Chapter Seven

Arts and the New Technologies

In a world moving rapidly along the edge of chaos, it is predictable that new art forms will emerge from new technologies. It is predictable also that in large measure their forms cannot be predicted.

Most of us are not knowledgeable even about current technological advances as they affect the arts. For us, now is as much the future as is 2010AD, so there is reason for this study to look at the *present* state of technology as it might be relevant to the arts. In any case, if many of the future developments are inherently unpredictable, this ground will be firmest we can find.

The arts have passed through various popularly understood technologically driven upheavals during the century. Sound recordings, film, radio and television have changed radically the ways we live our cultural lives, but nevertheless are media which in their most popular manifestations have been used primarily to represent live performances of music or theatre in a more or less naturalistic manner. Most of the new forms continue on from hand-crafted forebears. In the practice of the popular arts, the computer screen is not taken as *tabula rasa*.

When the use of these popular forms is not governed by the commercial imperative of catering to a mass audience, they have been the platforms for artistic experiment which may have nothing to do with naturalism or representation. Much of the technological and even artistic innovation has arisen from popular art forms, and maintains its identity with them. Other innovation follows from high arts practice and so is purposefully iconoclastic, in the sense that it looks to exploit the new media in their own terms, rather than attempt to push them into the mould of preceding traditions. This does not mean that there is, or even could be, a total break with the familiar. But in some instances, the re-conception of artistic procedures and the parameters of expression and meaning is of an order which brings significant discontinuities with the past.

Some difficulty was experienced in deciding a structure for this chapter. Logically, it would be convenient to deal first with the use of new technologies to assist in traditional forms of expression, and then to look at new forms engendered by the technologies. It was quickly apparent that there is no neat division, and an account of interesting lines of development would be chopped off arbitrarily only to be picked up later when the connections have been lost. On the other hand, to follow developmental lines within an art form could lead to difficulties in describing the many cross-disciplinary innovations. Nevertheless, the latter seems a more serviceable approach and so we deal firstly with developments by art form.

Music

It is in music that the effects of electronic and computer technologies probably have been felt most strongly and have been the most diverse and elaborate. Certainly, there is no style or form of music which has been untouched. Some of the consequences are now so familiar that readers might be surprised to be reminded of them. They certainly will not be news to musicians. Other consequences are known so far only to the experimenters. Some approaches to musical creation are radically different from any heretofore, and point up fundamental issues that will arise from use of the computer for arts production. This account will look at the accumulation of these changes, familiar and

unfamiliar, to show the enormous shift in some of the fundamental premises of the art form and the expectations of its practitioners and audience.

Recording. Sound recordings of music became available to the public a century ago. They were made through the mechanical capture of sound waves, translated into mechanical movements of a stylus which cut a shaped groove into a soft wax cylinder. To replay the music, the process was reversed, with movements induced mechanically as a stylus ran the length of thre groove translated eventually into sound waves. The sequence is comparable in current technology, except that sound waves are transformed into digital signals and vice-versa.

The progression of recording technologies has brought increasing fidelity to the original sound sources. Digital recording has eliminated the blemish upon fidelity resulting from the mechanical operation of recording and playback equipment; when there is no intentionally recorded sound, there is virtually complete silence. And all the sounds received and digitally encoded in the recording process will be transmitted into the record player in their complete detail. The current controversy comes from those with acute hearing who observe a certain infidelity and hard edge to digital CD recordings compared to analogue LP recordings. Analogue recording captures the entire continuum in the spectrum of pitches, but digital selects from it. The digital sound image might be compared metaphorically with a newspaper photo or television image, made up of thousands of dots which the mind must reconstruct into continuous images. An analogue sound image is like a fine grained photograph. A market is reappearing for LP analogue recordings, both for sound fidelity and because of their use by dance DJs. With the development generally of niche audiences in a global market, the future might see some restoration of production of analogue recordings and valve amplifiers upon which to play them. There is now a tiny market for the amplifiers. Alternatively, digital recording so fine-grained that the advantage of analogue is lost, may become available.

The increasing fidelity of the recorded sound is of course not simply a function of the reproduction equipment, but of recording equipment and the techniques of using it. Commonly in the recording of popular music, each instrument is recorded separately, and those separate tracks then can be modified individually in the creation of the final mix of all the sounds. With digitalisation, editing of the tracks can be extraordinarily precise, with the sound at any exact instant available for removal, substitution, or modification of any sort. This means that the producers and editors of a recording become equal partners with the musicians in the production of the artifact which eventually makes its way to the stores. While the recording of large aggregations like orchestras or choirs does not customarily use microphones in the same way, the editing is again able to effect very exactly conceived modifications on the original tracks.

The performance found on the released orchestral recording can have a perfection impossible to achieve in live performance. The live and relatively unassisted performance heard in a live popular music concert might be so much cruder in quality than that on the recording, that sometimes a band will maintain the illusion by miming to a replay of the recording. (This line of development reached its apogee in the Milli Vanilli affair, where it was discovered that a popularly promoted singing duo sang neither in public concerts *nor* in the recording studio. The recorded voices belonged to unaccredited others. What's wrong with that? the recording executives must have thought. In one of the Great Defining Moments of the Species, a new moral imperative emerged and Milli Vanilli disappeared forever from the trading statement.)

These developments have a couple of divergent effects. For some, the availability in the convenience of their living room of perfect recorded performances has resulted in a disinclination to venture out for live performances. Since the perfection is likely to be further enhanced with even greater fidelity, 3D sound (see below), and integration with visual images of increasing scale and verisimilitude or ingenuity, listeners of this persuasion will be confirmed in their inclinations.

Others miss the spontaneity, vulnerability, human-ness - the mistakes, in fact - of the unedited performance. It is interesting that ABC Classic FM finds that its ratings go up when it advertises a broadcast of a live performance, especially if it is believed to be broadcast from and at the exact time of the performance.

We can only conjecture about the balance between these two populations of music listeners, and the significance for the future. If the first prevails, questions follow about the viability of aspects of music performance which now depend financially on box office, such as performances of orchestras and opera companies, and the great majority of popular bands which are not sustained from record royalties.

Forty years ago the first stereophonic recordings were released in Australia. The writer is old enough to remember his first experience of stereo sound. It was a revelation akin to moving one's gaze from a flat photograph of a scene to the three-dimensional reality. New techniques are creating a further development in three-dimensionality. There are still problems in devising sufficiently consumer-friendly techniques for bringing 3D sound into the living room, but it should be expected that these will be solved in the medium term.

Spatial placement of sound in a normal stereo system is along an imaginary flat line between two speakers. The listener locates the position of a flute, say, by the relative loudness of the two speakers. Illusions of greater or lesser distance from the listener are created by resonating time and the loudness of sounds with respect to each other. All the sounds are heard from the direction of the speakers.

In 3-D sound, the listener hears the sounds as though they are coming from sources in every or any direction, and if the artist wishes, moving around in any configuration. There are two basic methods of achieving 3-D sound. One is to actually place speakers all around the listening area, on different planes both horizontally and vertically. The other depends less upon a multiplication of sound sources - and indeed can be made to work on the old stereo speakers - and more upon tricking the brain’s sense of directionality using new knowledge of the physiology and psychology of hearing and of computer technology.

Results have been best when the listener uses earphones rather than speakers; since in the latter case both ears can hear both speakers, there is some confusion and blurring of apparent spatial placement. However, newer techniques have been able to counter this "crosstalk" and so speaker listening now begins to rival the effect through headphones - and of course for most people is much more convenient. There has been some use of these techniques in popular music recordings for replay on ordinary stereo systems. For the most part they have not been especially successful because they have not been sufficiently thorough.

This psychoacoustic process involving two speakers is more suited to domestic use than to use in large performance spaces. Kimmo Vennonen of the Australian Centre for Arts and Technology (ACAT) in Canberra is among those who have been working on multi-speaker systems. ACAT has a geodesic dome in which a 16-speaker system has been installed. The speakers are distributed around the zone at three levels, with ten speakers near the base of the zone, one at its

zenith, and five midway between. There have been several generations of thinking about how to use this system. The current one combines psychacoustics with techniques "of encoding an infinite number of sound directions into a limited number of channels, and then decoding to a given loudspeaker layout on playback." (Kimmo Vennonen: "A Practical System for Three-Dimensional Sound Projection". Proceedings of *Synaesthetica '94*, Australian Centre for Arts and Technology, ANU, Canberra 1994) The system works with as few as four channels, but the sense of directionality would be more precise if more channels were available. It works best in a acoustically dead chamber so that the directionality is not confused by the reflection of sound from points distanced from its source. The potential of this system has not been worked through fully. On the basis of one hearing, the writer can offer the view that despite the generous array of speakers the sense of directionality is not comparable yet with that experienced in nature.

Film showings in cinemas often make rather awkward use of 3-D sound and there is a commercial potential for more successful solutions. Since much of the most commercially successful film depends on the richness of effects, it might be expected that these systems will be refined in coming years. (It is interesting that research into videophone systems has found that people's perception of video quality was related strongly to the audio quality.) Cinemas also offer the opportunity for composers to incorporate directionality and movement of sound as structural components of their work. Vennonen offers some guidance in the techniques of doing so.

The duration of the music held on a recording has influenced the art form. It has increased from around three minutes per side on the 78rpm discs of fifty years ago to around 20 minutes on LP to 75 minutes on CD. The three-minute side produced a popular song form of that duration. The advent of the LP removed the three-minute limitation and longer songs or song arrangements began to appear. However, a lot of pop songs still follow in the early tradition. On the other hand, the possibilities for non-stop music on the long-format CD and as generated indefatigably by computers come together in a new aesthetic at dance clubs and parties where there is no pause in the music for hours on end.

Presumably someone at Phillips decided that a duration of an hour or so was right for the market, since it would not have been difficult extend it by adding a centimetre or so to the CD radius. Now the CD format has won the market, there is lock-in of CD dimensions. Digital compression techniques would enable an increase in duration, but only at the expense of fidelity. Researchers in Europe are working on a compact disc with four layers of information imbedded at different distances below the surface, each separately readable by changing the focal length of the laser. Presumably, such a disc would accommodate about five hours of recorded music. One might conjecture however that Phillips was right: this is more than the market would want. While the space can be used for any digital purpose (e.g. all the Beethoven symphonies or most of a techno dance party on one disc, or a more fine-grained aural fidelity), it is more likely to be used for a combined audio and visual presentation, or for interactive CD-ROM discs.

The record industry believes that it achieves its highest sales when it offers two formats, e.g. LP discs and cassette tapes. The value of the cassettes is that they are unaffected by movement of the playing device and so can be used in automobiles and Walkman-type devices, and users can record onto them, albeit with a loss of fidelity. The advent of the digital CD saw the demise of the analogue LP, but there has been no commercially successful digital replacement

for the analogue cassette. Cassette sales are falling. The DAT format tape cassette was technically satisfactory but has found only a small market within the recording and broadcasting industries. It is no longer seen as a mass market prospect. The record companies have attempted to introduce a commercially successful second digital format and two consortia of companies are competing: one with a digital cassette and the other with a digital disc, both of which can be used by consumers as recording devices.

The musical world has been anxious about the success of these formats: on the one hand, if they fail it will be at cost to the record companies; on the other hand a success might be even more disastrous. Consumers will have a device which allows home recording from commercially released digital recordings with absolute fidelity to the original. The loss of record sales could be dramatic. This would be bad news not only for the record companies but possibly could destroy the economic viability of the music sector as we now know it.

It appears that everyone can relax for the moment. The more heavily promoted cassette seems to have had sales of less than 10,000 in Australia for the nine months to September 1994. In the same period, 428 mini-discs were sold. The news from overseas does not indicate any surge of support, and it seems that these formats might be doomed - a failed top-down intervention without bottom-up support. One can predict therefore that into the medium term the preferred format for high fidelity music will be the CD, and that home taping will be to analogue cassette for use mostly for mobile listening. One could guess that digital home copying will eventually use the personal computer.

Amplification. Many of the technologies developed for recording have been applied to the use of amplification in public performance. Fifty years ago dance bands played without amplification, excepting perhaps for a microphone and loan of the public address system for the singer. Now every instrument has a separate channel by one means or another into a mixer which is controlled throughout the performance by a sound technician, performing in real time much the same function as a record producer in a studio. The sound mixer, not the musicians, will determine the balance between instruments at any time, and can modify the sounds they make, e.g. through addition of reverberation or even edition of tonal quality. With this has come an escalation in the loudness levels at live performances of popular music to the point where there is evidence that a large proportion of the younger generation of listeners - not to mention musicians - have substantial hearing damage. Presumably this is an escalating cycle since the hearing-damaged need even more decibels to achieve the same apparent loudness. Perhaps we are seeing an evolutionary preparation for a comfortable life under the flight path.

Amplification was once a means of making soft sounds audible in large spaces. Then it became part of the essential aesthetic of rock music. Through the ubiquity of rock music, which can be played very loudly through ear-phones or car or living room speakers as well as in a performance venue, there seems to be a generalised expectation for louder public performance. A folk musician with acoustic guitar departs far from the campfire asethetic to be amplified just short of the threshold of pain. A recent opera by Australian composer, Michael Smetanin, was so loud in public performance as to bring complaints from some audience members. But the music director, Roland Peelman, believes that Smetanin understands the times and that such a loudness level is now in its own right a part of the current musical aesthetic.

There is now routine amplification of the pit orchestras for musicals, allowing for instance the use of a string quartet instead of a string section. In opera a certain

amount of surreptitious amplification, especially of the orchestra, is not unknown but pains would be taken to ensure that it was not discernible. The leader of one of Australia's best known orchestras speculated to the author about the desirability of amplifying the orchestra in public performance so that the volume and sound mix would replicate its sound on recording. Such a proposition made public would be seen by many as an outrageous betrayal of the orchestral aesthetic. But he believes that there has been an inversion of audience expectations: once it would have wished a recording to accurately reflect the live performance, now it would prefer that the live performance mirrors the recording. It is difficult to predict where this trend will take us over the next fifteen years, but it seems more likely to extend than reverse.

Broadcasting. In the early days of radio broadcasting, radio stations maintained their own bands and orchestras. The advancement of recording technology soon brought this to an end, and in Australia only the ABC symphony orchestras survive as evidence of the beginnings of broadcast music. As we all know, radio broadcasts of music are now almost totally from disc. The recording and broadcast industries are coevolutionary partners, despite their recurrent warring over who is serving whom and who should pay for what. The record companies produce the discs which can be broadcast, the broadcasts produce sales for the record companies.

The relationship will continue with the growth of narrowcasting and audio on demand: the two industries are essential to each other. What is more in question is the likely nature of free-to-air audio broadcasting if user-pays services take care of the interests of special interest users, the financial limits on diversity of user-pays services, and the nature of our shared audio culture in the light of these outcomes. These matters were addressed in the previous chapter.

Music has always had a place in television programming, albeit an uncomfortable one because as an aural form in a visual medium it is not particularly interesting. The attempt to solve this problem and capture the massive popular music audience for television resulted in the video clip. Although music and visual art have been combined for decades in film, the video clip could claim to be a new art form. Each clip is a work in itself, the visuals are often abstract or surreal, at best original in style and content. Indeed, one could speculate that, with the audience expectations comforted by familiar and formulaic music, the visuals are freed to attempt almost anything. The form has fed back into live performance, even outside the pop industry, with for instance various music theatre works written and produced in the style of the video clip as a quick succession of short takes.

Combined effects. Recording, amplification and broadcasting technologies are in themselves neutral on questions of content. But their development has had profound effects on the art form of music and on its audiences.

Performers once could reach only the audience within earshot of the natural sound - a few thousand people at most. Now a performer could in theory be heard almost simultaneously by everyone on the planet. It is relatively commonplace for musicians to perform live for an audience of 100,000. It is routine for a single music broadcast to be accessible simultaneously to tens of millions of people. Satellite broadcasts could stretch that to hundreds of millions or billions of people. The multinational record companies have distribution systems covering continents and the most successful popular music recordings can sell millions of copies across borders and cultures. If the communications highway is of sufficient

quality, a massive repertoire could be available on demand from the personal computer.

It is to the advantage of profit-motivated record and broadcasting companies to build a mass audience for a limited popular repertoire. Success in doing so has led to the emergence of multinational record companies that have been able to shape and feed demand across the Western world and a good part of the non-Western audience also. The motivation to reach as large an audience as possible with as little material as possible leads to the promotion of music to appeal to a low common denominator of musical understanding. Since adolescents are a very strong segment of the paying public for this music, the repertoire also plays to inexperience. The music in the event may have fine qualities, but the marketing imperatives are directed to other ends.

As noted in Chapter 3, Australian popular musicians have been successful in this international market, usually via adoption by one of the five major multinational record companies with operations in Australia. The success comes with conditions. A band intent on even a local success rather than on following only its own artistic light cannot afford to be too iconoclastic. It has to find a voice that distinguishes it from the competition but does not put it too far outside the narrow limits of audience expectation. Transferred to the international realm, this adaptation to the audience can be seen as a disbandment of that which makes it distinctively Australian (if there is such a thing). This is an area of contention in music as it sometimes is in film. In sum, for *popular* Australian popular music the development of recording and broadcasting technologies has opened commercial opportunities but probably has applied stylistic constraints.

The strength of the multinationals' promotion of rock and popular music is seen by many in the non-Western world as a sort of Western cultural imperialism (see Chapter 8). Whether this ascendancy of a single style (with variations) of music will continue is a matter of some conjecture, here if not in the industry. It is said that interest in rock music has been flagging. People are waiting for the emergence of the style to replace rock. This was the paradigm in classical music too: a musical progress down the centuries along a single dominant line. It is now a view held mainly by those few people who see themselves as the inheritors of this true faith. Most would observe a fracturing into a number of co-existing styles, none with more than a temporary dominance and none with a guaranteed future.

Is this not what we see also in popular music? Unless the need of adolescents to crowd together around a single common belief prevails, it seems likely that the popular music market in the coming decades will fracture in a similar way. It might become something like it would be now if rock music were subtracted: an array of co-existing styles, each with its enthusiastic supporters - funk, rap, soul, death metal, techno, house, country and Western, world music, jazz derivatives, etc. etc. Presumably this would change the modus operandi of the multinational record companies. It would revolutionise the operations of the commercial broadcasters; it would no longer make any sense for the majority of stations to compete in broadcasting the same repertoire. But those models may disappear anyway, as audio by subscription or on demand becomes available.

Looking more broadly at the effects of the recording and broadcasting industries on music and its audience, we see that now Western music of all centuries is immediately available to us, to the extent that history has preserved our knowledge of it. So also is the music from most of the other continents and cultures. This aids further the diversification of taste, artistic practice, and

markets. In Australia this new accessibility combines with the relatively recent official ethos of multiculturalism to encourage the growth of small interest groups of immigrants and the native-born in various of the ethnic musical styles. Within classical music we have seen the development of what is hoped to be historically correct practice of music written before 1850. Those interested in the newest experimentation in musical creation are able through recordings to keep abreast of current developments everywhere, something never before possible. All these phenomena can be expected to continue and their effects on musical taste to intensify as the provision for niche markets becomes richer.

But one of the most interesting effects has been in classical music practice. The classical music audience has accepted the repertoire of the 19C with some extension backwards into the 18C and earlier and a more reluctant and finally averse extension forwards into the 20C. Much of the activity depends on the repetition of a relatively fixed repertoire. Among the other art forms, only in classical ballet does one find a closely comparable practice. True, performance of the theatrical canon, especially perhaps Shakespeare, is somewhat comparable, but with the important difference that a great freedom of interpretation is allowed, even expected. Perhaps there is also a parallel in the practice of some traditional crafts, in particular, some styles of pottery.

Whether this stasis in the preferred classical music repertoire would have occurred without the availability of recordings cannot be known. Perhaps in fact recordings have broadened rather than confined public taste. However, since the repertoire is in a sense static (accepting the flux of fashion within it for one composer (like Mahler) then another), a sort of novelty is provided and interest is sustained by twists of interpretation and the relativities of perfection of performance. Put more plainly, connoisseurship is rampant.

In this, recordings and broadcasts have certainly played an important part. Once a listener could hear only what was presented in live concerts, and unless a person of some privilege, such experiences would be infrequent. It would have been relatively difficult to form standards of comparison.Now one could listen every waking hour to this repertoire on recording. A single interpretation can be heard again and again, and, like Mr Keating, the listener can suck every last drop of juice from it. Different interpretations can be compared. With the growing longevity of the recording industry, one can even compare the interpretations of today's performers with those seventy or more years ago: players from another era who may have known 19C composers personally. Our players also can listen to these recordings and be spurred to emulation. All performances now can be judged against the standards of the greatest virtuosi, not only with the blemishes of live performance but in the unreal perfection of the edited studio recording. Furthermore the aural concept of the works and the interpretations are much more clearly in the minds of both performers and audiences.

It must be that the bounds of what is understood implicitly about this music have expanded enormously as a consequence, at least among those who are interested in it. Orchestras of talented children now can perform virtually to a professional level works of a difficulty that would have challenged a good adult professional orchestra a few decades ago. Excellence is the name of the game and it is a more and more common commodity. Australia now has one orchestra and a number of small ensembles of high international standard, and there is a new prospect that others will follow.

One aspect of living in a world of rapid change is the spread of a great relativism in values, or for some people with a low tolerance of ambiguity, a

recourse to fundamental if anachronistic simplicities. There is a value in maintaining an area of artistic practice in which there is sufficient stability of repertoire to support a non-dogmatic steadiness in the criteria of value, and the opportunity to achieve against some relatively clearly definable standards. For the afficionados of classical music, these judgements can be made, not so much in a spirit of consumption as in the nurture of the spirit. It is deeply satisfying to them. Of course, judgements of excellence are made by adherents in all styles of music. What is peculiar to classical music is that the sequence of notes is fixed very precisely, and so the judgements are made about fine changes in the ways of presenting an unchanging object.

This music quite possibly is at risk in coming decades for reasons relating to generational discontinuities as suggested in earlier chapters, but also because the strongest driver of the tradition, the orchestra, is extraordinarily labour intensive even within the arts context, in a world that runs increasingly on machines, not employees. (A part of the economy with which it competes is its own machine-made recorded and broadcast product.) It is therefore highly dependent upon subsidy, a subsidy that reflects a value judgement by decision makers who grew up for the most part in a period where the Western classical music tradition was accepted as the zenith of musical expression, even by those who neither understood nor liked it. That view is already under strong challenge.

Another aspect of the adoption of a static repertoire is that the audience now for the most part neither seeks nor wants novelty. As composer Andrew Ford notes, in terms of Western history this situation is quite new. The people alive at the time this repertoire was composed would rarely hear any work more than once. Almost every concert brought unfamiliar works, and what is more, works that were freshly composed.

There are fears in classical music circles that unless the repertoire is revivified with new works accepted by a younger generation, the audience will disappear. The stasis in the classical repertoire and the unwillingness to hear new works are sources of frustration and anger among present-day composers and those who would wish to have a lively, complex musical art for our own times. Criticism is directed at the composers in turn for their preoccupation with their own aesthetic imperatives to the neglect of any consideration of the needs of the audience. In the last few years, some new post-modern works have aroused audience enthusiasm, thus almost guaranteeing attack by the modernists. This is not the place to go into the aesthetic disputation. Suffice to say that the success of these few works might signal a hope for a contemporary repertoire acceptable to this conservative audience, and so assist in the prolongation of the tradition. The outcome might begin to be apparent in the next decade or so.

Music publishing. The rise of the mass music market, the large record companies and their associated publishing operations, has seen many of the older publishers with interests in classical music abandon it for the fast profits of popular music. Most music publishers, even some of those that have retained an interest in classical music, no longer have any significant activity in print publication of new music; rather, they exploit the various copyrights for recording, broadcast, use in film and so on.

For music dependent upon the written score, salvation has come from the photo-copier and the new technologies of computer notation of music. Production of a print score can be achieved on a cottage industry basis, but effective distribution is difficult. This problem could be solved very effectively by the communications highway, even with narrowband and low interactivity. Excepting

the relatively few works that have a broad success with audiences, we can expect in future decades less and less interest in this music from commercial publishers, but easier accessibility via institutions like the Australian Music Centre which will hold both the catalogues for regional musical score collections and the collections themselves scanned onto hard disc.

Thirty years ago, American composer George Rochberg wrote works he described as collages, incorporating fragments of works of earlier composers into a sort of musical quilt (a musaic?). In recent years there is a style of popular music in which DJs borrow directly from recordings a succession of musical fragments which go to make up a whole ephemeral work. The recording thus moves from being a representation of a primary musical source to the status itself of primary source. This style of creation has parallels in other arts and seems likely to become more widespread. Perhaps Cutler observed and tried to address this phenomenon in the contentious proposal to surrender moral rights (p.121). It is a practice that is somewhat shocking to values concerning the integrity of the artistic work.

Electronic music. The creation of the musical object by electronic means now has a 50 year history From the outset there have been two approaches. One attempted to achieve the objectives of traditional music through electronic production. So for instance, engineers set out to replicate by electronic sound synthesis the sounds of acoustic instruments - flute, violin, percussion and so on. The other was a philosophical approach to explore the new possibilities for sound creation in their own terms, in the expectation that they would lead to the development of quite different precepts and a new musical form.

Electronic music based on replication of natural sounds

The attempts to replicate the sounds of acoustic instruments were only very modestly successful in the early years, basically because the means was the attempted electronic synthesis of wave forms like those produced by the natural instrument, a complex task achieved only approximately. However, the same period saw the amplification and controlled electronic distortion of the sounds of acoustic instrument, in particular the guitar, and the popular acceptance of this distortion probably led gradually to acceptance also of the non-natural aspects of synthesised sound. The connections to the tradition were not necessarily maintained through timbral identity. There were also musical productions like the switched-on Bach recordings where sound that plainly was synthesised was used for tongue-in-cheek versions of the Bach repertoire.

An Australian company, Fairlight, discovered a way to record natural sound into a computer, and to manipulate that timbre in terms of pitch and duration without changing its aural identity. This was a means to much more exact replication of instrumental sounds, or any others found in nature. The difference between a performance on a natural instrument and its computer imitation came to be less one of the basic timbre and more the nuances of performance possible for a live musician as compared with a computer.

These developments have made it possible to give a fairly accurate electronic imitation of performing ensembles of natural instruments. Along with the new digital techniques of mixing, synchronisation and editing, the computer production of sound has made it possible for a single composer to produce entire film soundtracks of this type in the studio. The audience member with attention on the film probably would not notice, or if he or she picked up the clues to electronic production, would not find anything untoward or missing. Often, to gain a warmer and more clearly human feeling, the soundtrack will combine computer sound and human performance. For reasons of cost and inconvenience, the exclusive use of

human performers is diminishing. Those alone are powerful reasons to expect that the trend will continue.

Versions of these studio facilities are available to composers, musicians - and to amateurs. A work can be entered into the computer via a keyboard or computer music notation software, the parts assigned to replications of different instruments or to sythesised timbres, and the computer reports back to the composer something very close to the sound of the work in performance. Various types of compositional drudgery can be handled at the push of a button - e.g transpositions or repetitions. Performing parts can be extracted from the full score with a great increase in legibility and saving of labour. This is all a tremendous aid to composition of a particular type. It is used also in self-instructional programs. One drawback in the eyes of some is that with minimal human input computers can churn out quite complex sounding and very extended music, misleading users in their understanding of the task of musical creation and boring rigid the unwarned friend. Another is that health food stores have become a hazard to aural happiness.

A lot of the development in the computer generation of music has taken place in the commercial music sector. The design of computer instruments available for retail purchase is generally aimed at the production of popular music styles: i.e. they come often with built-in press-a-button instrumental imitations and drum rhythms. There are computer controlled versions of the player piano, and computer instruments which combine performance aspects of acoustic instruments with computer controls, e.g. the device modelled on a saxophone where aspects of performance are controlled through a mouthpiece but the keys control not the length of a resonating tube but pitch or other settings programmed into a computer. Devices used in club-work can offer a solo singer/guitarist a stored band-on-demand accompaniment of great sophistication.

These instruments are used mainly for band imitations, but the more autonomous use of artificial sound has gradually become accepted and is the basis for some newer musical styles such as techno and “house music”. Rhythmically and in the simplicity of harmony and syntax these styles maintain a clear connection with popular music practice, but in some ways they are distinctly different from what has preceded them. Through them, aspects of popular music and the classical music cutting edge have approached each other more closely than has happened perhaps for decades. Current fashion at dance parties is for the music to continue unbroken for hours on end. Computer generation or management by DJs facilitates this. It has served to eliminate live musicians. In demonstration of the continuing interaction between these developing technologies and the musical ecology, a Sydney band, Harry’s Laundry, is fighting back with a sort of live techno-rock which it plays unbroken for four hour stretches. A new meaning, if you like, to life imitating art.

The other obvious commercial application of synthesised sound is in video games. In many of these the connection with music as popularly understood is abandoned, and supplanted by a soundscape designed to evoke threat, tension and triumph in the endless episodes of mortal combat. The sounds are triggered by the random sequence of actions. When eventually this technology is designed for other than angry adolescents, something better may come from it.

Electronic music sui generis

Until the emergence of house music, the exploration of electronic and computer-synthesised sound in their own terms as the basis for a totally new music was pretty much left to a branch of the classical avant-garde. This has been an

enormous challenge. It is possible to produce virtually any sound that can be imagined, to devise pitch sets with nothing in common with the traditional scales, to combine sounds in any way that is desired, to produce sequences of sounds of any speed and rhythmic complexity, to place and move sounds around the room at will. The limitations of human performance are irrelevant; in a sense, virtuosity becomes redundant, an anachronism. Anything and everything is possible. But having abandoned the traditional musical language which, being commonly understood, is a means of human communication, how are uses of these new electronic means to be made meaningful?

Whether an answer has been found is a matter of contention, even among the practitioners. In the writer's experience, computer works tend to be meaningful in somewhat the same way that contemporary modernist music is meaningful at the macro level: through gesture, shape, pattern and its variations and relationships, and shifts of energy levels through dynamics and rhythm, rather than through some analogy of the precise pitch relationships of the tonal tradition. But then, one must allow that meaning is always an imposition on data by the observer, and that the observer's latitude in imposing meaning is greater if the language, as in this case, is very abstract: i.e. in this case consisting of elements for which there is no commonly agreed meaning. I may be applying inappropriately a frame of reference that is familiar to me. It is interesting nevertheless that one can find some agreement among computer music buffs as to what is a good work and what is not.

What is especially interesting are some artistic philosophies which arise out of some of the compositional procedures (and vice versa). Traditional composition, like traditional painting, constructs a work note by note, brush stroke by brush stroke. The artist is directly responsible for every minute piece of the work. Composition with computers can proceed in the same way. But because the computer has such enormous computational ability, a quite different procedure is possible. The computer can be fed some rules for producing sounds and sound sequences. It will then compose a piece according to the rules it has been given. The piece may be quite complex - complex beyond the ability of that composer to devise sound by sound, complex beyond any possibility of human performance. The composer has had no part in the composition beyond setting the rules; on the other hand, if the composer had set different rules, the computer would produce a different piece.

What the computer produces under such rules generally is not a work with carefully constructed beginning, middle and end. There is more a sense of an unfolding continuum, from which a period is revealed to the listener. The work fits the dicta of process, not product. Procedural composition "affects the very essence of the creative process as the aesthetics are bound up with complexity as ambiguity and removing control", says composer David Worrall. "The(use of abstract languages) tends to lessen the still powerful bourgeois link between art and ego: to encourage the surrender of the self to the half-seen, gliding beautiful things glimpsed in a moment of reverie." (David Worrall: "Procedural Composition: An Overview". In Proceedings of *Synaesthetica '94*, Australian Centre for Arts and Technology, 1994. p.7)

"Traditionally, music compositions have been by linear addition. Computer programming has opened up speculative horizons: one can try out ideas from a broad range of possibilities that it was previously impractical or impossible to test. One can go beyond exploring the orderings and patterns of events using a series, for example, to more general processes such as patterns of change

(gradients and deviations) and divergences (relative size of deviations). Issues of continuity and discreteness (in pitch, time, timbre etc.) can be examined in a way never before possible.

"Given the levels of daily noise to which each of us is subjected, selection (filtering) rather than construction or development is a more common social activity and the procedural composer can explore this paradigm freely. The composer and/or audience can subtract rather than add: adapt rather than determine, persuade rather than manipulate and this fundamentally challenges the idea of art as a message-bearing medium....

"...the process of manipulating the sound or image procedurally involves a type of creativity that would not be present if the problem were approached in a different way. Invention does not happen in an abstract intellectual way; it happens during the process of solving real problems. Our tools shape our thinking and clearly notation [i.e. the use of the written score as the means of composition] is a tool for thought, so different tools encourage unexpected ways of thinking." (Ibid. p.10)

At Synaesthetica '94, a video piece was presented which had been made with a procedure analogous to that described by Worrall. A video camera was pointed at its own screen. Flowing patterns were created through this feedback loop, and recorded. From this flow the artist selected sections to edit into a finished work. The writer was carried away with the beauty of the work, and asked the artist how it was made. He remembers being slightly disappointed with the answer. The work seemed devalued by the fact that the images had been created by the electronics rather than the artist.

The process could easily be repeated by anyone with the right equipment. Mine was a traditional way of valuing, but it raises some questions.

The computer produces a flow of musical sound in accordance with the rules fed into it by the composer. If this places the composer at a remove from the outcome, what can we say about the output of a computer which is fed rules, one of which is that it can make up new rules? (Such a procedure is alluded to in the description below of cellular automata and neural networks.)

Whose piece is this? - the composer's or the computer's? How do we as humans assign value to it?

Worrall says that procedural art bears no message. If that is so, does it have a value to the human observer? Are our needs and pleasures not fundamentally the same as they were ten, a hundred, a thousand years ago? If there is no evident human communication in an art work, will we respond deeply to it, no matter how skilled and complex it is? What is the basis of our response or our judgement? Composer Ian Shanahan, in a discussion of modernist acoustic composition in the *Sounds Australian Journal*, offered the opinion that communication is a concept of lower order in composition than total integrity in the organisation of the elements of a musical work. This is a banner behind which many composers march. But if the computer has made performance virtuosity redundant, has it not also made it extraordinarily simple to achieve integrity of musical sequence and organisation according to a set of rules? If that can be taken for granted, perhaps the further achievement of making such a sequence meaningful to humans will reclaim the high ground.

We have some very curious habits which presumably are related to the satisfaction we gain from artistic works. We assign a monetary value to a Van Gogh original painting way above the value we would give to even the most exact copy, even though they therefore are of the same appearance and should give the

same aesthetic satisfaction. We will pay more for a handmade print or etching than for a machine print of the same work, even though the only visually apparent difference is that one is signed personally by the artist and the other is not. In both cases, presumably the extra value arises from the fact that the hands of the actual artist were once on these works. Will we withhold our appreciation of computer-generated music because the artist's hands were at such a remove from its creation? and/or because we will not allow an electronic device to usurp a sphere used heretofore by humans for the most profound expressions of humanity?

Some see this sort of procedure as the abandonment of responsibility by the artist. In its actuality, it is peculiar to creation with computers. But there are precedents elsewhere to which we attach great value. When Jackson Pollock threw paint on a canvas, he was relinquishing the traditional painter's control over the precise nature of the contact between the brush and the canvas. When John Cage offered musicians only the most generalised performance instructions and left all the choice of notes to them, or depended upon chance to produce the next sound, he was in a sense anticipating this compositional procedure at the computer. The meaning emanates as much from the philosophy of the procedure as from the resulting artistic object. Perhaps an important distinction is that whereas Pollock and Cage relinquished control to the care of the cosmos, computer artists relinquish it to a machine, or, in procedures in which the outcome is fundamentally unpredictable, to the cosmos with a machine as mediator.

There is a fairly complete opposition between the two philosophies that Worrall has described, and people who have grown up with the earlier one may have difficulty in accommodating proceduralism. Intuitively, one expects that proceduralism will become generally accepted as part of a spectrum of simultaneously co-existing aesthetic practices. This will be so not necessarily because computer music of the kind practised by Worrall will gain a wide public (the audience now and for decades has been consistently minute) but because it is part of a broader ethos of the times - an ethos, as he notes, which is based upon biological paradigms and the acknowledgement of a world of continuing flux and change, rather than the hard-edged predictabilities of Newtonian physics. And this, of course, refers us back to the assumptions of the new science of complexity.

One of the major if less obvious reasons for the low public profile of computer music is its lack of success in public performance. Computers can be used to produce music in the studio or in live performance. Studio production allows the composer to contemplate, refine, edit, just as would a composer of a work for acoustic instruments. The outcome is a fixed, recorded work, and its public performance is akin to playing a recording for a concert hall full of people. The performer makes two gestures: switch it on, then switch it off.

Computers also can be used in live, improvisatory performance. An analogy from acoustic music is a jazz or rock performance. A problem even in live performance on computers is that usually there is no correlation between the proportions of the physical movement or gesture of the performers and the resulting change in sound. Switches are clicked in the middle of a piece as well as at its ends. A tiny movement of a slide or switch can unleash an aural Armageddon. Composer Warren Burt claims that this is exactly the disparity that should interest an audience, and that he has worked with dancers who understand the equation perfectly. Perhaps he is prescient about an audience of the future. So far audiences have not been convinced and many composers implicity agree: they usually present computer music in correlation with a visual element like projected graphics.

There have been attempts to enlarge the visual aspect of computer performance. The saxophone-or clarinet-like instruments mentioned above can be programmed to produce only those types of sound that might more usually be associated with an instrument panel. There have been experiments for more than a decade with gloves carrying switches and devices that can sense the speed and direction of movement. Various sounds or sequences of sounds can be triggered by finger movement or the movement in space of the whole glove. There might be some prospect that this will be more interesting to audiences. Some of the gestures can be generous. But again, the sheer wealth of possibility is such that even the largest gesture can be overwhelmed by the scale of the sound sequence that it triggers. And there is no essential parallel between movement and sonic outcome.

The strategy that perhaps has found greatest acceptance - certainly it seems not to be problematical for the audience for modernist acoustic music - is the combination of computer generated sound with the performance of live singers or musicians. There is now a large repertoire of such works. One of the technical difficulties is in the alignment of the live performance with the computer performance. Usually the latter is a fixed recording with no flexibility and no visual indication of progress. A newish procedure developed at IRCAM in Paris allows the wiring of an acoustic instrument into the computer so that the computer "knows" exactly what notes in the score the instrument is playing. It then adapts the performance of the computer part. The live performer can slow or hasten the performance and the computer will fit its part exactly to the performer's wishes.

One of the most thorough-going efforts to deal with the computer as a tool for performance in real time is the Hyperinstrument project directed by composer Todd Machover at the Media Lab at MIT.

(Todd Machover: "Hyperinstruments. A Composer's Approach to the Evolution of Intelligent Musical Instruments", in *Cyberarts*, Miller Freeman, San Francisco 1992. p.67). One of the important strands of this project is to combine real-time computers with instruments, whether conventional acoustic instruments or instruments built especially for a particular performance. Machover also wants to involve musicians who are virtuosi on their instruments (for instance, he has written for cellist Yo-Yo Ma) as performers on computer instruments, and so builds smart instruments which are capable of following their gestures and intentions.

"...the systems reward skill. Hyperinstruments are extremely sensitive to the special nuances of the finest performers , and employ those skills to expand and enhance performance, all under the performer's control. The better you play, the better the computer reacts...

"We want this type of [virtuosic] performer to be able to come into our studio and understand the concept of the instrument or implementation in 15 or 20 minutes...The musician must be able to understand the concept quickly - but if the musician can learn the entire instrument in 20 minutes, then we've produced not an instrument, but a toy. So the instrument must be easy to understand conceptually, but worthwhile and rewarding to practise so the musician can improve on it over time. It must have depth while being easy to learn. Such instruments are not easy to design...

"We build our instruments for performers, but they work with powerful computers, so they also can be used as improvisation systems and composition systems...We believe the musician of the future should be a combination of performer, improviser, composer and conductor, and be able to switch easily between these roles, or to combine them in new ways..."

With the development of computer music instruments, the interest seems to have gone from the invention of new acoustic instruments. Research in that area seems mostly confined to means of improving the existing instrument types, either to produce cheap student instruments to a higher quality or to lift even higher the quality of the instruments used by professionals, whatever the cost.

However, one recent discovery is of wider interest.

William Sethares was taken with the sound of the rocks of Chaco Canyon in New Mexico: "musical, but inharmonic; resonant, but ambiguously pitched". ("Tunings for Nonharmonic Sounds", in *Synaesthetica '94. Symposium on Computer Animation and Computer Music*. Proceedings of the symposium, Australian Centre for Arts and Technology, Australian National University, July 1994) By inharmonic, he means that the sound was not constructed on the normal, "regular" basis of a fundamental and harmonics in simple mathematical relationships to each other. He analysed the spectrum of the sounds emitted by these rocks when struck, and discovered the intervals which produce the most and the least dissonance respectively as evidenced by a plotting of the dissonance curves created by the beating of upper partials. With this information it was possible to map a scale such that, if Chaco Canyon rocks were tuned to it, they would sound consonant with each other. In this instance, the dissonance curve led to design of a 16-note scale over two octaves. Sethares demonstrated the result not by tuning the rocks, but by sampling the timbre into computer and composing for it. The result is curiously pleasing although quite different from the Western modes and tuning.

This discovery would permit the use of all manner of sounding bodies, tuned to the scale which is best adapted to their sound spectrum. If it had been made fifty years ago, it might have aroused great interest from people such as Harry Partch, who invented a new orchestra of instruments and the music to perform on them. Now, since there is not a great deal of interest in new acoustic instruments, it may not be taken up at all. If it is taken up, then it must face the problem of such inventions: they cannot be used for the performance of the "harmonic" repertoire, but only the few pieces written for them by their enthusiasts. Obversely, the current instrumentation is mostly locked in: it has a musical culture of great depth with an enormous repertoire, and very skilled executants.

Theatre, film and television

These three forms arrived in a sequence, each borrowing from its predecessors. They now form some sort of co-evolutionary partnership, with each one surviving through the discovery and exploitation of the ecological niche that allows it to emphasise its particular strengths vis-a-vis the others.

At the risk of recounting the self-evident, let us look at some of the fundamental characteristics of each of the forms as revealed by their place in this partnership. It will not be possible for this report to deal with all art forms within the time constraints. It does not cover dance and some other theatrical arts specifically, but some of the comments on theatre may apply also to them.

Theatre

It is common to all the various manifestations of theatre, and the obvious basic distinction between theatre and the other forms, that the audience comes into a relationship with actual living people and solid three-dimensional objects on the stage, and in the body of the theatre. The effect of the live presence of both the performers and their audience is heightened by the fact that the form and circumstances allow the performers to vary the performance in response to audience reaction.

In response to the competition from the more ethereal forms, and other developments in society, theatre split in a number of directions, each of which exploits some aspect of the advantages it offers.

1. *Traditional theatre* continues to serve what might be thought of as the loyal core audience of the form, an audience that has certain expectations of style and content from which too radical a departure entails risk for the theatre company. This is theatre of the narratives and colorations of human intercourse; although there are great choices of genre within it, that essential identity is unlikely to be plucked away by new technologies. It has used the new technologies of computerised lighting and stagecraft to serve and enhance the achievement of its traditional purpose. It depends upon a local audience, often with a loyalty to particular theatre companies and their style of repertoire and production, and therefore its options are constrained within the preferences and the consequent financial support of that audience. There is a good deal of control by the artists, provided that they operate within those limits. The future of this form over the next fifteen years might be in some question in part because its value seems to lie in it being what it now is, serving its particular audience. Will this audience renew itself? Some doubts are expressed below. What if change were required? Were the genre more flexible, what niche would it then occupy?

2. *Experimental theatre* exploits the small ecological niche left by the somewhat enforced timidity of traditional theatre, and is rewarded by support from artist-controlled funding bodies with a value on innovation. It has moved away from theatre traditions towards performance art, with its input from the innovators in the visual arts. It is advantaged as an experimental medium in comparison with the film and television/video by its relatively low costs, and its flexibility in form eg performances can be totally improvised and any manner of relationship can be set up with the live audience, anything can be incorporated in performances including dance, gymnastics, mime, puppetry, music, film or video productions, food, smell. The performance space itself can be designed or adapted to the work. In other words, it can exploit its flexibility, tangibility and direct relation to the audience, all qualities which are denied to film and television. Some experimental theatre is strongly technology driven, but not to the point of losing that living presence. It is strongly artist-controlled, and tends to depend on a local coterie audience. It is protected from the market by the commitment of the artists and/or by public subsidy, without which it would not be financially viable. As to the future of experimental theatre: there is always room for experimentation. The question perhaps is whether the focus of experimentation will remain strongly enough in this area, or whether it will shift more decisively to computer based arts as in the construction of virtual realities.

3. *Hybrid or fusion theatre* is a product of closer global communications and the ethos of multiculturalism, combining Western theatrical traditions and those from other cultures. It may have the ethos of tradition or experiment and so share in one or other audiences. It is more often a one off presentation than the fixed program of any continuing company. To the degree that permanent companies are not dependent upon it for survival, it has a certain freedom from the expectations of a specific audience. Its future may lie in the increasing interest in multiculturalism, although whether the weight of interest lies more with the artists than the audience might be a survival issue.

4. *Community theatre and street theatre* take many forms - from amateur productions of standard repertoire to innovative professional street performances combining processes from any of the other categories. Perhaps what they have in

common is the intention of very directly serving the community. The ideology of special interest in the recent past was the use of these genres to discover and express community identity. I have the impression that this movement has gone off the boil, although the issue of identity is unlikely to be quiescent during times of rapid societal change.

5. *Theatre which is focussed more on objects than actors*, such as the works of Nigel Triffitt or Kim Carpenter's Theatre of Image, or puppet theatre. The former depend strongly on stage technology, and for the future may in some ways be the best placed philosophically among the theatre community to move into the creation of virtual realities.

6. *The lavish musical* uses the techniques of lighting and stage machinery of the previous category to create spectacle to support the sentimental progeny of the popular musical. The spectacle comes at great cost and so is part of a marketing strategy which depends on drawing very large audiences over a very long run. These musicals play in large cities around the world. Their audiences are drawn to the one-off show rather than the company, and are not in their essence local. Indeed, it is possible to see some parallels in the marketing ethos for film. They manage to combine something of the scale and impact of film with attractions of traditional theatre: the live cast and immediate presence of the stage spectacle. Many in the theatre industry have been hostile to the lavish musical because, they say, it addicts the audience to production values that cannot be equalled in ordinary theatre, and at the same time reduces its appreciation of dramatic content. The producers of the musicals say that they have brought millions of people into the theatre who otherwise would not be interested. One suspects that if theatre has a future, productions of this sort will be a part of it because, like the blockbuster films, they exploit some of the particular advantages of the medium in a way that appeals to a mass audience. The problem probably is one of finding fresh ways to present the same sort of material - a problem which more or less had eluded solution on Broadway for some years until Lloyd-Weber's string of successes.

There are problems confronting theatre as a whole which could determine its future. Like all the live performing arts, it is labour intensive, a characteristic increasingly unforgiven in the market-place. A large part of Broadway is closed down because the costs are higher than can be recovered by the productions. Frank Rich wrote recently in the *New York Times* that the hit play, *Angels in America*, would not have broken even financially when it closed at the end of a 20-month run. At the time (October 1994) there were only two straight plays on Broadway. It is ironic that the most expensive productions of all, the lavish musicals, are the ones that survive and make a profit. The audience will pay more for glitz than substance. "It is no longer possible to have a cat-or-chandelier-free hit on Broadway", says Rich. It may be that problems of this dimension are peculiar to Broadway, and Rich cites some specific causes. But as we know, sometimes the American experience indicates a future for other parts of the world. We certainly do see theatre costs rising in Australia.

In conversation with the author, the director of the industry association which takes in the non-profit sector, the New York Theatre Communications Group, stated the concern that theatre is not attracting a sufficient audience from the generation of young adults. She attributed the problem in part to a rigidity in the style of theatre on offer. The companies which had formed twenty or thirty years ago as experimental or avant-garde are still doing now basically what they were doing then. The audience for those companies is the audience that has aged with

them. There is no equivalent emergence of new ideas now with which a younger generation can identify.*

The question is whether the coming generation will see live theatre as cutting edge or anachronism. Is live theatre the place to discover and give form to its visions and predicaments, or will a lifetime of exposure to the electronic media and computers turn its attention to new computer-based forms?

In Australia, theatre audiences seem to be sustained and even grow. One has a sense of the increasing professionalisation, perhaps regularisation of Australian mainstream theatre. There is still an active experimental theatre with a young audience, but is it a focus of excitement for young people or is it recycling the inventions of past years? It may be that we will not go the way of New York, but better to consider those possibilities now than too late.

Film

Film began by borrowing from theatre and photography and in some aspects serving theatre's function better than could theatre itself. In its co-existence with theatre and television, these characteristics of film seem important.

There is an alienation from the body in the sense that the audience is faced with no tangible persons or objects. Film excapes from the three walls of the stage, escapes from a single dimension of presentation in that people, objects and sounds can be scaled up or down in size at will, is unconstrained by geography, or gravity or any other aspects of reality that can be subverted by the special effects experts.

On the other hand, film can be intensely personal, penetrating the psyche of a character through very precise manipulations of image, and a leading of the audience's emotional response through the music soundtrack. Audiences have a larger than life interest in the bodyless bodies of their larger than life screen favourites. While in this sense personal, film loses theatre's direct connection

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* It is interesting to note here that although Australians think of US arts institutions as largely unsupported by subsidies, the public subsidies to theatre in the larger New York-New Jersey metropolitan region, with a population somewhat less than that of Australia but a massive arts tourist trade, were A$10 million, to which may be added subsidies of $30 million from private sources, together a good deal more than that available to Australian non-profit theatres. (*The Arts as an Industry: Their Economic Importance to the New York-New Jersey Metropolitan Region*. Port Authority of New York, October 1993. p.19) Still they are in trouble.]

with the audience: once the final cut of a film has been decided, there is no significant flexibility in its performance in response to the audience. But this hardly affects its popularity. Perhaps the direct human contact from the theatre stage is not important to some types of personality.

The two aspects of film, the personal and the physically boundless, might be seen to lead to two different types of film: the one being an extension of theatre's examination of narrative and character, the other based on spectacle. The latter plays on illusion and the impact of the large screen, and in recent years we see more and more blockbusters, massive comic strips on film made with budgets of prodigious size. They are the media equivalent of the lavish musical. The impact of these films is not caught satisfactorily on the small television screen and so film has staked out its ecological advantage over the competition by exploiting this genre.

Film lives in an ecology of a nationally or internationally dispersed exhibition system which makes it possible to gain access to an immense paying audience. This audience can be served through the mass appeal blockbuster, and the mass

audience both enables and impels production of such works. The ecology also supports the financial viability of small, special interest "art house" films by finding small audiences in a large number of population centres globally. The film audience, unlike most theatre audiences, therefore is not a local one, and the production and marketing of film is conditioned accordingly. Audiences may have loyalties to particular performers or directors, but there is no motivation for loyalty to a company.

While small scale films deal with content as does theatre, the audience knows that there has been a culling process, especially with films from foreign sources. There is thus some guarantee of quality which is not available from the local theatre production to the same degree. In this respect, film has some advantage over theatre in playing its own game. There is also the matter of convenience: ticket prices are lower and probably there is a cinema near *you*.

Film's escape from concreteness is complete in the animated film. As they reach the regular audience, animated films have been predominantly a children's entertainment of animated comic strips, although the art house genre is often an extension of abstract art for adults. It is particularly in animation that new computer technologies will be felt, and a separate section is given to the current and imminent developments in that sphere. (See below)

The present and no doubt future challenges to Australian film-makers include problems of financing and distribution. These seem to be handled reasonably competently on the evidence of the current production levels and the successful international distribution of some films. The ever-increasing appetite of multiple cable television channels with eventual video on demand should ensure some exposure and earnings for even the films that don't achieve cinema distribution, as is now the case via video rental services. With proposals to open more studios of major international producers in Australia, there will be increasing input of foreign funds and internationalisation of the industry. This may lead to anxieties about whether Australia is giving over its talents to churning out profitable fare for the international market at the expense of smaller films that build our own sense of identity.

There are plans for film to participate in a world of interactive multimedia. Some interactive films are being made for cinema showing, with audience choice of optional plots as the film progresses. The choices can be constructed so that the audience is supporting or denying the impulses of key characters in the film, and that could be involving. The decision obviously must be by vote (delivered by push-button). Perhaps this will create a sense of community within the cinema. On the other hand, those who lose the vote might prefer to be interacting individually with a computer which obeys. One's feeling about this prospect seems akin to that with the 3-D specs films of some years ago: a briefly interesting gimmick leading nowhere in particular. If a more personal interactive multimedia becomes popular, presumably that could cut into interest in cinema film. But it probably won't win over the audience that likes blockbusters and it cannot compete with them on their terms

If the blockbuster audience tires of current fare and must be amazed again, there is always the massive scale of the IMAX theatre. For readers unfamiliar with the Imax (is there one in Australia yet?) the screen occupies about a third of the interior of a large sphere. It curves around more than the complete field of vision of the audience and reaches up to to 25 metres above them. The film is 70mm wide but the image is turned on its side to produce a frame ten times larger than the conventional 35mm frame. The film spool in the most elaborate IMAX theatres is

about 2 1/2 metres in diameter, is 25 kilometres long, is so heavy that it takes a forklift to put it in the projector, and runs about four hours.

A new development for IMAX is a new sort of 3D, in which the audience wears goggles with infrared sensors, liquid crystal lenses and stereo speakers. The effect is said to be stunning, with the image filling the whole three-dimensional space of the theatre. There are a couple of problems. While distant images are clear enough, foreground images are coarse-grained and blurred. Also, the edges of the goggles obstruct peripheral vision, and in one sense IMAX is basically *about* peripheral vision..

These films are travelogues, and the audience is entertained with helicopter rides in which suddenly there seems to be a drop of thousands of metres into which one could fall. And so on. The images are very beautiful, indeed awe-inspiring, but do not seem to have much potential as a dramatic medium for the reason that, in the writer's experience, the human figure is either inhumanly large and rather blurred or of more acceptable size but lost in the immensity of the screen. The Imax screen could be filled with an opera house interior, but how could it depict a living room?

It is a device which however might be suited to blockbuster action films in which the protagonists are usually cardboard figures in any case. And indeed such plans are afoot. Director Jean-Jacques Annaud says that the "medium cannot carry on showing rivers and mountains and planets. It must tell stories or die." There are technical difficulties relating to the physical clumsiness of the camera gear which could get in the way of effective story telling. The cost probably would be breath-taking, and perhaps could not be recovered from the sprinkling of IMAX theatres now existing. Sony is involved and there is speculation that it would bear the loss to build its image as a company at the cutting edge. There is more mention of the possibilities of the IMAX in the section on animation.

The contributions of computer technology to film production are in the theatrical techniques of lighting and stagecraft, in special effects - notably those borrowed recently from computer animation, in camera design and film processing, and soundtrack production. Higher production values and the production of special effects have been facilitated and economies achieved, and the achievements of the blockbuster in its current form probably have much to owe to the new technologies. However, one might question whether the medium has otherwise been changed in its fundamentals by these things. The computer will be felt more strongly in its use as a tool in animation. (Reference was made in the previous chapter to cable delivery of digitised films to cinemas, and its possible effects on the technology and economics of the distribution system.)

Television

Television began as a combination of film reduced to the small screen and radio metamorphosed into the audio/visual realm. Radio co-evolved into a niche where it can exploit its strength in the arts that are self-sufficient in the aural medium: music and talk. Television retains the informality and topicality of radio in its current affairs and chat shows, and has effectively taken over completely radio's former territory of drama, including soaps.

In its competition with theatre and film, television has the advantage above all of convenience. It is there in the living room with a choice of programs 24 hours a day. For a moment longer, the only cost is in the purchase of the set.

The cost of free service is support either from the public purse or from advertising revenue. The public stations live constantly with the conflict of proving public benefit via ratings vs. proving that the service could not be

provided commercially. The outcome is programming which is substantial but not too substantial, distinguishable but not innovative. The commercial stations have to deliver a mass audience to their sponsors, with predictable results for programming. There is a potential audience unserved, but it probably is very small. It might be more likely to be satisfied by on-demand services on the communications highway than by extra choice on cable television.

The small screen in the living room encourages informality. The need to fill 24 hours a day of programming encourages ephemerality. It is the medium best-placed to deal with the topical, whether through current affairs, or the reflection and melodramatisation of community life in the soaps. While there is no direct relationship between performers and audience as in the theatre, and the audience gets the final cut of the soap episode like it or not, the medium is more flexible than film in that subsequent episodes can pick up on audience responses.

The audience may give loyalty to channels, particular personalities or series, but its preferences can change in an instant with a flick of the dial. It is regional or national, rather than local, and this reflects in programming and marketing.

Television's most obvious advantage is its disadvantage too: you stay home to watch it. Theatre and film allow play for gregariousness of a sort, and especially in the case of film, this has been a major contributor to survival.

From the production end, the new technologies have delivered various efficiencies, in particular perhaps those of digital editing. For the viewers, technology has delivered stereophonic sound for free to air television. It can be expected that large, high definition, wall-mounted screens will be standard. Sanyo has just announced the development of a new technology that will deliver 3-D TV without spectacles. This could bring into the living room a more satisfying reproduction of the entertainments that depend on scale, and cause a further ratcheting up in the scale of cinema presentations of blockbuster film in order to maintain the difference. The other possibilities for television arise through the operation of the information highway.

The challenges to television from theatre and film probably will not grow. Rather, they come from those things already covered in the previous chapter: the multiplication of choice through cable, user-pays, video on demand, the interactivity of the improved CD-ROM. Free to air programming could suffer (see previous chapter), but for those with the ability to pay, the service will be much enhanced. Because the form of the new interactive technologies as perceived by the user is more similar to television than to theatre or film, it is television that probably will be most affected one way or another.

Dance

Dance as a live theatrical art faces many of the issues confronting theatre. The reader is invited to draw the appropriate parallels. The writer offers just a few comments about some aspects of dance art.

As has been noted in the section on recording and classical music, classical ballet maintains a live tradition around a relatively fixed repertoire. It has a large and loyal following which, as with classical music, makes judgements about the fine changes in presentation of an unchanging object, viz. the choreography of a classic work. In a world in which practically everything else is in flux, such points of stability could come to be even more valued. While there are those audience members who are committed exclusively to art of this type, there is nothing contradictory in combining an appreciation for classic art and innovative art.

While there are styles of modern dance, such as those developed by Martha Graham or Merce Cunningham, that have assumed something of the status of classical ballet (dancers take classes in Graham technique or Cunningham technique, for instance), at this stage it is difficult to see the modern dance repertoire or movement becoming fixed in the same way. It has developed during an era when originality is prized, and so there has been a continuing invention and diversity of style and rapid change in the art form. Because of the rapidity of change, older works can seem dated. Of course, classical ballet works are old and dated too, but this seems to be accepted more easily in the ballet ethos than the modern dance ethos.

Some of these changes have stayed fairly clearly within limits in which the moving body is dominant. Others have adopted aspects of theatre, where for instance speech is introduced and movement may become less dominant or of lesser quality or impact. Or it may move towards performance art; this can mean it is strong conceptually, but shallow in terms of movement. Some dance incorporates gymnastic skills, or is even created from a gymnast's viewpoint. This can be spectacularly successful for obvious reasons.

Fundamental to dance is a high kinesthetic intelligence, to use Howard Gardner's concept, allied with aesthetic and expressive power. Speaking for himself, the writer lights up when he watches dance that manifests that intelligence. Similarly, the expression of a musical intelligence in music or a visual intelligence in painting or sculpture carries a particular power. A good deal of experimental art combines disciplines, and of course it can be very effective as a total statement. However, the expression of those disciplines in such works is often pallid, and the conceptual content or whatever is intended to replace them is insufficient compensation.

Readers may or may not agree. The point of the assertion is that it seems to the writer that dance is fundamentally about this special intelligence of the moving *body*. Bodyless bodies on a screen are a sort of contradiction. Perhaps more than any other form, there is a special and intrinsic advantage in seeing this most tangible performing art live in the theatre. Even ballet, which in some ways seeks to escape the body - or rather perhaps to escape gravity - is nevertheless about seeing those bodies physically in front of you in beautiful or incredible movement. Despite a measure of success for dance on television or film, they seem a poor substitute for dance in the theatre.

If this is so, then professional dance's future remains based in the theatre, however it may also manifest in the media. That is not to say that dance should not take advantage of the new media and develop a range of aesthetic approaches suited to exploiting them. It is to say that special care should also be taken to keep dance alive through live performance.

Computer graphics and 3-D animation

The history of animation as a popular art carries the ethos of a children's entertainment. Commercially, animated film is still produced mainly for the children's market, or for advertising purposes. At the same time, there has long been a practice of animation as art film, and a more experimental one related perhaps more to gallery audiences than film buffs.

Animation will probably become more pervasive in adult art and entertainment, and in aspects of industry and commerce. The device of "animated" 3-D imaging has become an important design tool for architects, town planners and industrial and interior designers. (This is not 3-D per favour of special spectacles, but the two-dimensional rendering of moving three-dimensional

objects to give an accurate sense of three-dimensionality). Its use in the serious business of industry could be a strong counter to its juvenile identification. A dramatic extension of animation techniques has led to incorporation in adult non-animated films in a way that is in a sense imperceptible: e.g. in *Terminator 2* there are non-naturalistic effects involving live actors which the audience might be more likely to attribute to stunt men and real-world special effects than to animation. Animation will eventually be a crucial element in a sort of super-reality, when virtual reality technology comes of age.

New methods of animation are supporting enormous increases in the complexity and sublety of images, both through a great increase in technical power of the methodology, and economies in production costs. The results of these new computer animation processes are now emerging into film and television.

Traditionally, 2-D animation is created by hand, with the illusion of movement requiring that each frame of film be hand-drawn: 24 frames per second for film, and 30 per second for video. Computer software programs have facilitated this process by calculating and filling in the motions between hand-drawn key positions. This allows financial economies, but does not change the basic premises of the traditional animation practice.

The advent of the computer has been more telling in the development of 3-D animation. This animation is very complex, but since the problems are in a sense problems of computation, they are very suited to computer intervention - and such intervention has enabled enormous advances.

The procedures now used in computer animation might be divided into two broad classes: those in which the images are created totally within the computer, and those in which movement of the images is derived from the movement of objects in the natural world.

Instructed with simple mathematical formulae, the computer can create simple geometric 3-D objects, and combine them into more complex shapes. The computer can easily extend 2-D objects into 3-D objects - e.g. a square into a cube. An artist can draw into the computer elevations of an object from front, top and sides and the computer can combine them into a 3-D composite.

Other methods emerge continually. Particle systems allow the artist to direct movement of very tiny particles to produce a moving image which again can simulate natural phenomena like splashing water. Metaballs (no, Ralph, not meatballs) are like drops of liquid which the artist can stretch and merge on-screen to create the appearance of naturally curving surfaces. There are various methods for effectively simulating reflective surfaces.

These processes for creating images totally within the computer are the modern-day equivalent of the hand-drawn cartoon, inasmuch as the image is generated primarily from the artist's imagination. There are others which create abstract dynamic graphic images by rule-based procedures analogous to those described above for computer music. These include the use of fractals, cellular automata and others, described in the preceding and following sections. Video feedback has also been mentioned.

Images representing complex movements of living beings can be produced in new ways and at much reduced financial cost. The procedures take recourse to the natural world.

In one approach, computer animation begins with the creation of a 3-D sculpture of a cartoon character. A wire-frame version of the sculpture has the effect of putting a sort of 3-D grid over it. A computer can read the shape of the

character as it is placed in a number of positions in space. As with the 2-D process, the computer can then fill in the gaps as the character moves between these key positions.

If the artist wants to show very life-like movement, the animation becomes extremely complicated. Imagine attempting to capture through hand-drawings at 24 frames per second the movements of a human simultaneously walking, speaking and gesturing. "Motion capture" is a means by which many of these problems are circumvented: the movements of a human are "captured" and "mapped" to a computer-created animation, with results which may be virtually impossible to produce by hand. The process can take place in real time or through a more extended procedure where the best takes of several versions of captured motion are manipulated in the studio to produce a final result. While the process can produce extremely naturalistic movement, the computer can be programmed or manipulated to exaggerate or suppress or distort aspects of the movement to expressive effect.

Real-time motion capture generally requires a human to function as a sort of puppeteer. This 'puppeteer' wears apparatus such as a glove, head gear or even a full body suit in which sensors pick up physical movement and transfer it to the animated character on the computer screen. The puppeteer might also have responsibility for the character's speech, and so produces movement and speech simultaneously. This real-time manipulation is also possible by using an input device such as a joy-stick. It can be used to produce real-time animated performance in front of a live audience, although a good quality film or video production will require various sorts of editing and tweaking..

A French company produced a series of cartoons using these methods. It took about three months to develop the "sculptures" of the characters, but once they were completed and fed into the computer, it took only five weeks to produce the twelve-episode series, an enormous financial economy.

Another method uses three or more video cameras to capture the motion of a body through the movement of reflective markers attached to key points such as joints. The information is fed to image processors in a computer which calculates the position of the body through a triangulation process. The reflectors on the human subject correspond to key points on the animated character, and so can be used to cause it to move. The characters need not represent humans - they can be (animated) inanimate objects.

Producers have now also combined various of these procedures. It is possible to apply different processes to different parts of the character serially, recording each one onto a hard disc through a technique analogous to that in sound recording where tracks are overlaid one at a time to produce a composite.

The computer animator is able to further alter images by specifying "virtual" light sources and camera positions, and to move these, or the animated objects, around on paths s/he specifies. The light sources can be used in much the same way as theatre lighting, with lights diffused or focussed, close or distant, and so on. For the camera, instructions can be given which create the illusion of changing focus or depth of field.

The methods by which the computer puppeteers manipulate computer animations can be used to allow direct interaction by the public. For intance, there is a demonstration at the Museum of Television in New York in which visitors can manipulate the head of a computer cartoon character with a pair of joysticks (and then watch finished video film of the same character created by a gloved puppeteer).

Conceivably, with only minor development of such a facility, the results can be captured on video or disc and taken home. Perhaps in the future, the whole package could be run on the domestic PC, with the possibility of manipulation of multiple characters, addition of voices and creation of complete storylines.

In due course, it is quite conceivable that computer animation will be able to construct images of such refinement that they will be indistinguishable from film of living beings - including real persons. Clearly, there are serious ethical implications.

A final word on a new potential for animation. At the Imax Theatre at Porte de la Villette outside Paris, the show in late1994 opened with a short animated film of *Le Petit Prince*. The film has its charm, but is fairly inert, with lots of otherwise static images floated around the screen to no great purpose. However, it did reveal that with animation the artist would have total control over the use of the screen and could cope with the problems arising from the enormous scale, and indeed use it to create a new idiom. Whether this potential will be taken up one cannot know. Probably there are financial difficulties arising from the necessity to fill the screen adequately. A similar exercise in animation on a much reduced scale in the nearby Cinaxe is described below.

Fractals, cellular automata, genetic algorithms, the edge of chaos - and the arts

A procedure that is attracting the interest of both composers and graphic artists is the production of art based on *fractals*. The fractals result from the operation of algorithms and can have a visual expression: graphic figures displaying “self-similarity”, i.e. the detail of their form has the same appearance as the whole or a part of the whole - "self-similarity that is unvarying under the change of scale" (Peter Sorenson: “Fractals”, in *The Cutting Edge of Technology*. Sams Publishing, Carmel, Indiana, 1993. p112). This is easily understood when seen, but otherwise perhaps inscrutable.

The public is aware of fractals through their presentation as visual graphic art. Examples of fractal graphics have been fairly widely disseminated. In Canberra in July 1994 there was a public exhibition of computer generated art, much of which depended upon fractals. But computer musicians are using them also to generate sound structures/music, and at the same time in Canberra there were concerts which included such music.

The fractal algorithmic formulae can be very simple, but must be repeated millions of times for their realisation, each time using the result of the previous calculation as the starting point. Such calculation has become possible only through the advent of computers. Not only the calculations but also the visual or aural artworks depend upon the computer for their realisation.

The use of fractals to produce graphic or musical art shares a particular computer-age ethos with the computer music compositional procedures described already. The art works are not constructed directly by the artists but are the result of an instruction to the computer to follow certain rules. The outcome usually is not predictable in its detail, and so the artist's role is in a sense to set character and limitations of a more general kind.

Fractals are inherently mathematical, but not inherently visual. The same algorithm can have both a visual and an aural expression. However, despite the wish by some artists in this field for a simple and tidy world there is no discernible resemblance between its aural and graphic representation. It is one of nature’s discontinuities

Deterministic fractals are those in which the algorithm completely controls the outcome. *Non-deterministic fractals* include a random element, and are the ones most commonly found in graphical applications. They can be used, among other things, to produce simulations of natural forms such as trees or mountain ranges, and fractals are seen as an ordering principle of the natural world. Non-deterministic fractals are an embodiment of chaos theory, in which small initial variations introduced by the random elements have a ripple effect which builds to a disproportionately large influence on the outcome. The graphical expression of non-deterministic fractals with an aesthetic intent therefore is an artistic embodiment of chaos theory.

In Chapter 1, there is a brief account of Chris Langton's work with *cellular automata* and his development of the theory of the "edge of chaos". Like those for fractals, the calculations for a cellular automaton are sequential. Each new function of an algorithm results from rules for change based on the configuration from the previous operation. A one-dimensional automaton depends on only the single previous state, a two-dimensional automaton on a combination of the two previous states etc. Once the rules are established, the automaton generates itself. Readers will recall that Langton showed how, depending upon the rules you set up (or the values given to the variables in the algorithm), their graphical expression on the computer screen can be a rapid return to black emptiness, a frozen or static pattern, a boiling chaos, or a coherent, dynamic, changing pattern at the "edge of chaos".

As with fractals, the cellular automaton patterns will have a particular character depending upon the rules devised by the programmer. In this sense, if the programmer is an artist, they can be controlled in a general way, although not in their detail, in pursuit of a particular artistic objective. The control is expressed both in the design of the algorithm and the rules devised for its artistic expression - e.g. how the calculations will be expressed in terms of presence or absence of pattern, location of pattern, choice of colour and so on. It should be noted that since the patterns form through the continuing calculation of different values of the algorithm, the artistic outcome, except for Langton's Class 2 frozen pattern, is a dynamic one. Visually expressed, it is a moving image, a form of animation.

The "boids' experiment (see Chapter 1) is an example of a cellular automaton. Readers might remember that this experiment was devised to demonstrate that from the operation of a number of simple rules would arise complex behaviour that was in some aspects predictable, but in others emergent and therefore unpredictable. This perhaps shows the nature of the artist's control in much of creative work with computers.

Genetic algorithms mimic on the computer a model of evolution. Pieces of computer code split like reproductive cells to mate and, through small mismatches of binary code, to mutate. The fittest "offspring" survive according to rules of fitness devised by the programmers to address the problem to be solved. The others perish. The design of this procedure allows thousands of pieces of code to be interacting in parallel, simultaneously. They therefore can "evolve" millions of times faster than natural evolution. They have found uses in industry in, for instance, engine design to achieve designated efficiencies.

Eric Iverson of the University of New Mexico uses such a process to create a variant of David Worrall's proceduralist music. (John Iovine: "Artificial Life", in *On the Cutting Edge of Technology*, Sams Publishing, Carmel, Indiana, 1993. p.97) Computer music programs of this type generate a large number of random notes which are filtered according to the programmer's "rules" for the piece.

Iverson's rules extract a string of say four notes from the random notes which serves as a 'digestive enzyme'. It searches for the same sequence of notes throughout the random set. When it finds one it cuts the sequence into two pieces in the middle and is "rewarded" by being allowed to reproduce. The two enzyme cells then continue the search. At the point of reproduction there is a small chance of mutation by changing one of its four notes. This process is carried through until the random set has been eaten, and is transformed into these enzymes and their families of mutations.

The process then is reversed. The "enzyme" fragments are glued together under a rule that only those pairs that have a common note in a starting or ending position may be coupled. The result is a complete composition. Iverson likes the result about one third of the time.

An important aspect of the genetic algorithm is that because through mutation it evolves on the basis of its fitness in a particular environment, it actually can go beyond the input of the programmer. On the one hand it is bound by the programmer's rules, but on the other, within those rules it can act autonomously and in surprising ways. This means that its use in art production distances the artist further from control of the detail of the outcome.

Neural networks are another form of computation, modelled in this case on neural processes in living beings: the level of connectedness between brain cells and the relative strengths of connections. These connections determine fitness for particular situations and through rewarding successful connections and depriving unsuccessful connections of strength, the network learns. In effect, neural networks and genetic algorithms have in common this ability to learn in the one case and evolve in the other. But we can recall here the claim in Chapter 1 that evolution is a form of learning. Like all these theories which are tested through computer simulation, there can be a manifestation graphically on the screen or in some other form and this can be manipulated for artistic purposes.

There are publicly available programs now through which anyone with modest computer graphics capability can explore fractal graphics. The genetic or artificial life algorithm is available for play in a computer game called *Simlife* (Maxis, Orinda, California, or in local software stores). Or you might get one without asking: they are the basis for the computer virus. It is not clear where the artistic use of fractals and cellular automata is leading, but it is occupying the minds of some very talented people and will be tested over the coming decade.

Parenthetically, fractals have been used for ultra-high image compression for computer storage and for transmitting video over telephone lines. A 500:1 compression ratio is possible. An image can be deconstructed in terms of its fractal content, and reconstructed from the fractal formulae. There is great economy in the storage, but at the moment diseconomy in the compression process.

Artificial intelligence

An intelligent agent "can be defined as a character, enacted by the computer, who acts on behalf of the user in a virtual environment" (Peter Rothman: "Intelligent Agents on the Cutting Edge", *ibid.* p.16) That is, they are specialised software tools that can perform actions on behalf of users of computer environment, coupling an artifical intelligence program to a graphic representation of a character or object which acts as the agent or servant of the user. Intelligent agents are largely in the conceptual realm so far. The existing agents function as separate systems, rather than as part of some comprehensively organised virtual world.

The graphic representation - for instance, a cartoon character on the computer screen that has lifelike characteristics - is a device to make the intelligent agent more user-friendly. The real work of the agent can be done without such a complex interface. The most easily apparent task will be to act very efficiently on behalf of a user to do busy work or complex data search jobs. The telephone answering machine is a crude but widely used agent, and the newer versions have a low level interactivity in which callers are offered a range of possible actions to take in order to achieve their purpose in calling. Already in the 80s the Media Lab at MIT used vocal phone agents with quite lifelike properties - almost the quality of a personal secretary, instructing the boss on who called, what they wanted, the response given, and the schedule for the rest of the day.

A prospect often discussed is that agents will be used to scan the electronic newspaper, extracting only the stories known to be on subjects of interest to the user. The agent would be capable of learning what topics to look for by observing the choices made actively by the user. Agents will be able to search for data in large data bases at a very sophisticated level. They will be able to acquire knowledge and discover patterns in data and also infer relationships not specifically contained in the data (p.21) In a way, these procedures are comparable to those of proceduralist art where a purposeful selection is made from a flood of data in order to draw out some form of meaning.

More pertinently to the arts, agents also will be able to perform in deeply involving artificial worlds for entertainment and educational purposes. The chess-playing computer has been in the press for many years; the agent in one sense acts not for but against the user. So of course agents can play various roles in the drama of the new genre of computer games. They might be characters with particular personalities with which the player can converse. They have been valuable in military simulations relating to real world issues, and games with fictitious content can be constructed along the same lines. (The US military devised two agents as conceptual models of the USA and USSR (Sam and Ivan) and then used them to make predictions about the future relationships of the two countries and the world.)

Individual characters, each with its own goals, behaviours and needs can be created and allowed to interact to form a computational ecosystem or artificial economy, with their objectives being to increase their personal chances of survival or wealth. Agents based on the neural network model will be able to learn and evolve as they work at their assigned tasks.

In the visual representation of the agent, programs have been developed which allow a user to vocally instruct an animated character to perform certain physical actions like walking across a room. It is possible furthermore to instruct multiple agents to interact, with unpredictable and interesting results. Virtual actors will be able to mimic a person's appearance, mannerisms, performance. As with many of these things, an important limiting factor at this time is computer power. But the possibilities for the arts are incredible, if not a little sinister.

Virtual reality

Like most people, the writer's concept of virtual reality has come from press stories promising a multi-sensory immersion in a fabulous illusory world in which without effort or risk one will be able to ski down Everest or make love to Marilyn Monroe (before her death). Imagine his excitement when in a visit to the Museum of Television in New York he discovered a $3 virtual reality experience. Imagine his disappointment when this turned out to be merely a lurching trip through some crude and barely decipherable computer graphics, with only the visual sense

involved. Virtual reality (VR) for the average punter would seem as yet to be mostly a concept. But it is changing rapidly.

The concept is for a computer-generated (and so "virtual") world, experienced in three dimensions and probably involving not only vision, but also hearing and the senses of movement and touch. One will be able to interact with this world, by choosing how to move through it and causing it to respond to one's actions. At present the usual means of participation is a helmet or pair of goggles which place a 3-D video display directly in front of the eyes, and a glove through which one can control one's apparent movement through the apparent reality, and act upon it. When the head is turned, the images change accordingly. Look upwards and you see a ceiling, or the sky, and so on.

Virtual reality will bring together many of the technologies already described. 3-D graphics and animation are of central importance, and 3-D sound will add verisimilitude. The involvement of other senses is in theory possible, and has been realised to some degree.

It is not only a medium of entertainment. It could, for instance, be used as a training mechanism. It is possible already for a trainee surgeon to “operate” on a virtual reality image of a diseased body. Its most apparent forebear is the flight simulator developed by the US Air Force to train pilots. NASA took up from a successful USAF flight simulator and designed the Virtual Interface Environment Workstation, combining computer graphics, video imaging, 3-D sound, voice recognition and synthesis, head mounted display and data glove.

Flight simulators, rather than use a head-mounted display, more often use a screen which stands in for the cockpit window, with imagery something like one might see in those amusement arcade machines with the endlessly unfolding roadway. The trainee sits in a simulated cockpit mounted on a hydraulic platform which moves to simulate the dipping and sloping of a plane responding to the pilot’s direction.

The writer recently experienced an amusement “ride” named the Cinaxe at the Cite du Science and de l’Industrie outside Paris. An audience of sixty sits in a small theatre built on such a hydraulically driven platform, facing a cinema screen large enough to substantially fill the field of vision. Upon entering, it is instructed to fasten seat-belts. The screen and soundtrack give the experience of a rocketship ride through the canyons of a city of skyscrapers: firstly a ruined section, and then the remaining intact wealthy district of the city. The images are highly detailed animations of the buildings as they pass, and of another rocket which moves in advance of us. As might be expected, the ride is like a roller-coaster but freed of the constraints of real-world gravity and inertia. As the rocket soars and dives and jerks around the obstacles in the ruined city, the audience is thrown around violently in the theatre seats. There is a computerised linkage of these movements with the flow of the film and its images.

The ride lasts for four and a half minutes. It is more than enough. This writer was on the way to nausea at one point, despite the fact that we were in a theatre and it was “only a movie”.

The Cinaxe accomplished beautifully what it set out to do. Whether it could have a function other than as an electronic amusement park ride is open to doubt, but it did give some indication of the potential of a type of virtual reality, albeit in this case without interactivity.

New games on video and CD-ROM perhaps will be precursors in some of their aspects to virtual reality entertainments of the future. The top-selling *Myst* invites the player to discover the secrets of a mysterious island by exploring it,

picking up clues, throwing switches, reading books and messages found in the library and half-concealed around its passages and towers. The images are those of a high quality, soft edged comic strip. The exploration is effected with a mouse (i.e. the computer-control device). There seems to be no violence! Because of the relatively meagre capacity of the CD-ROM to store moving images or music, most of the images are still, and because of another of the current limitations, slow to form. The game is structured to require quite intricate reasoning to solve the mystery of this strange island. Those who enjoy books like *The Hobbitt* become very *immersed* in *Myst.* "Immersion" in the context of virtual reality is a semi-technical word, meaning that the viewer feels as though he or she is inside the computer space. Immersion in this case is about attitude, since the images are on a small screen. Fully developed, virtual reality will produce a full-sized world.

The Seventh Guest uses two CD-ROMs holding the equivalent of 360,000 pages of text, and includes high resolution 3-D animation sequences that allow the user to explore an entire house in a sort of screen based virtual reality. The *Return to Zork* combines 3-D computer animation and live video. Often the live actors were filmed against a blank screen and later a 3-D computer generated background was added. *Strike Commander* uses 3-D flight simulation and a story that changes based on the player's performance, for which there is a reward or punishment depending upon success or failure in achieving the missions.

In another version of a sort of interactive virtual reality, Brisbane artists train cameras on people standing in front of a projection screen. Their computer-modified images are thrown onto the screen along with computer-generated imagery or any other visual material. They can interact with each other, with the cameras and with the imagery and see the result as they do it. This interactivity is one of the most powerful contributors to the feeling of immersion.

There currently are virtual reality applications in education, medical imaging, molecular engineering, genetic engineering, medical diagnostics, air-traffic control, financial data visualisation, virtual flight and combat simulation. In Japan in one store, Matsushita's Virtual Kitchen, shoppers can put on data goggles and gloves to "walk around" a conceptual kitchen, moving cabinets and appliances to desired positions; the chosen layout is recorded, manufactured and installed in their real kitchen. Doctors and medical students at Stanford experiment with surgical procedures on virtual patients

There is experimentation now with the incorporation of artificial intelligence and artificial life. There are new virtual reality developments coming to theme parks. It is possible that networked virtual worlds will interconnect people in different locations, and will have multi-user capabilities. Virtual worlds will incorporate touch - users will be able to "feel" virtual objects. (Linda Jacobsen: "Welcome to the Virtual World", in *On the Cutting Edge of Technology*, Sams Publishing, Carmel, Indiana, 1993.)

One of the main constraints to these developments is the current limitations on computer speed and capacity. For real-time animation, the computer must be powerful enough to immediately 'redraw' the screen in response to user requirements. It also must make the objects look good, with high resolution and sharpness, depth of colour, smooth animation. TV quality is the minimum. To this end, a breakthrough is needed to improve image compression. CD-ROM technology is a great storage device, but it is as yet too slow for work in real time. (Trip Hawkins: "State of the Media", in *Cyberarts*, Miller Freeman, San Francisco 1992.p.11)

This book opened with a reference to C.P. Snow and his observation of two non-communicating cultures, science and the arts. We have noted the value of science to the arts, both in contributing new means towards arts production and in explaining the arts as a societal and psychological phenomenon. One writer, Bill Buxton, approaches the issue head-on to suggest the benefits of cooperation between the two fields. (Bill Buxton: “Snow’s Two Cultures Revisited”, in *Cyberarts:Exploring Arts and Technology.* Miller Freeman, San Francisco, 1992)

According to Buxton, if technology is to help cross Snow’s two-culture divide, the computer/human interface has to have the feel of a good artist's instrument - a brush, a piano...

Scientific visualisation is of great current interest. It involves "the graphic rendering of complex data in a way that helps make pertinent aspects and relationships within the data more salient to the viewer... to take better advantage of the human ability to recognise patterns and see structures." It helps to turn mere data into information. There is a clear role here for artists and visual designers.

But why limit this to the visual modality? There will be similar uses for other sensory modalities - like audition. "Let us pursue *perceptualisation*, rather than visualisation."

However, these terms seem based on the idea that humans simply soak up information. This is not how we learn or understand. That we do by exploration, by becoming actively engaged with the material. So we should strive `for *interactive perceptualisation.*

Here is a meeting ground for the two cultures. "The ability to tailor systems to reflect how we sense, think, and problem-solve requires contributions from both the arts and the sciences. Neither has a monopoly. Each needs the other."

" The principle design sensibility underlying these ideas is one of designing to exploit the user's existing skills - the skills acquired through living in the everyday world....our design objective: to design systems that accelerate the process whereby novices begin to perform like experts. (There is both) a qualitative and quantitative difference."

Specifically, the technology should reflect

- the nature of the user's sensory and motor skills - the audible range of sound, the length of the fingers etc
- the user's cognitive structures, the way we solve problems, or think
- our social skills and structures. Most computers were designed for a one-person/one-computer configuration. This doesn't reflect how we work and live. We need technologies that can accommodate people working in groups, along the lines of "groupware" software available for collaborative work in the office.

There is a need to attempt to help shape the evolution of technology in a humanistic direction. Perpetuating a gulf between the scientific and artistic cultures means that one side of the equation is not contributing to the evolution.

We can be sure that one way or another, Buxton’s precepts will be adopted. It is interesting that one of the criteria for assessing proposals for the Australia on CD project initiated through the Creative Nation policies is innovation in the concepts or methods of interactivity. Computer music instruments long have grappled with questions of interface between performer and machine. So in another way, have the hardware companies with such innovations as inputting through hand-writing rather than keyboard. We await Buxton’s more comprehensive solution.

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