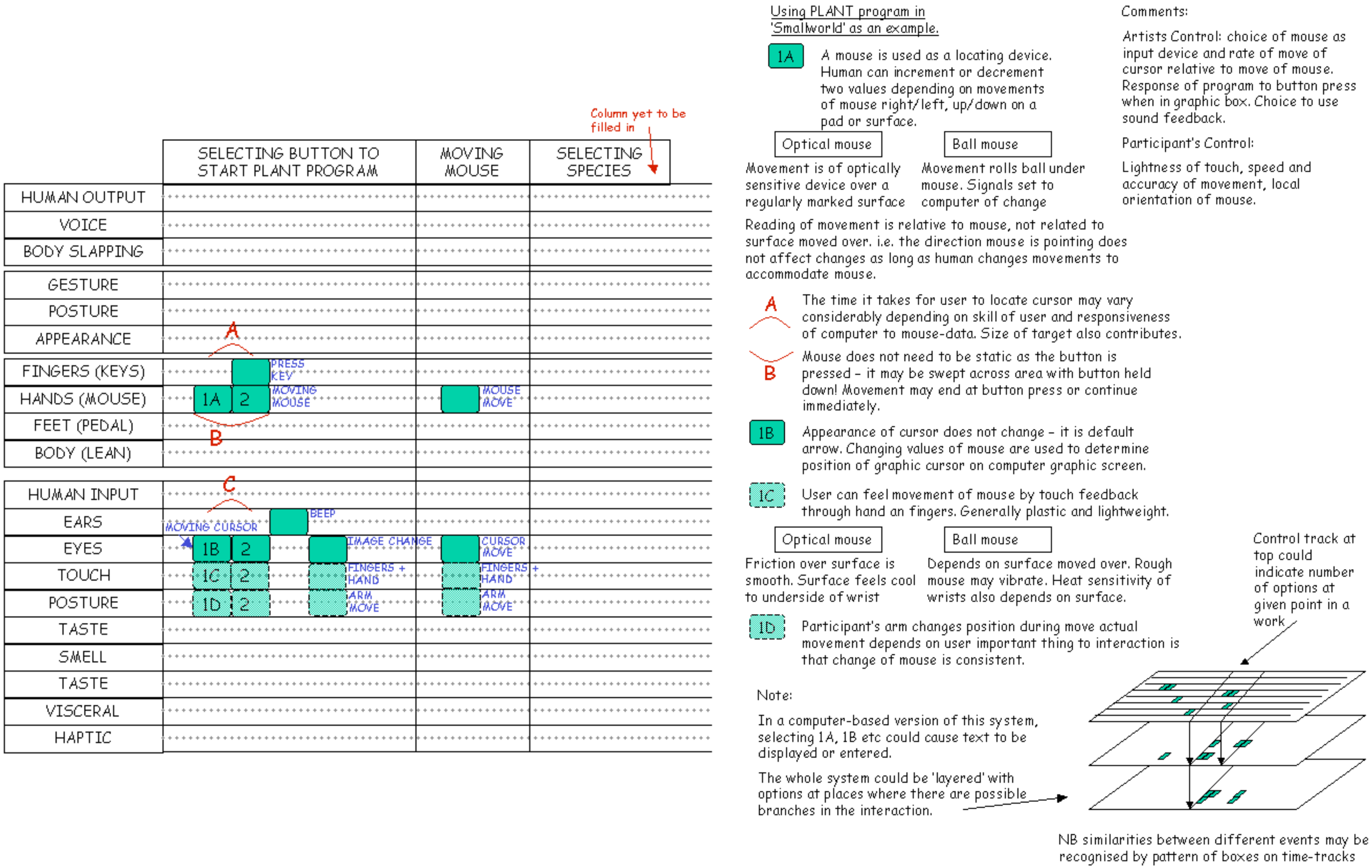
In the next section a method derived from the analogy with music is described as an example of how one of these models may be used to compose control in works.

### *4.2.2 Representing the change of characteristics over time.*

The analogy with music led to the devising of a method of recording how the degree of control afforded to participants changes over time; plotting the changes in degree of control on a horizontal line like a musical score. The degree of control could be recorded by representing the individual characteristics that contributed to that degree of control.

The characteristics are listed in section (4.3).

The method has been applied to a small part of the PLANT program in Smallworld and its value became immediately apparent. Figure 4.2.2.a demonstrates how the changes in the characteristics of the physical I/O devices during the execution of the PLANT program in Smallworld can be represented and analysed.



Column yet to be filled in
SELECTING BUTTON TO START PLANT PROGRAM
MOVING MOUSE
SELECTING SPECIES
HUMAN OUTPUT
VOICE
BODY SLAPPING
GESTURE
POSTURE
APPEARANCE
FINGERS (KEYS)
HANDS (MOUSE)
FEET (PEDAL)
BODY (LEAN)
HUMAN INPUT
EARS
EYES
TOUCH
POSTURE
TASTE
SMELL
TASTE
VISCERAL
HAPTIC
A
B
C
1A
2
PRESS KEY
MOVING MOUSE
MOUSE MOVE
MOVING CURSOR
BEEP
1B
2
IMAGE CHANGE
CURSOR MOVE
1C
2
FINGERS + HAND
1D
2
ARM MOVE
Using PLANT program in 'Smallworld' as an example.
1A
A mouse is used as a locating device. Human can increment or decrement two values depending on movements of mouse right/left, up/down on a pad or surface.
Optical mouse
Ball mouse
Movement is of optically sensitive device over a regularly marked surface
Movement rolls ball under mouse. Signals set to computer of change
Reading of movement is relative to mouse, not related to surface moved over. i.e. the direction mouse is pointing does not affect changes as long as human changes movements to accommodate mouse.
A
The time it takes for user to locate cursor may vary considerably depending on skill of user and responsiveness of computer to mouse-data. Size of target also contributes.
B
Mouse does not need to be static as the button is pressed – it may be swept across area with button held down! Movement may end at button press or continue immediately.
1B
Appearance of cursor does not change – it is default arrow. Changing values of mouse are used to determine position of graphic cursor on computer graphic screen.
1C
User can feel movement of mouse by touch feedback through hand an fingers. Generally plastic and lightweight.
Optical mouse
Ball mouse
Friction over surface is smooth. Surface feels cool to underside of wrist
Depends on surface moved over. Rough mouse may vibrate. Heat sensitivity of wrists also depends on surface.
1D
Participant's arm changes position during move actual movement depends on user important thing to interaction is that change of mouse is consistent.
Note:
In a computer-based version of this system, selecting 1A, 1B etc could cause text to be displayed or entered.
The whole system could be 'layered' with options at places where there are possible branches in the interaction.
Comments:
Artists Control: choice of mouse as input device and rate of move of cursor relative to move of mouse. Response of program to button press when in graphic box. Choice to use sound feedback.
Participant's Control:
Lightness of touch, speed and accuracy of movement, local orientation of mouse.
Control track at top could indicate number of options at given point in a work
NB similarities between different events may be recognised by pattern of boxes on time-tracks


Figure 4.2.2.a

The method promises to be a valuable tool in the continuing development of Smallworld and is proposed as a paradigm that may be adapted for use by other artists composing works, participants desiring a means of organising and directing their participation and anyone involved in a critical analysis of such works.

The system is easy to remember and may be used to not only to analyse works that already exist but to compose works and describe proposals.

There will be points in a work where choices can lead to branches in the "score". One way of representing this would appear to be to use a hypertext system (A6), enabling the artist or analyst to follow different routes through the description depending on what choices are available in the work. It is considered that a more appropriate way would be to exploit the programmed worlds metaphor and extend Smallworld, which represents the interactive behaviour of animals, to represent the interactive behaviour of human participants.

It is intended to develop the system described following the completion of this research and to incorporate it into a programming language for composing and controlling participatory works.

## 4.3 The characteristics identified.

The following characteristics have been identified and discussed in this thesis. Characteristics marked ● are considered to relate mainly to works that use computer technology.

● ***Degree and manner of control.***

A compound characteristic that all the other characteristics contribute to. The degree and manner of control of all participants (artist, program and audience) can be composed using models devised in any of a number of analogies that are encompassed by the programmed world metaphor (4.1) (4.2).

● ***The degree to which the program in a work can be changed during participation.***

Being able to change the behaviour of an interactive computer is its fundamental characteristic and can therefore be identified as an essential characteristic of works.

● ***The level of physical skill needed by participants to successfully participate.***

Works of art rely on the contribution of their audience to interpret them. Participatory works of art also rely on the physical contribution of participants to their interpretation and realisation. In works that use computer technology the quality of the realisation of the work will depend on the participants' skill in using the physical and programmed interface.

❍ ***The amount of practice needed to achieve sufficient mastery of the interactive procedures of a work to apprehend its qualities as an art work at a meta-level.***

❍ ***Whether participants are presented with explicit goals.***

❍ ***The type of intervention afforded to a participant in a programmed world.***

- ❍ ***The speed of response of the programmed element in a work and the way it is used.***
- ❍ ***The way in which feedback is used to direct participant attention.***
- ❍ ***The importance of the sheer exuberance of using motor skills successfully.***
- ❍ ***The degree to which participants expectations are prejudiced by pre-publicity and titles.***
- ● ***The similarity between the virtual machine perceived in a work and the actual computer.***
- ● ***The degree to which interaction is at an imaginary or actual interface.***
- ❍ ***The degree to which information can be changed in a work from one participant to the next.***
- ● ***The degree to which interaction between human and human is directed via an interface or via a computer.***
- ❍ ***Whether the work can recognise and behave differently towards different participants.***
- ❍ ***The degree to which a work mimics aspects of the personality of a participant.***
- ❍ ***The degree to which a work appears to have an individual character or personality.***
- ❍ ***Whether the artist and participant communicate with each other concurrently.***
- ❍ ***Whether the artist uses a work for reflective activity and then allows participants to use the work for the same purpose.***
- ● ***Whether there is communication between human and program.***

- ❍ ***Whether there is communication between several participants.***

- ● ***Whether programs are seen as participants.***

- ● ***The world model of a program, or its model of the participant.***

- ● ***The similarity of the program's world model to that of a human.***

- ❍ ***The degree to which communication is important in a work.***

- ❍ ***The visual similarity to the actual world of a programmed world.***

- ❍ ***The non-visual similarity to the actual world of a programmed world.***

- ❍ ***The apparent intelligence of a work.***

- ❍ ***The degree to which the work is presented as something other than what it actually is.***

- ● ***The way in which the participant is placed in relation to a programmed world:***

    - *outside looking in.*
    - *outside looking in but controlling a surrogate within the programmed world.*
    - *imagined to be inside a virtual environment.*
    - *inside an actual responsive environment.*
    - *interacting as if through a scientific instrument.*

- ● ***Whether the location of a programmed world is ambiguous.***

- ● ***Whether participants can interact with each other in a programmed world.***

- ● ***Whether the interface is considered to be a "sense of place".***

- ❍ ***Whether the programmed world extends participants' sense of themselves.***

- ● ***The conventionality of the physical I/O devices and their use.***

- ***The conventionality of the programmed interface and its use.***
- ***How convention is treated.***
- ***The degree to which the interface can be perceived as ordered and the conventionality of that order.***
- ***The combination of physical I/O routes used.***
- ***The time needed to complete the participation.***

## *5 WHAT THE ARTIST CAN PROPOSE AND THE SPECTATOR DISPOSE.*

Couchot remarked, regarding participatory art that uses computer technology, that, "the artists proposes, the spectator disposes" (Couchot 83). Using the characteristics identified in this research it is possible to consider *what* the artist can propose and the spectator dispose.

### *5.1 The contribution of the thesis to the development of a language with which to discuss works.*

In this research a number of characteristics of participatory art that use interactive computer technology have been identified (4.3). Some of these are more common than others and it is anticipated that as the technology develops new characteristics will emerge.

The study of input and output devices has been based on the natural human senses rather than specific technologies with the intention that the findings will have more than a contemporary relevance (2.2.1).

The characteristics identified do not describe all the possibilities that the artist can propose and spectators dispose, but they do contribute to a means of determining them: it is hard to communicate ideas about work at a meta-level until the necessary language has developed. This research contributes to the development of such a language by identifying characteristics and by proposing a method of analysing their part in specific works by recognising that such works can be seen as compositions of degree and manner of control.

### *5.2 The contribution of Smallworld to the research and its future development.*

The appropriateness of the method of supporting the theoretical research by parallel practical development of an actual work (1.4) has been proved by the development and exhibition of the Smallworld suite of computer programs. As anticipated, the direct experience of this process of development informed the evolution of the ideas presented in the thesis and the manner of their exposition.

The continuing oscillation between attention to development of the medium and development of the work within that medium in the course of the evolution of Smallworld was pursued in the belief that if the products of art practice that use computer technology are to be of any lasting significance (rather than ephemeral sensational novelties) attention must be paid to what the technology is used for as well as to how it may be used. This was exemplified in the practice of temporarily postponing learning new programming techniques if it threatened to compromise other aspects of the work.

The development of Smallworld has, therefore, been recorded both as the development of a medium and the development of a work within that medium.

Decisions made early in writing the program were often modified slightly or replaced entirely. This happened as new programming techniques were learned. These changes in programming technique often did not have an immediate effect on the way the program appeared to run, or the resulting images and interactions. They had a longer term effect by making the overall relationships between separate programs within Smallworld clearer, highlighting differences and similarities.

As the interface used by the designer and participant merged it became easier to achieve many goals and the principle emerged:

- the artist and participant should use the same interface.

This principle was balanced by another:

- if the authorship of the artist is important in the work, the participants' freedom should be limited so their attentions may be directed towards those aspects of the work that the artist considers important.

The important role that an interface has in determining the kind of work that will be produced using a system was indicated while developing the PLANT interface;  the only aspect of the system that had been changed was the interface,  yet it led to the generation shapes of a kind that had not previously been considered (4.1.4).  This is of particular significance when considering the argument that the artist who makes a participatory work should be well practiced in its use in order to anticipate how participants will experience it.

The 3D location interface developed for use in PLANT has since been incorporated in another program for locating  coloured cubes in 3D space conceived by Professor Ernest Edmonds of LUTCHI.  The design of the MPROG program was generalised and presented in a paper at the "Computer Graphics 1990" conference at Alexandra Palace (Bell 90).

Smith's use of a physical world simulation in a graphic interface (Durham 87) supported the idea that Smallworld could be modified so that animals retrieved data explicitly;  something done implicitly when their species' behavioural data was consulted to determine a response to a given situation. The idea of this application developed to the realisation that a user could then monitor whether individual animals were executing their data-retrieval tasks properly by observing the animated representation of their behaviour.  A monitoring task such as this could become more complicated as more sophisticated techniques were incorporated into the program to determine the individual's activities.  The possibility of representing the activities of A.I. programs behaviourally is therefore proposed as a feasible application of Smallworld-like programs.

The full potential of Smallworld has yet to be exploited. Many of the features already built into it have not been explored completely and it is open to the introduction of new behaviour options.

Changing interests in particular aspects of the suite were reflected in the way that photographs have been taken and exhibited and participants encouraged to attend to different aspects of the work.

One of the continuing interests that has affected the choice of aspects to attend to is in the emergence of apparent order from apparent chaos and apparent chaos from apparent order.

As an example of the emergence of apparent order from apparent chaos are the works in which patterns of optimum distribution are achieved. The patterns are similar to those achieved by calculating Voronoi or Dirichlit distributions (Green & Sibson 78, Arnold & Milne 84). This is illustrated in the background to the credits at the end of the accompanying videotape.

The order to chaos process is shown in sequences where the relative order of a number of groups of prey is disturbed as predators attack them.

The fact that the distributions at any given stage after the individuals are given their initial locations are determined rather than random is an important aspect of the work which was discussed in (Mahoney 85) and (Bell 85).

It was expected that the value of the characteristics identified would depend on their usefulness in practice (2). The immediate indication from their application to Smallworld as described in chapter 3 and in (4.2) is that the characteristics and method proposed for their analysis and composition have proved useful in practice.

## *5.3 Further research.*

This research has been of an exploratory nature. It was therefore expected that it would identify topics for further research, as well as finding answers to existing questions.

The system of composition and analysis of characteristics described in (4.2.2) is open to refinement and extension through its use in practice and it is anticipated that further characteristics will be identified as more works are produced and computer technology is developed.

The diagrams in (2.2) which illustrated the possible combinations of input and output devices indicate many further courses of practical investigation.

The development of programmed worlds discussed in (2.4) promises to be an area of considerable discovery with the current interest in “virtual reality” systems.

The use of programmed personalities (2.6.4) in participatory work is another area that promises rich rewards.

The most important implications of this research concern the need for the audience to be skilful enough to perform the interactive tasks necessary to participate in the works. The potential audience will have to develop the necessary participatory skills if participatory works that use computer technology are to develop into a new medium as many predict.

The nature of art exhibitions and the cost of many participatory works of art that use computer technology means that the amount of time available for participants to become proficient at art exhibitions is usually limited.

If participatory works are to be made available to a wider audience, artists need to find ways in which that audience can have enough time to become sufficiently proficient in their use.

Where works share common, conventional (2.3.1), characteristics with other applications of computer technology this goal may be more immediately satisfied. There already exists a strong culture of entertainments that use the technology (4.1.9) and the number of people with everyday experience of computer technology at work and in the home will increase. This will be advantageous to artists seriously pursuing the development of participatory works which use the technology as there will be an increasingly large number of people with experience of human-computer interaction.

Practical research in the development of participatory works will have to satisfy more than the criteria applied to computer entertainments and to systems used at work and at home if works are not to be dismissed as expensive computer games or tools to be used in practical applications. They also need to avoid the “bandwagonning” effect which led much Kinetic Art to be demoted to the role of executive toys (Jenkins & Quick 89). It is intended that the method of identifying, analysing and composing characteristics developed in this research will contribute to the avoidance of these effects by acting as a paradigm which will help artists and participants in the critical interpretation of their responses to the challenges and enigmas of future works of art which use computer technology.

## *BIBLIOGRAPHY*


ACE 89 — *Ace Advanced Computer Entertainment*, Future Publishing Ltd., Bath, UK, 1989.

AF 89 — *Amiga Format*, Future Publishing Ltd., Bath, U.K. 1989.

Antenna 90 — "The Real Thing", Antenna, BBC TV programme, Transmitted 25th April 1990.

Arman 84 — Arman, Yves, "Marcel Duchamp plays and wins joue et gagne", Marvel, Paris 1984.

Arnheim 77 — Arnheim, Rudolph, "Dynamics of Architectural Form", University of California Press, 1977.

Arnold & Milne 84 — Arnold, D.B. & Milne, W.J., "The Use of Voronoi Tesselations in Processing Soil Survey Results", *Computer Graphics and Applications*, March, IEEE 1984.

Ascott 66 — Ascott, Roy, "Behaviourist Art and the Cybernetic Vision" (Part 1), *Cybernetica,* V9, No 4, Namur, 1966.

Ascott 67 — Ascott, Roy, "Behaviourist Art and the Cybernetic Vision" (Part 2), *Cybernetica ,* V10, No 1, Namur, 1967.

Ascott 84 — Ascott, Roy, "Art and Telematics - Towards a Network-Consciousness", *Art and Telecommunication*, Western Front, Vancouver & Blix, Austria 1984.

Ascott 91 — Ascott, Roy, "Connectivity: Art and Interactive Telecommunications", Editorial, *Leonardo*, V 24, No 2, pp 115-117, Pergamon Press, U.K. 1991.

ATG 91 — "Art and Telecommunication Glossary", *Leonardo,* V 24, No 2, pp 253-258, Pergamon Press, U.K. 1991.

Banham 68 — Banham, Reyner, "Arts in Society: Cap'n Kustow's toolshed", *New Society*, 22nd August 1968.

Bann 78 — Bann, Stephen, Introduction in catalogue of *Constructive Context* exhibition, Arts Council of Great Britain, U.K. 1978.

| | |
|---|---|
| Barrett 74 | Barrett, Cyril, in "Concepts of Modern Art" ed. Tony Richardson and Nikos Stangos, Penguin, U.K. 1974 |
| Baumann 68 | Baumann, Norman, "Five year guaranty", in Reichardt 68. |
| Bell 85 | Bell, Stephen, "Computer Generated Images", Broadsheet, Bell, U.K. 1985. |
| Bell 87 | Bell, Stephen, "An Experimental Installation of the Interactive Program 'Smallworld' at the Art Exhibition of the 45th World Science Fiction Convention", Monograph, Loughborough University of Technology 1987. |
| Bell 89 | Bell, Stephen, "Using computers in art practice: from computer-plotted drawings to interactive computer art", Paper presented at First International Symposium on Electronic Art (FISEA), Utrecht 1988, published in *NASCAAD Newsletter*, Spring, Middlesex Polytechnic Further Education Unit 1989. |
| Bell 90 | Bell, Stephen, "Pavlovian Polygons", *Computer Graphics 90 Conference Proceedings,* Blenheim Online, London 1990. |
| Benthall 71 | Benthall, Jonathan, *Studio International*, November 1971. |
| Benthall 73 | Benthall, Jonathan, "Computer Arts at Edinburgh", *Studio International*, October 1973. |
| Beyls 86 | Beyls, Peter, "Intimate machine interaction: an illustrated definition", *The Visual Computer* (1986) 2 pp 152-158, Springer Verlag 1986. |
| Beyls 88 | Beyls, Peter, "Introducing Oscar", Draft received in October 1988. |
| Biggs 89 | Biggs, Simon, "Hybrids: Technology and Unreason", paper presented at *Breaking Down Barriers* conference, Lancashire Polytechnic, Preston U.K. 17th - 18th November 1989. |
| Bocock 74 | Bocock, Robert, "Ritual in Industrial Society: a sociological analysis of ritualism in modern England", Allen and Unwin, London 1974. |
| Bolt 84 | Bolt, Richard, "The Human Interface; where people and computers meet", Wadsworth, Inc. 1984. |

Bratko 86 Bratko, Ivan, “Prolog Programming for Artificial Intelligence”, Addison Wesley 1986.

Brisson 82 Brisson, Prof. David, “Size Constancy, Terry Pope’s Glasses and the Moon Illusion”, Leonardo, V15, No 3, pp205 - 207, Pergamon Press, U.K. 1982.

Cabanne 71 Cabanne, Pierre, “The Documents of 20th Century Art: Dialogues with Marcel Duchamp”, Viking Press, New York 1971.

Clocksin & Mellish 81 Clocksin, W.F. & Mellish, C.S., “Programming in Prolog”,Springer Verlag, Berlin Heidelberg 1981.

Cohen 82 Cohen, Harold, “When Machines Can Generate Images Faster than You Can Pull an Edition Who Will Belong to the World Print Council?”, at conference of World Print Council, San Fransisco, 15th May 1982, World Print Council 1982.

Cohen 83 Cohen, Harold, “Harold Cohen”, exhibition catalogue, The Tate Gallery, London 1983.

Cohen 88 Cohen, Harold, “The A.I. Paradigm”, *First International Symposium on Electronic Art*, Utrecht 1988.

COM 89 “Report on the work carried out by the Co-operative Machine Group”, LUTCHI report MMI/062, HCC 59, Loughborough University of Technology, 1989.

Cornock & Edmonds 73 Cornock, Stroud & Edmonds, Ernest, “The Creative Process Where the Artist is Amplified or Superseded by the Computer”, *Leonardo,* V6, No 11, Pergamon Press, U.K. 1973.

Cornock 77 Cornock, Stroud, “Art and Interaction”, monograph, Leicester Polytechnic, U.K. 1977.

Couchot 83 Couchot, Edmond, “The Digital Image”, in *Electra* Exhibition catalogue, Les Amis du Musée d’Art Modern de la Ville de Paris, Paris 1983.

Cratty 72 Cratty, Bryant J., “Physical Expressions of Intelligence”, Prentice Hall Inc., New Jersey, 1972.

de Kerckhove 91 de Kerckhove, Derrick, “Communication Arts for a New Spatial Sensibility”, *Leonardo*, V24, No2 pp 131-135, Pergamon Press, U.K. 1991.

Dewdney 84 Dewdney, A.K., “The Planiverse: Computer Contact with a Two-Dimensional World”, Pan Books Ltd., U.K. 1984.

Dewey 34 Dewey, John, “Art as Experience”, Minton Balch, New York,1934.

Dietrich 86 Dietrich, Frank, “Visions of Mind”, *ACM Siggraph Art Show Catalogue*, ACM 1986.

Dissanayake 74 Dissanayake, Ellen, “A Hypothesis of the Evolution of Art from Play”, *Leonardo*, V7, pp211 - 217, Pergamon Press, U.K. 1974.

Durham 87 Durham, Tony, “The Ark that floats in and out of real life”,*Computing* May 21st, VNU Business Publications, 1987.

Edmonds 75 Edmonds, Ernest, “Art Systems for interactions between members of a small group of people”, *Leonardo*, V8, pp 224-227, Pergamon Press, 1975.

Edmonds 75 Edmonds, E.A., “Beyond Computable Numbers”, An Inaugural Lecture, 18th February 1987, Loughborough University of Technology, U.K. 1987.

Foley et al 90 Foley, James D., van Dam, Andries, Feiner, Steven K., Hughes, John F., “Computer Graphics Principles and Practice; Second Edition”, Addison Wesley Publishing Company, 1990.

Gaines 78 Gaines, Brian, “Man-Computer Communication - what next?”, *International Journal for Man-Machine Studies*, V10, pp 225-232, Academic Press, 1978.

Gaines & Shaw 84 Gaines, Brian R. & Shaw, Mildred L.G., “The art of computer conversation”, Prentice Hall International, 1984.

Gaines & Shaw 86 Gaines, Brian & Shaw, Mildred, “From timesharing to the sixth generation: the development of human-computer interaction. Part 1”, *International Journal for Man-Machine Studies*, Academic Press, 1986.

Gardner 88 Gardner, James, “Obituary: Edward Ihnatowicz”, *The Guardian*, Wednesday Nov. 9th 1988.

Gardner 70 — Gardner, Martin, "Mathematical Games: the fantastic combinations of John Conway's new solitaire game 'life'", *Scientific American*, October 1970.

Gerstner 64 — Gerstner, Karl, Preface to "Nouvelle Tendance" catalogue, Musée des Arts Décoratives, Paris, April-May 1964.

Gibson 84 — Gibson, William, "Neuromancer", Victor Gollancz Ltd., 1984.

Gombrich 79 — Gombrich, Ernst, "Sense of Order; a study in the psychology of decorative art", Phaidon, 1979.

Goodman 69 — Goodman, Nelson, "Languages of Art; an approach to a theory of symbols", Oxford University Press, 1969.

Green & Sibson 78 — Green, P.J. & Sibson, R., "Computing Dirichlet tessellations in the plane", *The Computer Journal*, V21, No2, Cambridge University Press, 1978.

Hansen 69 — Hansen, W.J., "User Engineering Principles for Interactive Systems", Proceedings of Int. Joint Conference on A.I., IJCAI - 69, 1969.

Horizon 90 — "Signs of Life", *Horizon*, BBC TV programme, transmitted 11th June 1990.

Horizon 91 — "Colonizing Cyberspace", *Horizon*, BBC TV programme, 22nd April 1991.

Humphrey 86 — Humphrey, Nicholas, "The Inner eye", Faber & Faber, 1986.

Ihnatowicz 85 — Ihnatowicz, Edward, "Cybernetic Art: A Personal Statement", Edward Ihnatowicz, 1985.

Jenkins & Quick 89 — Jenkins, Jim and Quick, Dave, "Motion, motion Kinetic Art", Gibbs Smith, 1989.

Kikauka & Paterson 87 — Kikauka, Laura, with Paterson, Nancy, "Misplaced Affection: A Computer-Controlled Interactive Household Appliance Environment", Leonardo, V20, No3, Pergamon Press 1987.

Knowlton 86 — Knowlton, Kenneth, "Why it isn't art yet", *ACM Siggraph Art Show Catalogue*, ACM 1986.

Krueger 76 — Krueger, Myron W., "Computer Controlled Responsive Environments", PhD Thesis, The University of Wisconsin-Madison, 260 pp, 1976.

Krueger 83 Krueger, Myron W., “Artificial Reality”, Addison Wesley Publishing Company Inc., 1983.

Krueger 85 Krueger, Myron W., “VIDEOPLACE: A Report from the ARTIFICIAL REALITY Laboratory”, *Leonardo*, V18, No3, Pergamon Press Ltd. U.K.1985.

Krueger 91 Krueger, Myron W., “Artificial Reality II”, Addison-Wesley, Reading M.A., 1991.

Lansdown 78 Lansdown, John, “Not only computing - also art”, *Computer Bulletin*, March, British Computer Society, U.K. 1978.

Lao BC 300 Lao Tzu, “Tao Tê Ching”, circa 3rd Century BC, translated by Ch’u Ta-Kao, George Allen & Unwin 1959.

Leopoldseder 90 Leopoldseder, Hannes, “Multitrends for Millenium III”, *Der Prix Ars Electronica International Compendium of the Computer Arts*, ed. Dr. Christine Schöpf & Dr. Elke Schuster, Veritas-Verlag, Linz, Austria 1990.

Leopoldseder 91 Leopoldseder, Hannes, *Der Prix Ars Electronica International Compendium of the Computer Arts*, ed. Dr. Christine Schöpf & Dr. Elke Schuster, Veritas-Verlag, Linz, Austria 1991.

LeWinter & Baron 90 LeWinter, Renee & Baron, Cynthia, “Artistic Challenge: Establishing aesthetic standards in computer art”, *Computer Graphics World*, February, PennWell, 1990.

Loftus & Loftus 83 Loftus, Geoffrey R. & Loftus, Elizabeth F., “Mind at Play”, Basic Books, 1983.

McDonald & Concklin 82 McDonald, David D., & Concklin, E. Jeffrey, “Salience as a simplifying metaphor for Natural Language Generation”, *International Joint Conference In AAAI*, 1982.

Maher &Bell 77 Maher, P.K.C. & Bell, H.V., “The man-machine interface - a new approach”, *Proceedings of the International Conference on Displays for Man/machine Systems*, pp122 - 125, Lancaster, 1977.

Mahoney 85 Mahoney, Karen, “Animal Magic”, PAGE, Computer Arts Society, U.K. 1985.

Malina 88 — Malina, Roger F., "Re: Interactive Computer Art - Comments to Frank Dietrich", *Fine Art Forum*, V1, No 43, (electronic mail bulletin) February 1988.

Malina 90 — Malina, Roger F., "The Beginning of a New Art Form", *Der Prix Ars Electronica International Compendium of the Computer Arts*, ed. Dr. Christine Schöpf & Dr. Elke Schuster, Veritas-Verlag, Linz, Austria 1990.

Malone 82 — Malone, Thomas W., "Heuristics for Designing Enjoyable User Interfaces: Lessons from Computer Games", *Proceedings of the Conference on Human Factors in Computer Systems*, Gaithersburg, M.D., March 15-17 1982, Association for Computing Machinery 1982.

Mandelbrot 82 — Mandelbrot, Benoit, "The Fractal Geometry of Nature", W.H.Freeman, 1982.

Marr 85 — Marr, David, "Vision: The Philosophy and The Approach", *Issues in Cognitive Modelling*, ed. Aitkenhead & Slack, Laurence Erlbaum Associates Ltd., 1985.

Martin 79 — Martin, Kenneth, "Chance and Order", The Sixth William Townsend Lecture, 1979, Waddington Galleries, London, 1979.

Means 84 — Means, Loren, "Digitization as Transformation: Some Implications for the Arts", Leonardo, V17, No3, pp195 - 199, Pergamon Press, U.K. 1984.

Metheny 68 — Metheny, Eleanor, "Movement and Meaning", McGraw Hill Inc., 1968.

Michie & Johnston 84 — Michie, Donald & Johnston, Rory, "The Creative Computer; Machine Intelligence and Human Knowledge", Viking, 1984.

Milner 88 — Milner, Kate, artist's statement in *Art and Computers* exhibition catalogue, Cleveland Gallery, UK, 1988.

Minsky 85 — Minsky, Marvin, "Communication with Alien Intelligence", *Byte*, April, McGraw Hill Inc., 1985.

Moholy Nagy & Kemeny 22 — Moholy Nagy, Laszlo & Kemeny, Alfred, "The dynamic-constructive system of forces", *Sturm*, No12, Berlin, 1922.

ONE 90 — *The One*, January, EMAP, U.K. 1990.

OED 61 — "The Oxford English Dictionary on Historical Principles", Oxford Clarendon Press, 1961.

Pask 68 — Pask, Gordon, "The colloquy of mobiles", in (Reichardt 68).

Pope 64 — Pope, Terry, "Perception and Construction", Structure/Series 6 - 2, pp 34 - 37, Joost Baljeu, Amsterdam, Netherlands, 1964.

Popper 75 — Popper, Frank, "Art - action and participation", Studio Vista, London, 1975.

Praz 70 — Praz, Mario, "Mnemosyne: the Parallel Between Literature and the Visual Arts", Princeton University Press, 1970.

Prince 86 — Prince, Patric, "Computer Aesthetics: New Art Experience, or the Seduction of the Masses", *ACM Siggraph Art Show Catalogue*, ACM 1986.

Pye 90 — Pye, Michael, "Polygons and pixels: the city as techno-art", *The Independent on Sunday*, 11th February, Newspaper Publishing PLC 1990.

Reffin Smith 84 — Reffin Smith, Brian, "Soft Computing: Art and Design", Addison-Wesley Publishers Ltd., 1984.

Reichardt 68 — Reichardt, Jasia, (ed.) "Cybernetic Serendipity: the Computer and the Arts", Studio International Special issue, London And New York, 1968.

Reichardt 72 — Reichardt, Jasia, "Art at Large", New Scientist, May 4th, 1972.

Reichardt 89 — Reichardt, Jasia, "Computers, Sequences and Consequences", *Breaking Down Barriers* conference, Lancashire Polytechnic, Preston U.K. 17th - 18th November 1989.

Richardson 83 — Richardson, Ann, "Participation", Routledge & Kegan Paul, 1983.

Robertson 87 — Robertson, Philip, "A Perceptual Framework for Colour Image Display", Lecture presented at LUTCHI Research Centre, 16th June 1987.

Rogers 89 — Rogers, Yvonne, "Icons at the interface: their usefulness", *Interacting with Computers*, V1, No1, Butterworth & Co. (Publishers) Ltd., 1989.

| | |
|---|---|
| Rokeby 91 | Rokeby, David, artist s statement in *Der Prix Ars Electronica International Compendium of the Computer Arts*, ed. Dr. Christine Schöpf & Dr. Elke Schuster, Veritas-Verlag, Linz, Austria 1991. |
| Rosebush 87 | Rosebush, Judson, (ed.) "Advanced Computer Animation Course Notes", ACM Siggraph, 1987. |
| Rosenberg 67 | Rosenberg, Jakob, "On Quality in Art: Criteria of Excellence, Past and Present", Phaidon, London 1967. |
| Sartre 50 | Sartre, Jean Paul, "What is Literature?", Trans. B. Frechtman, Methuen, Lond. 1950. |
| Saussure 59 | Saussure, Ferdinand de, "Course in General Linguistics", Philosophical Library, New York 1959. Fontana, 1974. |
| Scrivener 82 | Scrivener, S.A.R., "The interactive manipulation of unstructured images", *International Journal for Man-Machine Studies*, Academic Press, 1982. |
| Shackel 87 | Shackel, B., "Human Factors of Input and Output Devices", in *Techniques for Computer Graphics*, ed Stirling, Springer Verlag, 1987. |
| Shaw 90 | Shaw, Jeffrey, artist's statement in *Der Prix Ars Electronica International Compendium of the Computer Arts*, ed. Dr. Christine Schöpf & Dr. Elke Schuster, Veritas-Verlag, Linz, Austria 1990. |
| Shotton 89 | Shotton, Margaret A., "Computer Addiction?", Taylor and Francis, 1989. |
| Sullivan 81 | Sullivan, Julian, artist's statement at the International Festival of Electronic Music, Video and Computer Art", reproduced in PAGE, The Journal of the Computer Arts Society, No50, Computer Arts Society 1981. |
| Sutherland 65 | Sutherland, Ivan, "The Ultimate Display", in *Proceedings of the 1965 IFIP Congress 2*, 1965. |
| Swift 26 | Swift, Jonathan, "Gulliver's Travels", 1726. |
| Tebby 83 | Tebby, Susan, "Patterns of Order in Constructed Art", PhD. Thesis, Leicester Polytechnic, April, U.K. 1983. |

| | |
|---|---|
| Thomas 88 | Thomas, Michael J., “The Game as Art Form: Historic Roots and Recent Trends”, Leonardo, V21, No4, pp421 - 423, Pergamon Press, 1988. |
| Weizenbaum 76 | Weizenbaum, Joseph, “Computer Power and Human Reason”, W.H. Freeman, 1976, Pelican 1984. |
| White 90 | White, Norman T., artist’s statement in *Der Prix Ars Electronica International Compendium of the Computer Arts*, ed. Dr. Christine Schöpf & Dr. Elke Schuster, Veritas-Verlag, Linz, Austria 1990. |
| Wilson 83 (i) | Wilson, Stephen, “Computer Art: Artificial Intelligence and the Arts”, Leonardo, V16, No1, pp15 - 20, Pergamon Press Ltd., 1983. |
| Wilson 83 (ii) | Wilson, Stephen, “Environment-Sensing Artworks and Interactive Events: Exploring Implications of Microcomputer Developments”, Leonardo, V16, No4, pp288 - 292, Pergamon Press Ltd, 1983. |
| Wilson 86 | Wilson, Stephen, “Using Computers to Create Art”, Prentice Hall, U.S.A., 1986. |
| Wilson 87 | Wilson, Stephen, “Artist as Explorers of the Technological Frontier”, Academic Computing, pp 32 - 52, September, 1987. |
| Wilson CV | Wilson, Stephen, curriculum vitae, 1987. |
| Wright 89 | Wright, Jeff, “Altered States”, *Computer Graphics World*, December, PennWell, 1989. |
| Young 78 | Young, J.Z., “Programs of the Brain”, Oxford University Press, 1978. |

## *APPENDIX A: Notes on artists and works mentioned in the main text.*

### *A1 Myron Krueger.*

In (Krueger 83) Krueger described each of his works; first technically then as an audience experience, then discussed its finer points. This format is retained in the following summary.

### *A1.1 Glowflow.*

"Glowflow" was exhibited at the University of Wisconsin in April 1969. Krueger assisted Dan Sandin, a physicist turned artist, Jerry Erdman, a minimalist sculptor, and Richard Venezsky, a computer scientist, to realize the work. "Glowflow" used sound composed by Dr. Bert Levy.

In a darkened room transparent tubes ran around the walls. In these tubes phosphorescent particles in water were illuminated in columns that the tubes passed through then travelled along the tubes losing energy as they did so. There were six columns and four lights per column.

The computer program could switch on the lights in the columns that caused the particles to glow. Pressure pads placed in the room sent signals to the computer when someone was standing on them.

There were also six loudspeakers in the room; sound was produced by a Moog synthesizer.

There were fifteen to twenty people in the room at any time, numbers were controlled by letting some people in as others left.

After getting accustomed to the low light level people would explore the space. The following events were observed during the exhibit:

- sitting or lying down
- "interacting" with people
- quiet contemplation
- community among strangers

- games
- clapping or chanting
- inventions of roles by participants
- one woman kissed every disoriented man as he entered
- some acted as guides, explaining the installation

Krueger wrote that:

> The room seemed to have moods, sometimes being deathly silent, sometimes raucous and boisterous. (Krueger 83)

He remarked that:

> Since Glowflow publicity mentioned ... responsiveness, many people were prepared to experience it and would leave convinced that the room had responded to them in ways that it simply had not. The birth of such superstitions was continually observed in a sophisticated University public. (Krueger 83)

This phenomenon is like that noted by Ihnatowicz (A3), and Weizenbaum (Weizenbaum 76) and is discussed in (2.6.1). It happened even though Krueger and the other members of the team who made "Glowflow" were reluctant for the work to have obvious response to obvious input from the visitor.

> It was feared that if immediate responses were provided, the participants would become excited and think only of eliciting more responses. (Krueger 83)

They believed that active involvement could conflict with atmosphere and they relied on delays and complexity to make the establishment of causal chains difficult.

Krueger's conclusions from his involvement in this work are discussed in (1.1.2).

## *A1.2 Metaplay.*

Metaplay, Krueger's first independent work, was exhibited at the University of Wisconsin in 1970. In the work Krueger focussed on interaction and the participants' awareness of the interaction.

A video was back-projected onto an 8' x 10' screen on one wall of a darkened room. The remaining walls were painted with phosphorescent paint. 768 pressure-sensitive switches were on the floor under black polythene sheet, arranged in a 24 x 32 grid. A camera observed the space.

There were two approaches to interaction in the work:

> 1) Live video images of spectators and computer-graphic images drawn by a "facilitator" in a room in another building were superimposed. The facilitator was a person who could draw on a data tablet but "did not always possess any recognized artistic skills". (Krueger 83)
>
> 2) As the viewer moved around the "environment" the computer responded with electronic sound and graphic images on the video.

Krueger considered the use of a video projector important:

> The most versatile existing real time displays are the graphic display computer and closed circuit video. The problem with both of these media is scale; the standard 25" monitor is too small to be an environmental display because we are conditioned to sit and watch rather than interact with it physically. (Krueger 83)

The work used computer graphic imagery:

> The ability to rapidly erase, recall, transform, and animate images required considerable processing and created a far more novel means of expression than a pencil and paper could provide.

> ... the facilitator could draw on the participant's images. For instance a bathtub could be drawn around a seated participant's image in a way which made him or her appear to be seated inside of it ... it was possible to draw a graphic door that opened when a participant touched it.
>
> ... the facilitator could communicate directly by writing words or attempt to induce the participants to play a game such as tic-tac-toe. (Krueger 83)

Krueger's observation that we are conditioned to sit and watch rather than interact physically with a small monitor depends on how conventionally the monitor is presented. Convention is discussed in (2.3.1).

The advantage of developing the work through practice showed itself in the way that the basic ideas for many of Krueger's works appeared serendipitously.

> On one of the first days of the show, I was trying to draw on someone's hand. He did not understand what was happening and moved his hand. I erased what I had drawn so far and started over where his hand had moved. Again he moved. This became a game with him moving his hand just before I finished my drawing. The game degenerated to the point where I was simply tracking the path of his hand with the computer line. Thus by moving his hand he could draw on the screen.
>
> Drawing by this process was a rough process ... But neither the facilitator or the audience was ever concerned by the limitations of the drawings. What excited people was interacting in this peculiar way. Through a video-human-computer-video communication link spanning a mile. (Krueger 83)

When the second, computer controlled, approach was used no live image was superimposed on the computer graphic. To avoid competition for audiences attention and to avoid confusion about whose behaviour elicited a particular response only one person was allowed to enter at a time. The participant could draw on the screen by walking around the room. The program took into account the amount of time a person spent in the space introducing more complex drawing relationships as time passed. A dot following the person left a trail. This trail could catch up with a stationary person or follow an arbitrary path.

Musical feedback also depended on the person's location:

> The length of the room corresponded to a continuum of tonal complexity with simple pure tones at one end and progressively more complex sounds towards the other. The breadth of the room controlled the rhythmic complexity with silence on one edge, regular rhythms towards the centre and complex arrhythmias leading to a busy collage of sound at the other edge. (Krueger 83)

At any given moment there was a randomly selected sound from a number of options appropriate to the location of the person.

There was no concession to the concept of a 'piece' that started when the user entered and climaxed as the participant left.

Several issues relevant to this research are raised by this work:

Krueger insisted that the interaction was within the environment. He developed this idea further in later work. There are other possibilities, however, and this issue is discussed further in (2.4.3).

The interaction in the first version of the installation was between participant and facilitator, with the computer acting as a communication device. In the second version the interaction was between participant and program. It is interesting that Krueger recorded innovations that emerged in the first version as a consequence of the human-human communication that were adopted and used later but does not record any occurring in the second version. This probably also reflects the difficulty of noting what participants have achieved in human-computer interactions in order to modify future works. This is discussed further in (2.7.4) and in chapter 3.

The question of who is communicating with whom is discussed further in (2.5.2).

### *A1.3 Psychic Space.*

This work was exhibited in the Memorial Union Gallery in Wisconsin in 1971. Krueger's intention in this work was that it should concentrate more on human-machine interaction than computer-facilitated human-human interaction. The automatic nature of the exhibit meant that Krueger was not present to observe participant behaviour as much as in "Glowflow" and "Metaplay".

It was intended at the start that there should be just one person in the Responsive Environment but later this restriction had to be compromised as queues formed.

The exhibit consisted of a rectangular space "large enough to run in yet still small enough to provide intimacy" (Krueger 83). The floors, wall and ceiling were covered with black polyurethene except for one end wall consisting mainly of a rear-projection screen.

The floor was divided into a grid of 400 sensing modules measuring 2' x 4'. A DEC PDP 11 computer directed control of sensing and sound. The installation also included an Adage graphic display computer. As in "Metaplay" the Adage image was back-projected onto one wall.

There were several ways in which "Psychic Space" could be run, one way being the maze. In this version the participant walked around the space and a symbol representing them moved through a maze displayed on screen. The maze program ran on the Adage with the PDP 11 being used to send information to it about the participant's location.

A participant's involvement began with a training period. Initially there was just a symbol on the screen that moved as a person moved around the room. After a couple of minutes a square also appeared. If the person walked so that their symbol hit the square, the square vanished to be replaced by a maze with the person's symbol at the entrance. The maze was easily recognized as such so participants had little trouble in understanding the goal.

People had to take small steps for the symbol to stay in the corridors of the maze. They soon took advantage of the fact that constraints were visual and did not constrain their movement and thus were able to “cheat”. The programming had anticipated this and when a person first tried to step across a boundary it stretched. On further occasions the line would disappear in similar circumstances but the whole maze design would change. Later still the symbol representing the person’s location would split in half. Other options led the movement of the user to push the whole maze across the screen. There were about twenty ways that the program could respond to “cheating”.

The goal itself could not be achieved:

> When reaching the goal seemed imminent, additional boundaries appeared in front of and behind the symbol, boxing it in. At this point the image slowly shrank to nothing. (Krueger 83)

Audience behaviour would change. After initially seeing the maze as a problem to solve. Krueger wrote, participants began to investigate the maze in more varied, “whimsical” ways.

An alternative way of using the space involved musical responses. The floor could be played like a keyboard as well as indicating the position of the user. Krueger experimented with different responses to the discrete events that constitute a footstep; raising of heel then ball of foot etc.. The installation responded with high notes at one end of the exhibit, low notes at the other. This was occasionally rotated by 90 degrees. Seeking “... a human-machine dialogue resembling the guitar duel in the film ‘Deliverance’ ”, Krueger introduced a version where during a pause in the user’s movement the previous notes were repeated. The next sequence was repeated at a higher pitch.

Some participants' responses were rather like playing an instrument. The parallels between playing an instrument and participating in an interactive work are discussed in (4.1.5).

In another option the sound-responses were designed to lead the person to some phosphorescent panels at one end of the room. A flash of light would cause silhouettes to be left on the panels.

The lessons that Krueger claimed to have learnt through "Psychic Space" were that the experience had to be designed to be short enough in duration for more people to experience it. The maze experience lasted for approximately fifteen minutes, for example. This led to Krueger's desire to create a facility for on-going evolution of the "Conceptual, compositional and technical aspects of Responsive Environments."(Krueger 83)

The question of timing an event is important as it can vary. Kikauka (2.10) had an interesting approach to this aspect of work. The subject is also discussed further in (4.1.2).

### *A1.4 Videoplace.*

From 1974, Krueger has developed his ideas through the use of "Videoplace". When writing of it in Leonardo in 1985, he described it as follows:

> The VIDEOPLACE environment is dominated by a projection screen that faces the participant. A camera positioned below the screen picks up the participant's image and transmits it to the system. The live image is combined with computer-generated graphics and the composite image is projected onto the screen. Specially built computers analyze the person's image and determine the effects of his or her actions on the objects in the projected graphic scene. Currently, the participant's colorized silhouette, rather than a fully detailed image, is displayed. The silhouette is used because it is an honest representation of what the computer perceives.

> ... the participant's image can be placed in front of or behind graphic objects on the screen. It is also possible for the computer to analyze the relationship between the person's image and the objects. Since the graphic objects are completely under the computer's control, the person's image can appear to make things happen in the graphic environment. The image can lift, push or throw graphic objects.
>
> The participant's image can also be manipulated by the computer. It can be colorized, shrunk, rotated, or moved anywhere on the screen. In addition, a sequence of frames with the participant in different poses can be stored and replayed. By these means, the person's image can defy gravity, swim graphic oceans or interact with graphic creatures. A second person, in another location can also appear on screen and share an experience. (Krueger 85)

During the "Metaplay" exhibit, Krueger had observed what he called "videotouch".

> People feel that their images are extensions of their identities. What happens to their images happens to them. What touches their images, they feel. They immediately accept the reality of any image that includes their own. For example, a person alone on the screen with a graphic object will touch it, half expecting it to react. If two people in different places find their images together on screen, they will interact.
> (Krueger 85)

This discovery is very powerful and has been exploited by Krueger in many ways. It can be interpreted as a special form of projection, which is discussed further in (2.4.3).

Videoplace could be used in many different ways, one of which he called CRITTER:

> ... a graphic creature, called CRITTER, perceives the participant and engages his or her video image in whimsical

interplay. Synthesized sound communicates the personality of the creature.

Initially, CRITTER flits about the screen, just out of reach. If the participant makes a move towards it, CRITTER avoids contact. However, if the person is still, an emboldened CRITTER moves toward him or her. If the person moves away, CRITTER gives chase. If the participant remains still and slowly holds out his or her hand, CRITTER will land on it.

Having made contact, the creature climbs the image of the person's outline, adjusting to the local terrain as it climbs. If the person moves during the ascent the creature clings until the participant slows down and then continues climbing until it reaches the top of the person's head.

Attaining this goal becomes a punctuation for the interaction. Each time it happens, CRITTER takes a different path in its ensuing behaviour. The first time, CRITTER does a jig in celebration. Then, it analyzes what the person is doing. If the participant's hands are down, CRITTER paces nervously. If one of the hands is at shoulder level, CRITTER does a flying somersault and lands on that hand. If the hand is stretched out horizontally, CRITTER jumps to that hand, turns around and executes a back jackknife to the bottom of the screen. If an arm is extended to form a steep slope, CRITTER dives off the head and rolls down the arm. At the last moment, it catches the participant's finger and dangles. The person can dislodge CRITTER by a shake of the hand.

When CRITTER climbs to the top of the head for the last time, it jumps up and down - causing the person's image to disappear. (Many participants report an urge to look down at their bodies when their image disappears.) (Krueger 85)

Hardware has also been built to reduce the participant's silhouette to the same size as the Critter. Of the future development of this version of Videoplace Krueger wrote:

> The scene itself will be an active element in the mature medium. Instead of a realistic portrayal of a three-dimensional world, it will represent a fantastic landscape that has the ability to transform itself. Obviously, the relationship between the participant and the scene need not be limited to the laws of physics. VIDEOPLACE is an artificial reality in which the laws of cause and effect are composed by the artist.
> (Krueger 85)

Two other ways in which “Videoplace” can be used are “Individual Medley” and “Fractal”.

“Individual Medley” itself has a variety of modes. Krueger described one in which the eight most recent silhouettes of a participant are stored as the participant moves. If the participant pauses, the stored images are played back with variations. When the participant leaves the environment the final image is left on screen for the next participant to see:

> The newcomer, initially believing this to be a passive display, discovers its interactive nature only after becoming a part of the piece. (Krueger 85)

The movement and position of a participant's arms controls “Fractal”:

> The position of each arm and the rate and degree of arm motion produce a kaleidoscope of color and form with accompanying audio. The participant can learn to control color combinations as well as sound and visual patterns. ... Each of these experiences is the physical exploration of an abstract space.
> (Krueger 85)

About 50 different variations of “Videoplace” have been developed. In the 1985 article Krueger explained that the interactions in Videoplace were “composed”. This idea is explored further in (4.1.5).

## *A1.5 More recent developments.*

During the past few years “Videoplace” has made appearances regularly at exhibitions and conventions in the U.S.A. and Canada. In 1990 Krueger was awarded the “Golden Nica”, at the “Ars Electronica” festival in Austria, for his achievement for technological innovation in the generic field of interactivity.

In 1991 he published a second edition of “Artificial Reality” (Krueger 91) which brought the documentation of his work up to date and included references to other developments in the technologies and concepts related to the programmed worlds approach to human-computer interaction, such as “virtual reality” and “cyberspace”.

## *A2 Stephen Wilson.*

Wilson has been experimenting with using Artificial Intelligence techniques in computer controlled participatory works since 1979. He wrote in 1981:

> I have tried to introduce AI into my artworks, but they must be regarded as elementary applications of AI. They can be regarded as simulated personalities with which viewers can attempt to establish relationships. (Wilson 83(i))

> The heart of the simulated personality provided by an example of AI Computer Art is the conceptual information inherent in its program, and it can exist and unfold only through a process of collaborative interaction between viewer and machine.
> (Wilson 1983 (1))

He has explored his ideas in a number of works.

## *A2.1 Responsive Linking Piece No. 1.*

In this work the participant sat in front of a computer keyboard, loudspeaker and TV monitors. The participant was asked to type out their name and the program then responded with its own name. The program then asked questions like “How old are you?”, “Do you feel sad or happy today?”. The program generated a sound and a computer graphic image based on each answer, the graphic marks gradually accumulating to form an image based on the viewer’s answers. The participant could then compare their graphic with the combined effect of all the previous participant’s graphics.

Of it Wilson wrote:

> The ‘relationship’ the program is intended to establish with viewers is as important as the cumulative graphic. The built-in simulated ‘mentality’ does more than ask questions and generate graphics. It addresses viewers personally, comments on answers to personal questions, remembers and comments on previous answers, compares answers with those of other participants, informally jokes about itself as a Computer Art

> program, makes comments about the sexiness of their touch on its keyboard and so on. The success of the relationship building has been evidenced by some viewers reporting that they occasionally forgot that they were interacting with a machine and by others that they thought of the machine as their ‘friend’. (Wilson 1983 (i))

Some time after reassuring the participant that their private answers were safe from other participants scrutiny, by first asking them if they would like to see how a previous participant answered and then refusing “as it is a private matter”, the screen was blanked out, alarm bells sounded and the display showed an apparent interrogation of the information entered by the participant via a national defense computer network. The program apologized for revealing the participants private answers and asked them to continue. Wilson’s intention in the piece was to produce a sense of loss of security of personal information.

While allowing participation Wilson assigned a considerable degree of control to the program in the work. Degree of control is discussed further in (4.1). The work also drew attention to participant’s own willingness to be misled by use of different kinds of feedback. Directing attention in this way is discussed in (2.7.3). It is interesting to consider just how much of the “personality” was projected onto the machine by participants and how much was inherent in the program.

### *A2.2 Interactive Computer Theater.*

This event, staged by Wilson in 1981 included 135 participants who were split into groups by a microcomputer program. People were assigned to groups based on a self-assessment of whether they were leaders, diplomats, quiet participants and so on. Each group had a monitor connected to a central microcomputer. At certain stages in the performance, which included computer graphics and a story in text, the groups voted on decisions about how the event should continue; should the hero respond to cries for help, for example. The participants were unaware that one of the groups, for some reason participating from behind a curtain, was actually simulated in the program.

> The process of decision making, as facilitated and made public by the computer, was as much a focus of the event as were the graphics and story. At the end of the event, the groups yelled and lobbyed (sic) each other loudly for certain choices because they realised that they had seen only one of the many possible stories. (Wilson 83 (ii))

In this work Wilson was able to arrange interaction between humans and what they thought was another group of humans but was actually a program. Wilson does not document the specific effectiveness of the program's contribution, but the tendency of peoples' prejudices to influence their experience is mentioned in relation to Ihnatowicz's (A3) and Krueger's (A1) work. Wilson intentionally exploits and brings attention to this tendency in several of his works. The subject is discussed further in (2.6.1).

This combination of interaction between groups of humans with a program simulating a group of humans constitutes a specific type of interactive situation, discussed in (2.5.2).

### *A2.3 Exploring Frames of Mind.*

A large photograph was hung on the wall next to a monitor screen. Computer text on the screen asked participants to choose to explore the photograph in either a political or aesthetic frame of mind. They were then invited to rub their hands over the photograph. Photocells behind the picture informed the program when a certain area was being touched and the computer would display text related to objects depicted in that area.

The approach made use of the computer to access and display stored data in response to a user's input and demonstrated how presenting the data can affect the way it is interpreted; the users did not necessarily have complete control over how data were presented to them.

Graham Howard exhibited a hypermedia based work at the "Art and Computers" exhibition (3.5) that had a similar character to this. The potential of such works is discussed in (A6) and (2.3.1).

## A2.4 Street Events.

In 1981 Wilson installed works in public places; the passing public could touch sensors on shop windows which caused a program to display text and graphics and make sounds.

In “Street Action”, people working on two windows were enabled to co-operate in the production of a computer graphic image. Occasionally the program would ask the participant a question about a nearby feature of the environment. If answered it would reward them by opening up more options.

> The scene was refreshing to watch: people touching a window they usually walk passively past, running to look at details of the environment, and talking and laughing with strangers. (Wilson 1983 (ii))

The sensors could also be set up to run “Memory Melody”; the computer accumulated the musical choices of participants. At the end of the event a month’s worth of choices could be played.

In “Community Standards”, five randomly selected graphic designs were generated and participants were asked which one they liked best. After each vote, the program displayed a cumulative image based on the most popular design elements.

In “Interactive Escalator” (installed on an escalator), participants could effect video, sound and lights by touching sensors. The program staged special events if several people touched separate sensors simultaneously.

These multi-participant works challenged Krueger’s assertion that works should be for one participant only. They also challenged Krueger’s assertion that interaction should be in a closed environment. This relationship between work, participant and environment is discussed in (2.4.3). Wilson’s works supported the connection between democratization and participation discussed in (2.1) and enabled people to explore their relationships with each other. The interaction was between humans, with the computer as mediator, one of the types of interaction discussed in (2.5.2).

### *A2.5 Yes-No Battle Against Chaos.*

This was a work that used voice input to influence the program. The computer randomly generated an image and the participant could, by saying Yes or No accept or reject the marks as they were added to a graphic composition.

> Participants became aware of the power of the words 'yes' and 'no', and the rhythm of alternating design generation and spoken yes or no became a kind of poetry. Some people yelled their answers, some whispered, and some changed tone after strings of rejections or affirmation. (Wilson 83(ii))

This work demonstrated how an arrangement with a simple form of input from the participant can be used to good effect. Input does not necessarily have to be very sophisticated to enable interaction. Input devices are discussed in (2.2).

### *A2.6 Magic Word Chorus.*

There were two parts to this work. In the first, participants sat alone with the computer and made choices about a graphic image being generated. When it was complete they assigned a unique word to it. In the second part of the work all the participants were asked to say their special word when they felt like it and the resultant cumulative graphic would be displayed.

Again this work encouraged humans to participate with each other.

### *A2.7 Time Entity.*

Exhibited as part of the CADRE computer art festival in San Jose, California in 1983, and in the Gallery of San Francisco State University this work modelled an artificial creature. The creature was obsessed with its future and its 'mortality'; it had monthly, diurnal and heartbeat length rhythms written into it.

> Physically, the entity was a computer graphic animation that moved on a video projection screen accompanied by computer synthesised sound. It also had tactile and kinaesthetic life. Humans interacted with it by touching specially constructed, pleasant feeling touch pads. It lived in a forest of upside down pine trees. The smell was overwhelming and many visitors remarked it was the first good smelling computer art they had ever encountered. Its appearance and behaviour changed with its age since birth, the time of day, and time of month. It had a regular heart beat rhythm that pulsed its visuals and sounds.
>
> Visitors could observe it move and grow or could actively affect its time life by touching the pads. For example, they could speed or slow its pace or choose to make part of it grow or die. They could choose to make the action happen immediately or at a specific minute in its future. At any given moment, its visual and sound appearance was the result of its intrinsic growth tendencies and all the interactions up to that point.
>
> It had additional time-related features. Visitors could ask to see snap-shots from its past. It saved a record of its current state every hour it was alive. They could also choose to send messages with it into the future. By using the touch pads, they could spell a simple sentence and tell the Entity to present it at a specific moment in its future.
>
> ...
>
> The intelligence of the program was rudimentary ... The total installation was quite successful. Visitors reported that they indeed had a sense of an encounter with an unusual creature. (Wilson 87)

Wilson was aided in the realization of the project by Matthew Kane, David Lawrence and Eric Cleveland, graduates of the Conceptual Design program at San Fransisco State University where Wilson was an Associate Professor in the Art Department.

The similarity of encountering an unusual creature is reminiscent of Ihnatowicz's work, of Krueger's Critter; sub-section (2.6.4) addresses the subject of programmed personalities.

The ability of participants to leave a message to be presented later is significant in the context of the discussion of how much the participant can change the program in (2.6.3).

## *A2.8 More Recent Works.*

In "Parade of Shame", presented on SF Cable TV and at SIGGRAPH art show in 1985, viewers and visitors to the art show affected computer graphics via calls to the station automatically processed by Wilson's program.

> Participants' choices about the pace, process and direction of evolution affected the unfolding action (Wilson CV)

In "Synthetic Speech Theatre", at CADRE Festival San Jose, 1986, four programmed personalities conversed with viewers via synthesized speech and voice recognition. A computer enabled each voice to come from its own space in the room.

"Hi Stranger, Welcome to City Hall", at the SF Arts Festival, 1986 consisted of four interactive robots which used synthesized speech and computer controlled video switching to simulate bureaucrats.

"Demon Seed", at SIGGRAPH art show, Anaheim, 1987 consisted of four choreographed moving and talking robot arms simulating demons in various world cultures. They were partially controllable by the audience.

## A2.9 Wilson's Laws of Input and Output.

Wilson's approach to using computer technology is encapsulated in the "laws" he included in his book "Using Computers to Create Art" (Wilson 86) which are included in sub-section (2.2.4):

The fundamental truths illustrated in Wilson's laws are often overlooked by artists for the reasons described by Wilson below, but they are important factors in a work. Input and output are discussed in (2.2).

Wilson pointed out that:

> ... outputs have been even less explored than inputs because most personal computers do not include ways of getting impulses out among their standard components.
> ...
> Output possibilities are difficult for artists to explore because these effects often require complex electronic and mechanical skills and knowledge. Even when a computer outputs digital pulses, the artist needs to create or find electronic interfaces that convert the signals into forms useful for controlling devices.
> ...
> After the pulses are converted, artists must often fabricate the mechanical devices that will accomplish the desired actions in the world ...
> The relative superiority of computer technology over robot technology illustrates the problems of these conversions. Computer "mental" activity appears more sophisticated and subtle than does robot "muscular" activity. Home computers are much further evolved than are home robots. At this time in technological history, electromechanical devices are relatively costly and complicated to develop. (Wilson 86)

Wilson included a table of input and output devices, reproduced in (2.2).

His works illustrate that participatory works that use computers can have multiple participants and that it is legitimate to pursue the practice of making individual works rather than developing a medium. The implications of his comments on computer “mental” activity and “muscular” activity are important and discussed further in (2.2) and (2.3).

## A3 Edward Ihnatowicz.

### A3.1 SAM.

Edward Ihnatowicz exhibited “SAM” (Sound Activated Mobile)in the 1968 “Cybernetic Serendipity” exhibition held at The Institute of Contemporary Arts in London. “SAM”, although it did not make use of a digital computer, was the turning point which led to the eventual conception and building of “Senster”, discussed later in this section, which did make use of a computer. Ihnatowicz described “SAM” as follows:

> SAM consists of an assembly of aluminium castings somewhat reminiscent of vertebrae, surmounted by a flower-like fibreglass reflector with an array of four small microphones mounted immediately in front of it. The ‘vertebrae’ contain miniature hydraulic pistons which enable them to move in relation to each other so that the whole column can twist from side to side and lean forwards and backwards. A simple electronic circuit uses the signals from the four microphones to determine the direction which any sound in the vicinity is coming from and two electro-hydraulic servo-valves move the column in the direction of the sound until the microphones face it. (Ihnatowicz 85)

Ihnatowicz’s matter-of-fact description of the mechanics of “SAM” contrasts with Reyner Banham’s comments, which bring to mind the ambiguous attitude of societies to automata that imitate life:

> ... what is so startling about Sam is that it can snap round to attend to a noise as suddenly as a human being, can peer up and down as quickly as a cat hearing a mouse or a bird. It can do so because of a mounting that superficially resembles a human neck, but works rather differently - a superimposed set of highly polished articulated yokes in metal mounted one on top of another. The forms of these yokes are - to quote Paul Valery, talking about something different - nets comme des ossements, and the blood-and-bone analogy is reinforced by the plastic tubes that rise in pairs through the central void of this ‘spinal

> column' to bring hydraulic power to its articulations. It's about the most beautiful fragment of sculpture I have seen in a decade - and the most disturbing. Beautiful because of the forms of the yokes, their finish, their articulation, their congruence in motion. Disturbing because the old atavism still shies at the sight of any patently man-made creation moving and responding in a manner that millenial tradition insists is the prerogative of the creations of the Almighty. (Banham 68)

### *A3.2 Senster.*

From 1970 to 1974, the work for which Ihnatowicz is most well-known was exhibited at the Philips company's permanent publicity show-place the "Evoluon", in Eindhoven. The work was the "Senster", the first sculpture to be controlled by a computer (Ihnatowicz 85). Jonathan Benthall's description, written at the time, was as follows:

> About 15 feet long by 8 feet high, the Senster consists of six independent electro-hydraulic servo-systems based on the articulation of a lobster's claw, allowing six degrees of freedom. ... The Senster has a 'head' with four sensitive microphones which enable the direction of a sound to be computed, and also a close-range radar device which detects movement. The whole is controlled in real-time by an on-line digital computer, which tells the servo-systems how to move in response to various combinations of sound and movement from visitors to the Evoluon. The acoustic 'head' is so designed as to give a vivid impression of an animal's eyes flicking from one object to another. The servo-systems can position the head within a second or two anywhere in a total space of more than 1,000 cubic feet. (Benthall 71)

Ihnatowicz said of his work that it was ultimately aimed:

> ... at making the spectator aware of just how refined our appreciation of motion is and how precisely we are capable of interpreting the intention behind even the simplest motion. (Ihnatowicz 85)

The works no longer exist, except perhaps in disassembled components, but there are video films of “SAM” and “Senster”. Although we can not, ourselves, interact directly with these works now, by watching a recording of a young girl trying to gain the “attention” of “SAM”, or of people trying to attract “Senster” we get an insight into the work in a way that is rarely if ever possible with other forms of art. To do this we interpret other people's behaviour using a skill that Nicholas Humphrey considers the prime use of human consciousness - making sense of oneself and other people by understanding what it feels like to be human “from the inside” (Humphrey 86). We understand how people are trying to relate with Ihnatowicz’s creations in the video by putting ourselves in their place and imagining how we would feel in their situation. Watching people examining a painting or a passive sculpture gives us much fewer clues about the way they are relating to the works; watching people examining Ihnatowicz’s works is different - we can apply similar skills to those we use in social relationships in everyday life. These skills are addressed in Smallworld and are discussed further in chapter 3.

Social interaction is hardly a new subject for artists - humans in social relationships have been depicted in painting and other art forms since prehistoric times. What we can see in Ihnatowicz’s work, however, is social interaction with a machine; people used behaviours similar to those they might use with animals to get them to perform tricks. They involved themselves in what, in an equivalent of the “Mona Lisa” might have been attempts to get the subject to smile.

That our appreciation of motion is refined and that we are capable if interpreting the intention behind it is evident in dance, mime, body-language etc.. (Metheny 68, Cratty 72) If Ihnatowicz intended to make a work of art about motion and meaning why did he use a machine rather than a dancer or an actor? Some clues may be found by considering why Ihnatowicz made his first moving sculpture - “SAM”.

“SAM” was made because Ihnatowicz was dissatisfied with the abstract sculpture he had been making:

> ... the shapes I was making were too arbitrary and the aesthetic criteria by which I was judging them, unreliable.

> (Ihnatowicz 85)

“SAM” provided non-arbitrary criteria by which to approach the design of the abstract shapes:

> I felt that I could produce more convincing shapes if I were to design them as some imaginary, idealized pieces of machinery and refined to the point where the shapes would show nothing of the process of manufacture by which they were produced but clearly indicate the function they were to perform.
> (Ihnatowicz 85)

What Ihnatowicz did was to make the “abstract shapes” a design problem rather than a free-form sculpture. In the final works, although characteristic of Ihnatowicz’s work these joints are not the main focus of our attention or that of the participants we watch on video. The participants’ attentions were held by the interaction itself, as is our own as observers.

There was no pretence that “Senster” or “SAM” were anything other than machines; very sophisticated ones, unlike the majority of historical automata which imitate living things in a more literal way. This is pertinent to continuing interest in the subject of “realism” which is discussed in (2.4.2). Ihnatowicz’s approach was to some extent followed in the realisation of Smallworld (3).

Ihnatowicz wrote of “Senster”:

> Its behaviour, controlled by a computer, was much more subtle than SAM’s but still fairly simple. The microphones would locate the direction of any predominant sound and home in on it, rather like SAM but much more efficiently, and the rest of the structure would follow them in stages if the sound persisted. Sudden movements or loud noises would make it shy away. The complicated acoustics of the hall and the completely unpredictable behaviour of the public made the Senster’s movements seem a lot more complex and intriguing than they actually were. It soon became obvious that it was that behaviour and not anything in its appearance which was

> responsible for the impact which the Senster undoubtedly had on the audience. (Ihnatowicz 85)

Jascia Reichardt confirmed Ihnatowicz's statement:

> Senster provoked the kind of reactions which one might expect from people who are trying to communicate with a person or an animal. It appeared more as an organic creature that is capable of evaluating the messages that are sent, and responding to them. (Reichardt 72)

She compared the experiences of people seeing Ihnatowicz's Senster to those of people who used Weizenbaum's "DOCTOR" program (Weizenbaum 76), mistaking the program's responses for those of a human doctor sitting at a terminal in another room.

This is again significant to the discussion of realism in (2.4.2) and programmed personalities in (2.6.4).

Ihnatowicz only learned about computing and programming in the course of making "Senster", but became convinced in the process that:

> ... computing could be a valid and important artistic medium. (Ihnatowicz 85)

The intention was that, as the "Senster" was computer-controlled and the computer could be re-programmed, more sophisticated programs would be developed during the course of its exhibition to change its behaviour. Thus exploiting one of the essential characteristics of computers (4.1.3). Philips withdrew their support and this part of the project was not realised.

> Alas, smaller brains had failed to realise that Ihnatowicz had given birth to the eighth wonder of the world, designing the first device to simulate the responses and controls of a living organism. (Gardner 88)

### *A3.3 The Bandit.*

The third, and last, piece of participatory work that Ihnatowicz was able to realize was “The Bandit”. Exhibited in 1973 at the Computer Art Society show at the Edinburgh Festival, Ihnatowicz described it as a “simple lever”.

> ... a fairly simple program enabled it to interact in an apparently purposeful way with anyone who moved the lever and by statistically analysing the resulting motion succeeded, in the large majority of cases, in classifying the person in terms of sex and temperament. (Ihnatowicz 85)

Jonathan Benthall wrote of “The Bandit”:

> Obviously there is scope for refining the psychological criteria, but as art the concept seems to me brilliant. Ihnatowicz draws on the eroticism latent in all machinery: the lever becomes a phallus, partly responsive or resistant to the visitor and partly determined by strange forces outside the visitor’s ken. Whether the computer guesses our sex rightly or wrongly (its on-line typewriter clacked out that I was classed as ‘precise masculine’), the artwork can be seen as a beautiful and serious play on the theoretical riddles of the ‘tool’, or what it means to manipulate and be manipulated, and of what it means to distinguish an object from a presence. These philosophical enigmas are not set out in academic jargon but are captured at an intuitive, not wholly conscious level, accessible to everyone from the professor to the cleaning-lady. Isn’t this what art is about? (Benthall 73)

In section (2.5.1) there is a discussion of how much a program needs to “know” about human behaviour. With the Bandit, Ihnatowicz was dealing with a way of enabling the program to draw conclusions about the person it was interacting with. This is a non-trivial concern technically, philosophically and emotionally. Baumann’s description of feeling magnetic fields (A9) is similar to Benthall’s description of philosophical enigmas being copied intuitively. This is discussed further in (2.7).

It is in the nature of art that one work of art can provoke thought about many different subjects. One can attend to the different aspects of a work separately in an attempt to comprehend them but the combination is what makes a particular work unique. In Ihnatowicz's work, one aspect which can be attended to is the sculptural castings of the joints. Another aspect of the work which can be attended to is the overall shape of the machine; in the case of "SAM" its similarity to a flower. The workings of the machines, their articulations, are also open to scrutiny. Yet after watching the video for a while, Ihnatowicz's achievement is that even with this knowledge the dismantling of "SAM" and the "Senster" seems less like a machine having been taken apart and more like the news that a famous zoo inmate has died.

The degree to which an automaton can appear to have life has been explored further by Wilson, whose work "Time Entity" is described in (A2.7).

Even after the introduction of the microprocessor, prohibitive costs led to the abandonment of work like Ihnatowicz's Senster. Ihnatowicz himself wrote:

> Although I have continued to work on the problems of motion and perception, I have not built or exhibited any more pieces, chiefly through lack of money. I have watched others quit the field and found promising youngsters reluctant to enter it, deterred by the high cost of equipment and materials.
> (Ihnatowicz 1985)

He proposed that, just as makers of high technology keep costs manageable by mass production, so might artists who make technological art. Ihnatowicz argued that there is no reason why replicas of "Senster" should not be as interesting or valid as works of art as the original.

Recognizing that "... a considerable shift in some of our attitudes towards art" would be required, he admitted that adoption of mass-production techniques would only make sense if there were a market for such works. It must be remembered that "multiples" challenge the idea of the uniqueness of an art object as a commodity. The expertise of promotion, advertising and salesmanship would need to be adopted:

> We live in an industrialised, technological and commercial world and if art is to have any relevance it cannot hide in the romantic, artist-in-the-garret cocoon but must be prepared to come out and join in the fray. (Ihnatowicz 85)

Ihnatowicz was unfortunately unable to realize his vision before his death in 1988.

## *A4 Norman White.*

White has been exhibiting electronic work since 1969. Since 1975 he has concentrated on the development of interactive work:

> ... pseudo-organic machines which express themselves primarily through motion. (White 90)

## *A4.1 Facing Out, Laying Low.*

An early work of White's, exhibited in 1977 and later modified, was described by Brian Reffin Smith:

> *Facing out, Laying low* is a kinetic sculpture, interacting with its environment via its perception of the light patterns around it. ... the work is called *Facing out, Laying low* because that is what gangsters are said to do when on the run from the police. The work sits on its plinth in the gallery, skulking almost, squatting silently but ready for action. (Reffin Smith 84)

The work had a perspex construction so that all the electronic components could be seen. The work could scan its surroundings for changing light patterns. Its internal microcomputer could be programmed in different ways to change its behaviour.

> Usually, the control program is designed so as to cause the work to search constantly for changing light patterns in its vicinity, and to respond to them with audible patterns which give clues as to what decisions are being made by the computer. (Reffin Smith 84)

## *A4.2 Telephonic Armwrestling.*

White, with Doug Back, armwrestled each other whilst on opposite sides of The Atlantic; Back in Toronto and White in Paris. At each location there was a device which could send signals to the other via a modem link. When one participant applied pressure to his device the other could feel the movement at the complementary rod at the other end of the link. The telematic link was of the kind described in figure 2.5.2.d where participants' communicate via a program which mediates their communication. The work was a rare example of remote E/E I/O (2.2.10) via electronics. It was fundamentally a human-human rather than a human-program interaction.

### *A4.3 The Helpless Robot.*

In 1990 White's proposal for "Prix Ars Electronica" was awarded a distinction.

The "Helpless Robot" would be a 5' high free-standing sculpture which could not move of its own accord, but using an electronically synthesised voice could coerce passers-by to move it.

White wrote:

> I see the work behaving as the classic "hustler". For instance, it might enlist human cooperation with a polite "excuse me ... have you got a moment?", or any one of such unimposing phrases. It might then ask to be rotated: "Could you please turn me just a bit to the right ... No! Not that way ... the other way!" In such a way, as it senses cooperation, it tends to become ever more demanding, becoming in the end, if its human collaborators let it, dictatorial. Such a shift from entertainer to tyrant hopefully does not go unnoticed. Ultimately, my purpose behind the work is not to exploit, but to instruct.
> (White 90)

White's work is of a kind that occupies the actual world, rather than being part of a simulated world. In this way it contrasts with Krueger's "Videoplace" works (A1.4) and Smallworld (3). The implications of this are discussed in (2.4.3).

## *A5 Participatory works at "Electra".*

In the "Electra" exhibition in Paris in 1983 there were several participatory exhibits.

### *A5.1 A breath interface.*

Edmond Couchot exhibited a work in which spectators could blow gently on the computer-graphic image of a bird's feather. The feather would move according to the strength of the breath.

This extension of input is of interest with relation to the discussion in (2.2.9) of physical input and output.

### *A5.2 A summary of other exhibits.*

Couchot described the other interactive exhibits as follows:

> Yves and Jean-Paul Chambaret plot an animated figure in space with a computer-controlled laser beam which the spectator can modify at will. With Tom Dewitt's Pantomation System one can draw a three-dimensional object in space (with one's hand or whole body) and, after computer processing, monitor its evolution visualized in colour on video screens.
> Manfred Mohr presents a device using three graphic screens connected to a computer on which mobile cubes can be seen. The user can modify the angle and speed at which the cubes rotate and a printer records the position he selected on paper.
> Brian Smith organises a sort of graphic 'duel' between two protagonists settled (or arbitrated) by an impartial computer.
> Herbert Frank shows his video games where one can intervene in the process of generating shapes displayed on the screen.
> The graphic system presented by Sonia Sheridan - EASEL developed by John Dunn - allows one to make and mix coloured photographs and drawings. The device can be handled as easily by a child as by a professional. Nelson Max proposes what one could call a real interactive film. Thanks to a simple analogue

> system the spectator can act upon a moving three-dimensional image of a marine landscape (islands surrounded by water) and modify at will the colour of sea and sky and the position of the sun and moon above the horizon. (Couchot 83)

Couchot's descriptions reveal little of the relative success or failure of the works mentioned; there is no attempt in this catalogue of works to compare their different characteristics. It would seem that it is sufficient to report that the works are interactive without considering what Krueger referred to as "the quality of the interaction" (1.1.2) in them.

## *A6 Hypermedia works.*

Hypercard, introduced in 1988 as a “software erector set” for Apple’s “Macintosh” computer is a product that several artists have been experimenting with.

Hypercard uses an index-card metaphor; on screen you see a “Hypercard” card which can contain words, sounds, pictures, and controls in various combinations. The cards can be organised, shuffled, cross-referenced and sorted. It is possible to build interactive data-retrieval programs without needing to write in a more traditional scripted language. There is a simple “Hypertalk” scripting language that may be used.

At the “Art and Computers” exhibition in 1988-89 (3.5) two exhibits used Hypercard to make their work participatory. Kate Milner describes her work in the catalogue:

> “Dominic” is an attempt to tell a story in an inter-active medium. It is made up of a number of frames, (referred to as “cards” in Hypercard), which contain images and text. Each frame has a particular meaning and is connected to a number of other frames with related meanings. The way in which the story is revealed depends upon the sequence in which the frames are seen. No one sequence is more correct than any other. “Dominic” is not a puzzle about trying to find the correct route, nor does the sequence chosen affect the ultimate understanding of the story.
>
> I have been interested in using images, particularly images which appear to move to the viewer, as both a way of revealing meaning and a way of navigating through the work. In Dominic the viewer is first presented with pictures which he or she learns to manipulate by exploring randomly. The explanatory text is only available once the viewer has learned how to navigate around the work. As far as possible I have treated the text visually. The computer screen challenges the convention of reading text as if it were on a page. There is perhaps, in this application, a chance to break down the distinction between text and image.

> The introduction of an inter-active element into what might best be described as a fiction raises alot of questions. The author, to some extent, relinquishes authority to the viewer by allowing him or her to create their own route through the work. How far can this be taken before the work ceases to have any meaning? How far is a work of art defined by its form? And if the structures behind the work are hidden from the viewer can he or she be expected to comprehend its meaning? "Dominic" is not an answer to these questions, it is an attempt to suggest one way of using the exciting new medium of hyper-text.
> (Milner 88)

Graham Howard's work, mentioned in (A2.3), also made use of the Hypercard approach to information organisation and retrieval. In the work exhibited, the viewer was faced with two screens with arrays of photographic images displayed on them. By selecting a part of the image with a mouse the viewer initiated a sequence which played the sound of a camera taking a photograph, enlarged the chosen image on one of the screens and displayed text and further graphics.

On the wall behind the computer were large composite photographs of similar images to those on the screens.

Both Howard and Milner demonstrated how a commercial product, designed to enable people to organise and retrieve data in the form of images, sounds, etc., can be used creatively. The value of conventional interfaces, including hyper-media is discussed further in (2.3).

Milner raised the question of authorship and how far the relinquishing of authority can be taken before the work ceases to have any meaning. This is discussed further in (4.8.4) and (4.8.5).

In 1991 Paul Sermon was awarded a "Golden Nica" at "Prix Ars Electronica" for his work "Think about the people now" which used a Hypermedia approach on a Commodore "Amiga" computer (Leopoldseder 91). The work enabled people to explore a database of static and animated images, text and sound which addressed the events and media coverage surrounding the self immolation of a protester at the Remembrance Day Ceremony at Whitehall.

## *A7* *Misplaced Affection.*

This work, exhibited by Laura Kikauka assisted by Nancy Paterson, in 1983, and 1985 in an expanded version at the "A Space" gallery in Toronto, used household appliances and modified domestic furniture controlled by computer which responded to the presence of a visitor to the installation.

The work had an interesting way to control the duration of a participant's presence, a problem discussed in (2.1.1) and (4.1.1). The work demonstrated how computers can be used to control electric devices in the way espoused by Wilson (2.2.4).

The program had a random element built into it so no two encounters were the same. The following description is of what might typically happen.

The installation was entered through a door in what looked like the back of a stage set into a "shabby 1950s-style living room"(Kikauka with Paterson 87). A switch on the door sent signals to a computer and switched a group of mechanical toy dogs, stripped of their synthetic fur, which "welcomed" the arrival of the visitor. The work entered its "Welcome" mode with a piercing mechanical voice emanating from a sofa "commenting on the events taking place and conversing with the 'guest' much as a 'host' would"(Kikauka with Paterson 87). The components in the room, including lamp, clock, electric kettle and fireplace, could be activated in any or all of four modes. The TV screen showed text that revealed different attitudes to that of the voice. The installation used a voice synthesizer which pronounced phrases selected randomly from 100 pre-written into the computer.

The installation moved from the "Welcome" mode to one called "Technical/Consumer Love" in which the furniture rather than the visitor became the centre of attention. The TV set turned on with a car salesman yelling his pitch, the stereo played an album called "Music to Live By", the vacuum cleaner switched on and the voice from the sofa spoke about "incredible suction". Mechanical toy babies began to cry and crawl in their play-pen and were reprimanded for interrupting the "host":

> 'Buzz words' such as 'resolution', '64k', 'interface', are mentioned often; such words provide pleasure (technical love)

> to individuals who are talking about things they know little or nothing about. (Kikauka with Paterson 87)

The installation passed into two more modes entitled “Heavy Hint” and “Get Out/Rude or Crazy”.

In the “Heavy Hint” mode the tone of voice changed and phrases such as “one of these days you’ll have to stay longer”, were used to encourage the visitors to leave the installation.

If the visitor remained long enough the installation entered its “Get Out/Rude” mode in which the speed and pitch of the voice changed and the items in the room switched on and off “at a viciously fast and freakish pace”(Kikauka with Paterson 87). As the voice became increasingly inaudible and inarticulate:

> Any feelings of control over their experience or the system itself which the ‘guest’ may have felt, will have disappeared by this point.
> (Kikauka with Paterson 87)

Having “broken down” the system was reset when a new visitor entered the room.

The participation in “Misplaced Affection”, once the door had been opened, was dependent on the visitor realising that they were being treated as a guest by the “host”. It was clearly a programmed environment, but it addressed the visitor without the visitor being able to change events in the way they could in, for example, Krueger’s “Videoplace”. In its mode changes the work indicated, however, how the degree of control afforded to participants, whether actual or apparent, can be altered to give shape to a time-based work. Kikauka and Paterson took their cue from the theatre:

> *Misplaced Affection* is a performance in which the audience is invited to participate. To do so, participants need only be prepared to consider their perception of technology and the role it plays in their lives. The experience of the installation is related to theatre and the extended experience of time. Rosalind

> Krauss has said that, in a sense, "the entire range of kinetic sculpture can be seen as tied to the concept of theatricality". The transformation of space in a dramatic context and the projection of a sense of the sculpture itself as a character are evident in *Misplaced Affection* and contribute to the sense of interaction. (Kikauka with Paterson 87)

Kikauka also invited participation in a broader sense through her work, in a way that is reminiscent of more explicitly political works:

> From the comfort and security of 'anyone's living room', I ask the viewers of Misplaced Affection to remake technology, in their own image. (Kikauka with Paterson 87)

"Misplaced Affection" treated the furniture as actors in a drama that the visitor was subject to, but they could not change it, controlling only when it started and when it ended. The work did, however, demonstrate how a participatory work may be based in an actual rather than a graphically represented environment.

The degree to which a programmed work is part of the actual environment is discussed in (2.4.3).

The work also demonstrated how a work's behaviour can be programmed to change over time and how the duration of the piece may be controlled.

The idea of resetting work is discussed in (2.6.3).

## *A8 The Colloquy of Mobiles.*

For the “Cybernetic Serendipity” exhibition, Gordon Pask, Yolanda Sonnabend, Mark Dowson and Tony Watts produced an installation of computer controlled sculptures called the “Colloquy of Mobiles”, which Pask described as follows:

> It is a group of objects, the individual mobiles, that engage in discourse, that compete, co-operate and learn about one another. Their discourse evolves at several levels in a hierarchy of abstraction. The trick is that if you find them interesting then you can join in the discourse as well and bring your influence to bear by participating in what goes on. It is a crude demonstration of an idea that could be developed indefinitely.
>
> ...
>
> Each individual mobile has a set of programmes that determine its motions and its visible state. Each individual learns how to deploy its programmes in order to achieve a goal; namely, to reduce an inbuilt drive. Its level of ‘satisfaction’ is reflected partly in its behaviour and partly in a visual display. As a whimsy, we have called one sort male, the other female.
>
> ...
>
> Whereas males compete among themselves and so do females, a male may cooperate with a female and vice-versa, for one possesses programmes that are not in the repertoire of the other and jointly a male and female pair can achieve more than both individuals in isolation. Ironically, this property is manifest in the fact that a male projects strong beams of light but it cannot satisfy an urge to have them play on its periphery, whereas a female (who cannot shine light) is able to reflect it back to a male (and, when she is competent, to reflect it upon the right position). To co-operate or even to engage their programmes, the mobiles must communicate. They do so in a simple but many-leveled language of light flashes and sounds. You may engage in this discourse if you wish to, though your goals may be alien to the goals of the mobiles; for example, you might be trying to achieve a configuration that you regard as pleasing.
> (Pask 68)

That the assignation of male and female mobiles is referred to as “whimsy” is revealing as the implication of sexual roles for the mobiles along with their sparse mechanical appearance would otherwise invite a more serious comparison with Duchamp’s “Large Glass”, and the possibility of an allegorical interpretation of the work. In several of the works described in the following pages the artists responsible appear to prefer their work to be considered whimsical or playful. The contrast between this approach and that of artists like Ascott is undeniable and must have contributed to the dubious reputation gained by “Computer Art”.

The audience participation in “Colloquy of Mobiles” was not essential in the sense that the mobiles would continue working without audience intervention, but participation was possible.

Pask described the work as an attempt to go one step further in the direction of active and reactive environments that have a property he described as “aesthetically potent”:

> An ‘aesthetically potent’ environment is an environment of any sort (auditory, as in music, verbal, visual, tactile perhaps) that people are liable to enjoy and which serves to shape their enjoyment. (Pask 68)

The simple equation of aesthetics with pleasure and enjoyment seems to lack rigour in the light of other work that has been pursued in art discourse, but the popular equation of beauty with art persists and is often used to justify the classification of work as art.

The character of the mobiles as male and female referred to behavioural differences of the machines more than to any similarity to the humans who could join in the formal conversation. The human’s contribution was independent of the “sex” differences of the mobiles or those of the humans. The mobiles were more strange pseudo-animals than robotic replicas of human beings. The kind of participation possible to the human participant was to fulfil the role of one of the mechanical partners in a communication by directing light; the mobiles would respond to the human as they would to each other. This type of participation is discussed further in (Bell 90) and was explored in the development of Smallworld discussed in chapter 3.

## *A9 Feeling the Data.*

When one considers the importance afforded to the contribution of participants in these works it is surprising how seldom participants' responses are recorded. Norman Baumann, writing about the work of Nam June Paik in the catalogue of "Cybernetic Serendipity" did, however, record his impressions, for as he wrote:

> While there is no answer [to the question "what does it all mean"] beginning with 'The meaning is ...', a few observations may make this kind of art more comprehensible. (Baumann 68)

"Tango Electronique", referred to by Baumann, consisted of a changing image on T.V. screen:

> You turn a knob and the screen explodes into patterns. After a while you get a feel for it, and are able to control the image. (Baumann 68)

> In the first place, it is a responsive environment. Unlike ordinary art exhibits and ordinary television sets, here the observer can actually touch things and make it the way he likes it.
> (Baumann 68)

> Some of his more complicated machines, such as *Tango Electronique* are more like musical instruments than artworks. You don't watch it you play it ... Passive art is a real threat to our culture. If the viewer does not enter into art, he cannot possibly hope to understand it. A major thrill of Mr. Paik's exhibit is pushing the button yourself, and knowing that you made that little blip there ... (Baumann 68)

Baumann's comparison of the work to musical instruments is interesting, particularly in the light of observations which would be made later by Krueger regarding the composition of participatory work (Krueger 83). This idea is discussed further in (3.7) and (4).

In another type of Paik's work, visitors to the exhibits could use magnets to distort images on T.V. screens.

> Get the feel of magnetic fields! What are magnetic fields? Something that everybody knows about from textbooks, but that nobody has a feeling for. Before I used a Paik T.V., I did not believe, despite all my physics, that magnetic fields really deflected electrons. A television set was one more black box: WARNING! Do not remove this cover! The feeling of holding a magnet in your hand, and seeing a visible, striking result, must be experienced to be appreciated. This is not chickenshit iron filings, but a real, living, breathing MAGNETIC FIELD, that you can really use to deflect real, live, glowing electrons. (Baumann 68)

Baumann wrote of the complexity of the patterns, affected by other instruments in the room etc. :

> Whilst it is possible to completely analyze these patterns in the traditional way, I would expect such effort to end in either frustration or in such complexity that it is impossible to observe any relation between the analysis and the feeling that you get when you look at it. Nikolai Rashevski once described the inconvenience of describing an animal in cartesian equations. 'When the dog wags his tail; what happens to your equation?' When you learn to play on a Paik T.V., you are forced to see these patterns of technology in terms that are different from those you learned in physics. Your electronics will make it more enjoyable, but perhaps you will learn that you can't impose a traditional scientific order upon everything. In art as in the world! (Baumann 68)

Baumann's reference to the inconvenience of describing an animal in cartesian equations is amusing when one considers how much time and effort is being expended working out how to animate 3D computer graphics of animals and humans. With regard to participatory works his comments on being able to 'get the feel' of magnetic fields and to control their effect without having to analyse them is significant and discussed in (2.7.5) (3.5.1) and (3.7.1).

## *A10 Artists working at The Slade in the late 1970s.*

The ideas in Smallworld were influenced by the work of the following artists, all of whose work reflected a “programmed worlds” approach to using computer technology in art practice. Their work did not include human-program interaction, but all their works included the interactions of autonomous agents, modules, or cells.

Chris Briscoe’s agent’s interactions with each other were based on rules derived from the physical effects of gravity. The effect of these agents on each other were plotted over a period of time. some of the changing values related to the automata in Briscoe’s work were also used to control sound-generating devices.

Crabree’s agents were depicted as animal-like inhabitants of an environment of tree-like growths. In a series of cartoon-strip like frames the interactions of these creatures; changing positions, consuming each other etc., could be observed.

Sullivan’s work dealt more with cellular automata of a kind similar to those in Conway’s game of life (Gardner 70). Sullivan was interested in the kind of effect that animating the changing state of these automata on film could have, and in developing much more complex algorithms related to natural phenomena like tree growth.

Peter Beyls, an artist whose work “Oscar” is described in (2.5.2), was a student at The Slade in the late 70s. There is a visual similarity between his “L & H” works (Beyls 86) and the “Space Game” (Figure 3.1.3.b) reflects a similar interest which in the ensuing years has led to some remarkably similar ideas; Beyls uses “Actors” (Beyls 86) in a similar exploration to that pursued in the development of Smallworld’s “Animals”.

Paul Brown, also a student at The Slade in the late 70s, had developed a participatory work which involved placing computer-drawn tiles of a giant puzzle together to make Celtic-like knotted patterns (Lansdown 78).

## *A11 The game as art form.*

In 1988 Michael Thomas wrote an article in Leonardo about the use in the twentieth century of the game as an art form. Games are a long established form of human-human interaction that, although not usually immediately associated with fine art, are regularly used as a means of ordering audiences' involvement in participatory works. As, for example, in the works of Cornock and Edmonds (A12).

Thomas traced the history of "the game as art" to Marcel Duchamp, who wrote:

> A game of chess is something plastic. You build it. It is a mechanical sculpture. (Arman 87)

> In chess there are some extremely beautiful things in the domain of movement, but not in the visual domain. It's the imagining of the movement or the gesture that makes the beauty in this case.
> (Cabanne 71)

Thomas also indicated the relationship between chance used in games and Duchamp's "Three Standard Stoppages" - standards measurements used in the composition of his works made by dropping three lengths of string onto a glued surface from a height of one metre.

The actual practice of Duchamp can, in Thomas's terms, be seen as game-like:

> The anti-artist presents his or her work as a 'move', cast not as an artistic statement but as a question: "is this art?" The viewer then makes a move either by accepting the object as art or by setting forth his or her opinion on the extent to which it is art. Such a situation lends itself to a two-party discourse on the nature of art, reminiscent of the players interacting in a game format. (Thomas 88)

Thomas also drew attention to the work of Öyvind Fahlström:

> Fahlström created variable metal paintings to which small elements, such as pictures of figures or objects, were attached by magnets.
>
> ...
>
> Fahlström described these works not as paintings but as machinery to make paintings.
>
> ...
>
> Fahlström's work developed into the variable paintings ... and, later, into stand-up plastic figures that were set on tables and rearranged. Ultimately he enlarged these into life size figures and objects and then arranged and rearranged them in room installations.

Although it was colourful and game-like, Fahlström was able to address his works to serious political issues such as the activities of the C.I.A. and World super-powers.

Thomas identified works by several other artists working in the 1960s and 1970s who investigated the game as an art form. He concluded that taken together the work of the artists he described constituted a recognisable art form and identified art made using computer technology as providing "the most powerful potential of the art game today":

> The game as art has the potential of becoming an accepted fine art form, and yet also shows promise as a folk-art form. More and more people are buying computers for private use and utilizing them for everyday purposes, including computer games for pleasure. As more people learn how to program. more can begin to invent their own games. In fact, software for inventing games is already available on the market. (Thomas 88)

The significance of Thomas's observations regarding the potential of computer technology to game-as-art can be seen in Smallworld, where the war-game was used as a model for structuring participatory work (3.2.2.v). The immediate significance of the relationship between computer games and participatory works is discussed in (4.1.9).

## *A12 Cornock and Edmonds.*

### *A12.1 Interplay.*

Cornock and Edmonds illustrated their 1973 paper by describing “Interplay”, a project in which the computer played a management role:

> ‘Interplay’ involves the design of an environment that would establish a strong interaction among a group of individuals who have no prior knowledge of that environment and where that environment would not contribute any programmed information (entertainment) to the individuals present. The situation is organized as a system that is able only to respond. In order to respond, it is necessary for the system to apprehend and, to this end, it was equipped with an array of sensors. A given input via one of the sensors may lead to a given output or combination of outputs in sound and light. ‘Interplay’ is, in effect, a large colour and sound organ where the keyboard is represented by the topographical floor surrounded by an audio-visual envelope. ... The movement of people on a sensitive floor was to cause changes in the illumination of a domed ceiling (15 meters in the diameter) above them ... A given input would result in a given output. (Cornock and Edmonds 73)

Cornock and Edmonds anticipated that a tendency to seek order would assert itself:

> ... leading to the establishment of control and communication within the group for a limited period.
> (Cornock and Edmonds 73)

The project was similar to Myron Krueger’s work “Metaplay”, described in (A1.2). The use of the idea of the artist making an instrument to be played is discussed further in (4.1.5) and the major implications for participatory art that can be drawn from the similarity are discussed in (4.1.6) to (4.1.8) and chapter 5. The tendency to seek order is discussed in (2.3.3).

## *A12.2 Play as a route to creativity.*

Cornock and Edmonds considered play a positive route to creativity.

> To encourage these tendencies the inputs in the 'Interplay' project are processed by an on-line computer so as to amplify them ... We would therefore consider this system as one leading to amplified play situations that are potentially creative. (Cornock and Edmonds 73)

The relationship between art and play has been discussed by Dissanayake (Dissanayake 74) and is discussed further with respect to participatory work in (3.2.2.v). The formalisation of play in participatory works making them games with rules is discussed in (4.1.9).

Another work described by Cornock and Edmonds was "Datapack":

> Our 'Datapack' (1969/70) art system is an example of a matrix that consists of participants, a display, a computer installation and a designated area around the Vickers building next to the Tate Gallery in London.
>
> ... This system is organized so that the participants are involved in three phases: (1) the initial contact with the display (explanations and instruction), (2) the use of a computer terminal and (3) possession of the output from the terminal in the form of a drawing by graph plotter of the Vickers Building in two elevations, against which (in different colours or line thicknesses) are plotted volumes of air space ('sculptures'). The number, shape, size and disposition of the 'sculptures' are determined by the interaction of the participant with the computer. The final output, including the typed record of the interaction or 'conversation' and explanatory material are presented to the participant in a transparent envelope. (Cornock and Edmonds 73)

Again the interaction was considered in terms of a game; The significance of the game was in the process which the participant was involved in:

> ... and in the concepts formed by the individual concerned and not in the aesthetic merit either of the intentions of the designers of the art system or of the designated volume of air space. ... the burden of the exercise lays with the individual and his own conceptual behaviour when confronted with the art system using our chosen matrix. (Cornock and Edmonds 73)

Cornock and Edmonds were interested in their paper in the conceptual side of the work over and above the phenomenological side. Their particular contribution was of a way of representing and discussing the position of the computer in a work.

Cornock and Edmonds included in their argument the idea that the work must have an overt complexity to have human value.

In their terms, the participants in a dynamic situation or matrix should be involved in a problematic thought process. This is supported by Malone's findings, discussed in (4.1.7).

## *A13 Nouvelle Tendance.*

Popper discussed the work of the group Nouvelle Tendance in (Popper 75). Reproducing an introduction to an exhibition written in 1964 by Karl Gerstner, who had been working on "do-it-yourself" pictures since the early 1950s.

> What does Nouvelle Tendance aim for? Our aim is to make you a partner. Our art is based on reciprocity. It does not aspire to perfection. It is not definitive, always leaves the field open between you and the work. More precisely, our art depends on your active participation. What we are trying to achieve is for your joy before the work of art to be no longer that of an admirer but of a partner. Moreover art does not interest us as such. It is, for us, a means of procuring visual sensations, a material which brings out your gifts. As everyone is gifted, everyone can become a partner. (Gerstner 64)

In 1963 the Groupe de Recherche d'Art Visuel had written in a manifesto:

> We wish to put the spectator in a situation which he initiates and transforms. We wish to develop in him an increased capacity for perception and action. (Barret 74)

This didactic intent to transform and in some way enhance the spectator's capabilities continued throughout the 1960s and echoed artists' involvement in agit-prop activities in revolutionary Russia. Some artists intended to enhance people's political sensibilities by placing the participant in a similar situation to their own, some to enhance their artistic sensibilities. Some clearly intended to do both. The matter of participant skill is discussed in (4.1.6).

### *A14 Chico MacMurtrie and Rik Sayre.*

MacMurtrie and Sayre received a Distinction for their work "The Tumbling Man" at "Prix Ars Electronica" in 1991. Their piece consisted of a humanoid pneumatic robot which could be controlled by two participants. The participants wore suits which registered their movements and a program interpreted these movements to affect the actions of the robot.

The piece involved communication between the two participants as they each had only partial control over the robot's limbs; the participants had to cooperate and coordinate their movements to get the robot to do what they wanted it to do.

MacMurtrie received an Honourable Mention for another of his works in 1990. "The Trees are Walking" a complex installation which included several pneumatic robots. The work could be used for performance or could be triggered into action by audience participation. One of its features was the release of pleasant or unpleasant smells at appropriate moments.

## *A15* *Very Nervous System.*

David Rokeby was awarded a Distinction at "Prix Ars Electronica" in 1991 for his work "Very Nervous System". A sound installation in which changes in the field of view of a video camera are interpreted by a program which responds with sound. The system was such that repeated input would lead to the same sound being repeated. The immediacy of the feedback of the system was such that after a short period of involvement, participants could find it hard to discern whether the movement was controlling the sound or the sound encouraging particular movements.

The relationship between feedback and degree of control in this work was thus remarkably ambiguous. Rokeby stated:

> The installation could be described as a sort of instrument that you play with your body, but that implies a level of control which I am not particularly interested in. I am interested in creating a complex and resonant relationship between the interactor and the system. (Rokeby 91)

## *APPENDIX B: Slides of images produced using Smallworld*

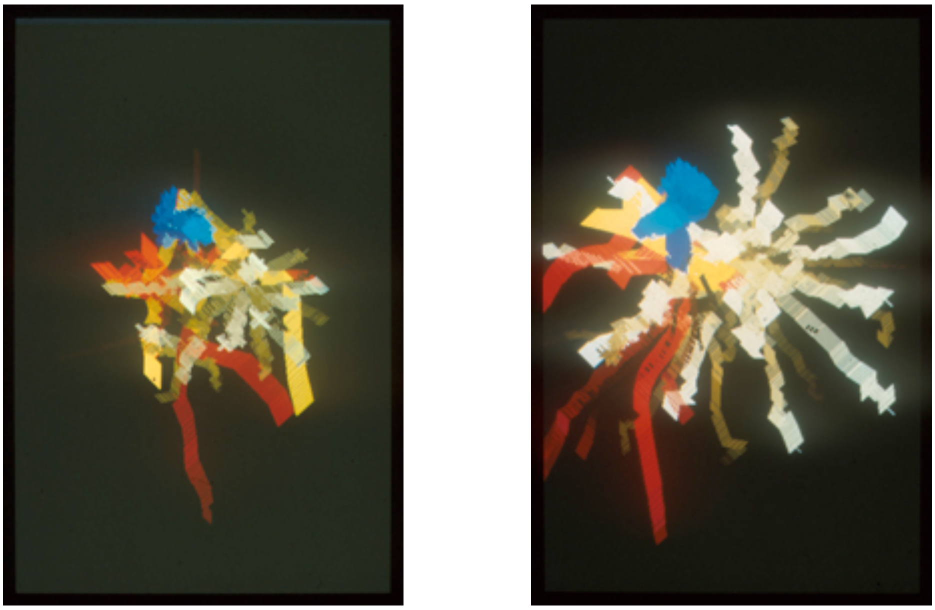
### *Note*

The original Thesis included 25mm colour transparencies, represented here in the following prints. 

B1 – B5 Are examples of images exhibited in 1985 at The Gulbenkian Theatre, Canterbury; the Drafting Design and Graphics Exhibition, Olympia, London; and the Ikon Gallery in Birmingham. The work consisted of colour photographs of static images taken for a computer graphics screen.

B1

Six Predators (red trails) chase and 'eat' their prey



B2 and B3

Similar starting points for various species generate different trails over the same 'time' (number of iterations of the algorithm). The different movement rate of the red species in B2 and B3 causes different shapes to be generated.

B4

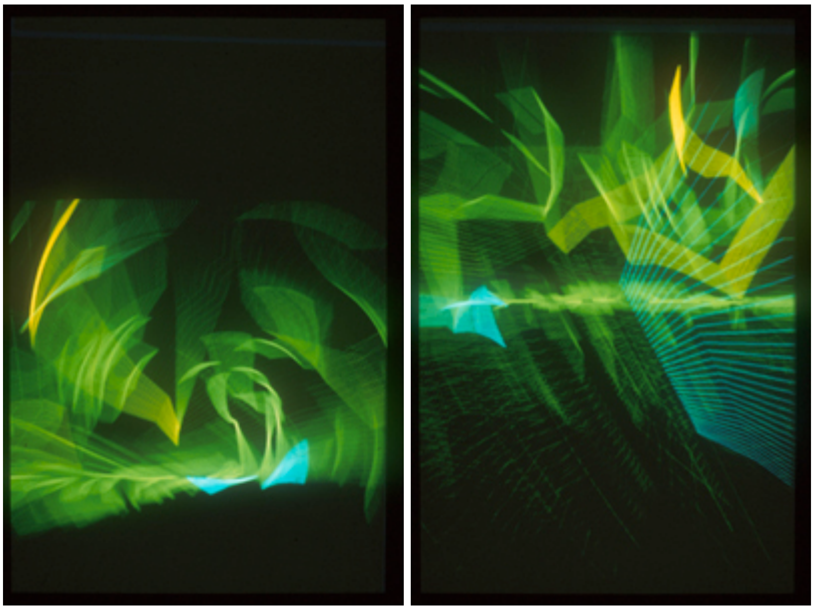
B5

As in B2 and B3, using the same starting locations but changing the movement rate of species.

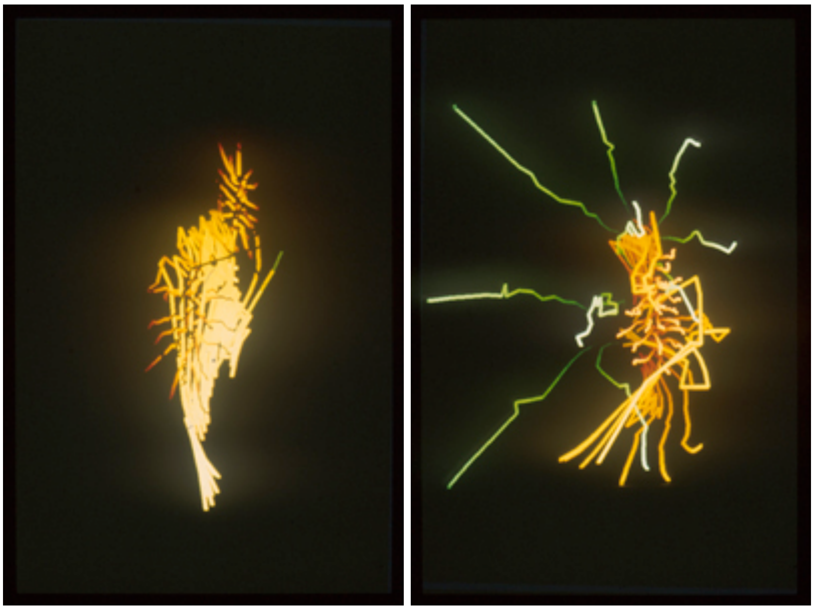
B6

Combining the two shapes on the left to create the shape on the right. A simple depth-cueing colouring technique reveals the 3D nature of the trails

B7 – B10 are examples of prints exhibited in Brighton at the 1987 World Science Fiction Convention.

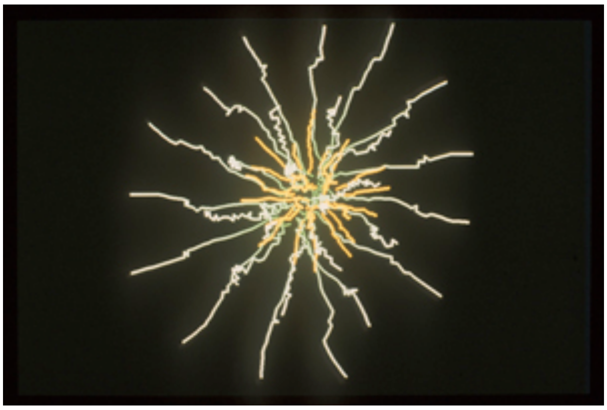


B7 and B8
Time exposures of Smallworld shapes

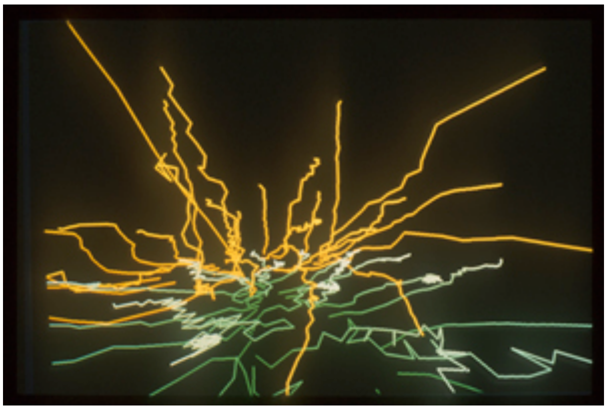


B9 (Prospero) and B10 (Caliban)

Shape generated by visitor to Brighton exhibition

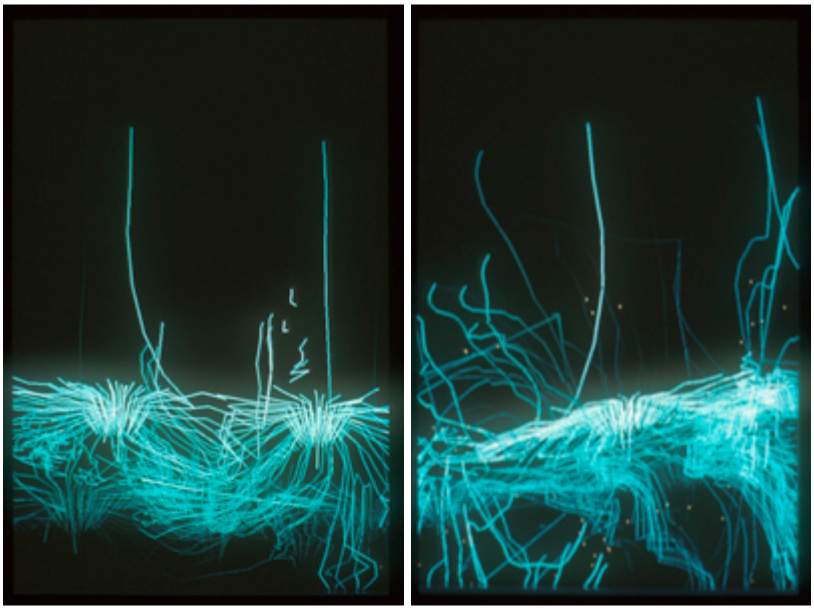


B11

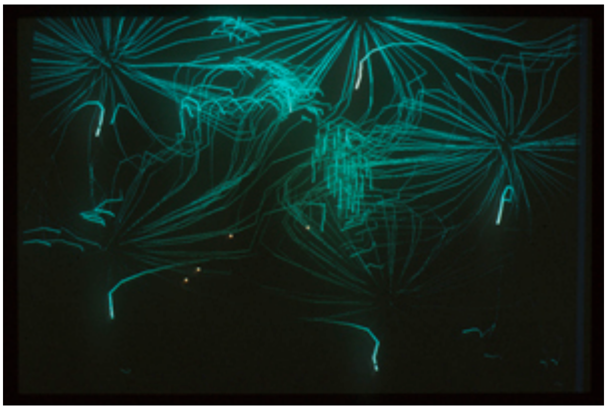


B12

B12 – B14 are examples of prints exhibited in 1989 at the Pilkington Library, Loughborough University of Technology



B12 and B13



B 14

# APPENDIX C

This appendix was originally submitted as a videotape.
The following information was printed for the box containing the tape.

## Smallworld Documentation

An appendix to ‘Participatory Art and Computers’
A Doctoral Thesis submitted in partial fulfilment of
the requirements for the award of Doctor of
Philosophy of the Loughborough University of Technology



**Smallworld Documentation. PAL. 25 Minutes. No Sound**

00.00 PLANT and SWORLD programs exhibted in ‘Art and Industry’ at Imperial College London, 1986

02.40 The MOVIE program, 1986

03.16 PLANT, SWORLD and ZOOMWIND programs exhibited at ‘45th World Science Fiction Conference’, Brighton, 1987

06.55 TRACK program 1987

07.55 SIRIOR shape generated by visitor to Brighton Exhibit 1987

10.44 PLANT, DEPTH and FIRE programs exhibited in ‘Art and Computers’ at the Cleveland Gallery and Jarbeurs Centre Utrecht, 1988

13.37 FIRE examples

16.39 Version of PLANT, DEPTH and FIRE programs used for ‘Smallworld Vistas’, Loughborugh University of Technology 1990.

19.23 Flocking and CGAL animated experiments shown at ‘CG 90’ conference, London, 1990

**Software:** Smallworld - S.C.D.Bell; CGAL - Prof. P. Comninos
**Hardware:** Silicon Graphics IRIS 2500 Turbo and 3500, Apollo DN 10,000