Thesis:

The Evolution of Computer Graphics.

The Artist/Designer in a high-technology environment.

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AN EVOLUTION OF COMPUTER GRAPHICS.

THE ARTIST/DESIGNER IN A HIGH-TECHNOLOGY ENVIRONMENT.

by

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CONTENTS

"The children of a culture take up the tools of a culture and the first tools are the tools of communication".

(Margaret Mead from a lecture at Columbia University in New York City in 1966).

The impulse to communicate through graphic images is natural to man and this can be well demonstrated by the fact that they arose very early in most cultures.

Stylised pictorial representations of everyday objects are also the basis of some schemes for writing the spoken word. It is little wonder, therefore, that there has long been a desire for graphic facilities in computer-based information systems, to extend their applications and increase human productivity.

If a new idea or invention is a success it soon becomes part of our everyday lives. As time passes, we find it harder and harder to imagine life without it. In recent history this has been the case with electric lights, cars, airplanes, telephones and for many people, radio and television. But few innovations will change our lives more than the computer.

The idea of computer art (an art unique to the computer) remains after twenty years "an unrealised myth, its horizons barely in view, its forms still to be manifest". Ironically, most of what is understood as computer art today represents the computer in the service of these very same visual traditions which new technology aimed to replace.

Present society, called the society of information or the age of electronics, is changing its features day by day through the new culture provided by technology. The mass media can be found at the core of this present-day culture and can provide us with an enormous variety of information (everything from details of viruses in our bodies to far-away planets). Thus the techniques of science make us recognise as real those objects which, until recently, were thought of as simply dreams or products of an imagination. Besides, the striking progress of image processing methods and simulation techniques (developed in fields such as medical science -Slide 52- geomorphology -Slide 44- and space flight -Slide 70-)has enlarged our world of vision remarkably during the last fifty years. What was not easily seen before, is now reproduced and has come to be a common sight in our lives today.

Because the artist has traditionally been defined as a creative person with sufficient hand-eye co-ordination to produce art, some critics would contend that computer-generated art is not art at all, since the artist is not in intimate contact with his creation.

But closer inspection would reveal that the computer artist, who may not have the traditional technical skills, has the skill of programing to actively direct his system to create images. The same argument is relevant in the case of photography. This time the artist photographer has to be skilful in the use of his/her camera, taking note of such terms as shutter speeds, aperature settings etc.

In this thesis I will attempt to present the artist/designer's perspective with regard to computer graphics and image construction. It is not intended to be a technical paper on computer graphics, nor a history of animation. It is an attempt to explain how various technologies have merged to create a new imagery tool, still in continuous development. I have provided a varied selection of slides at the end of this work to illustrate some of the points which I will discuss. Some are entirely abstract, fulfilling the artist's free-floating fantasies (Slide 66); some represent engineering feats (Slide 34); some are solidly commercial, produced to meet a client's needs (Slide 7). But above all; the computer's role in these works should be understood realistically. The computer is not an artist - not a creative robot - but an instrument, like a piano, with all its keys and strings. It doesn't make beautiful music until an artist sits down and plays.

In the first part of this thesis I will focus on some major historical events which show the development of imagery technologies. These will include the invention of movable type, the birth of photography, the advent of television and of course, the mighty silicon chip.

Following my review of the history of computer technology, the next section of my thesis will describe the fundamental operating elements of a computer. This is an essential background for the next part in which I will look closely at one area of art and design in which the computer is playing and will play an important role. This is the field of animation and film.

In the final part I will discuss the theoretical foundations of computer art/graphics and its confrontation with aesthetics. Questions like: Will machines replace the creative artist? Are they difficult to operate? and What are the limitations? It will be discussed with plenty of quotes from those for and against the new technology. I will also speculate about the future, the hopes, expectations and fears in a fast-developing world. Finally, in my conclusion I will review some of the points which I have discussed and put the current computer graphics scene in perspective.

C H A P T E R   O N E

THE ORIGINS AND DEVELOPMENT OF TECHNOLOGY AND ART

Early Developments:

Most people have reacted with surprise to the artistic products of the computer but in fact these are merely the logical result of a development that is thousands of years old, and covers many fields of science and art.

Throughout history the word-idea, or pictography, has been represented visually by man with the aid of a tool He created these tools of communication or language to deal with his thoughts and ideas. In order to survive, early man had to develop his ability for experimentation and invention. In the first organised communities, he had to learn to represent his environment and his daily life in order to share his knowledge. The impulse to communicate through graphic images is quite natural to man, as can be demonstrated by the fact that they arose very early in most cultures, however seemingly primitive.

Visual messages appeared much earlier in history than script. The paintings of animals in the caves of Western Europe go back as far as the Ice Age, between 60,000 and 10,000 B.C., while written language was invented around 4,000 B.C. Representations of reality evolved into a more complex operation when new imaging techniques were developed and when different philosophical attitudes required a more realistic representation of the world.

It was the fifteenth century by the time western man developed tools to create illusions in the broadest sense of the word. Renaissance man cast aside the symbolic representation of the world, which was held by medieval man, and constructed new images. The two greatest achievements of this period were the invention of the rules of perspective and the developmnet of the chiasoscura (shading) techniques. Fresco and oil painting techniques were also important in enriching previous artistic practices. Hence, by the time the Renaissance period was over, methods and techniques had changed forever the way that reality was represented.

After movable type was introduced in the second half of the fifteenth century, the area of communications experienced a major transformation. Printing liberated images from their old static supports, and made them 'portable'. This allowed the distribution of ideas which opened the world to philosophical and political movements. It was the beginning of a powerful communication network that provided social systems with mobility of information, which would be reinforced by future technologies.

The printing field developed independently of other technologies. In I796 the process of lithography was discovered by Sunfelder; in I897 the first monotype machine was invented, and in I906 the offset press was developed. By I920 designers perceived that the solution to all visual communication problems could be found through machine printing, as the architect Le Corbusier once wrote "Machines that make you well"

Photography:

In the second part of the nineteenth century, the impact and influence of photography on the general process of image-making can be compared to the impact that computer graphics is having in today's world. Before the invention of photography there was no other way of simulating reality other than painting with 'realistic' techniques. The artist was somebody who made visible the invisible, visualised concepts and emotions, and created illusions of space, colour and even content. The desire to record reality by chemical means had been a common dream to artists and scientists for centuries. It became a reality when some knowledge of the behaviour of light and optics was combined with the use of light-sensitive materials.

The first photographs were taken during the I820's and I830's by two French photographers, Nicephore Niepce and Louis Daguerre. From their experiments with the camera obscura (a method of tracing images), they managed to capture images on silvered copper plates which they called 'daguerrotypes'. In England W.H. Fox Talbot succeeded in fixing images on light sensitive paper in I835. These were the first photographic prints.

During the remaining part of the century technical improvements in cameras, film, processing techniques, etc. followed these early discoveries. Cameras got smaller and more advanced and when the roll-film was introduced by the Eastman Company in I889 photography soon became the hobby of millions. History is repeating itself today, almost one hundred years later, but this time with computers.

An English photographer working in California during the latter half of the nineteenth century took up the challenge of studying human and animal movement by photographic means. His name was Eadweard J. Maybridge, and his series of photographs contradicted all previous representations of movement by artists. Now photography had won a powerful victory in its correct role as 'evidence' in nature and culture.

Realism Versus Fantasy:

The initial reaction to photography among some artists ranged from fear to lack of interest, but others promptly experimented with it and integrated it into their working habits. What they found most amazing about this new technique was its ability to record reality without any human intervention. Paul Delaroache, a French academic painter, made a far-fetched statement in 1839 after reviewing Daguerre's new invention: "From today painting is dead". It exemplifies the reaction and feeling of many artists of that time. No less amazing was the fact that any inexperienced person could operate a photographic camera and create realistic images. The same reactions have been applied in recent years to the computer's powerful ability to create images.

The influence of photography became stronger when portable cameras began to be mass marketed in the 1880's and when photoengraving and photolithography revolutionised the printing industry (following the invention of the halftone photo-block process by Georg Meisenbach in Munich in 1882). Photography was capable of documenting the social changes that took place in the world at that time; it was immediate reality and led to the formation of the 'realist' movement in painting.

Photography also transformed the way of looking at reality, resulting in it becoming a major tool in dealing with images. But it never replaced painting because both techniques run parallel to each other and never compete for the same goals. Computer systems may copy the techniques but the results can be quite different if necessary. A good example is - the two similar subjects but different techniques shown in slides 22 and 28.

For a long time photography was considered 'less valuable' than painting - its only use being its ability to liberate painting from the tedious work of portraying reality. It is now properly regarded as an important component of modern art. If one analyses some of the reasons which led to photography being considered inferior to painting, the results can be quite interesting, because a similar phenonomon is happening (or will happen) with computer art/graphics. Here are a few of those reasons:

Photography does not have anywhere near the large amount of hand-craft that is involved in painting, and it is more closely related to graphic techniques (lithography, silkscreens, etching, etc.) because it uses a "master" original to produce copies. That doesn't take away from the visual value - Photographs can be the subject of very extensive, expressive manipulations. They are a lot more than just an automatic recording of reality. For example, Bauchaus, Dadaist and Surrealist artists such as Man Ray, Max Ernst, Laszlo Moholy-Nagy and El Lissitzky found a valuable expressive medium in photography for use in collage, graphics and abstracts. The photograph was no longer a representation of the model but the model itself.

It liberated painting from portraying reality, from story telling and even from dealing with a subject. It could be said that it was used as an excuse by abstract and avant-garde artists for their creations.

Better, faster and more precise equipment has led to the spread of photography to all areas of the earth. But with all this sophistication and control of the photographic image, it must be remembered that although not all photographers are artists - some definitely are.

The possibility of motion as a component of the creative imaging process was becoming a possibility towards the end of the nineteenth century, but remained untouched by photography for many years. The next chapter focuses on the development of techniques that introduced motion as a component of image-making

Moving Images:

Movement is a sign of all living organisms - everything from humans to the smallest microplasms. It is one of their essential characteristics from birth to death. Even the things which we depend on for our existence- sound and light - are themselves forms of energy in motion. All through this century, scientists have been deeply involved in analysing, measuring and exploiting physical energy. The conversion of energy by splitting the hydrogen atom led to nuclear power; the concentration of light into a narrow band led to the laser beam and to holography; the utilisation of electricity led to the computer. All these cases show form of dynamic movement.

As a source of inspiration, it would be difficult for the artist not to be influenced by such discoveries. Kinetic Art utilises the forces of gravity, electricity and imagination. It integrates these in a creative manner with most of its attention given over to movement. Both this and film animation are the purest forms of expression to convey motion mechanics. Kinetic art creates actual movement by animating real objects and constructions (for example sculptural mobiles and light paintings). Animated film-making differs in that it achieves its effects through the mechanisms of cinematography (photography processing, editing) and cineprojection. It has the freedom to creatively exploit some of its own mechanical processes, as well as newer inventions in machine technology. It can be said that film is the art of disciplined movement and animation, in its true sense, is the art of mobile graphics. Let us look back over the past few centuries and follow some of the major developments that have led to the highly advanced film animation industry of the present decade.

Throughout recorded history, man has attempted to reproduce the world of movement. In its earliest form the motion picture was most likely the shadow of moving hands cast by firelight, perhaps upon a cave wall. The first step towards the modern motion picture came with the introduction of the magic lantern in the seventeenth century by Christian Haygens. Optical enternainments were fashionable in the late eighteenth century with shadow shows, panoramas, dioramas and magic lanterns. All of these required the use of light to either create an image on a screen or to illuminate pictures producing illusions of depth or the effect of changing natural light. There were also domestic versions in the form of boxed peep shows. But if there was anybody at the beginning of the nineteenth century who conjured up visions of rows of people sitting in the dark watching moving pictures projected from a magic box, they would have soon found themselves packed off with bell, book and candle. Yet it was at this time that the various links,which combined to produce moving pictures by the end of the century, were being forged.

P.M. Roget the English mathematician, was the first to study the phenonomon of persistence of vision; on which cinema is based. In I824 he demonstrated the principles and some of the effects of this optical illusion. J.C. Paris, an English doctor, marketed the Thaumatrope in I826 as a toy. It consisted of a circular card carrying a picture on each side. When this is rapidly rotated on its axis, like a coin spinning on its edge, persistence of vision causes the two images to superimpose. From this demonstration developed the experiments of the Belgian scientist, Joseph Platean. In I832 he introduced the Phenakistiscope - the first instrument to animate a series of pictures through persistence of vision.

One development followed another over the next few decades. Technical advances in one area always seemed to lead to further advances in other areas. Today similar advances are constantly occurring with the developments in micro-chip technologies. The benefits are passed on to the artist/designer who uses computer-based imaging systems.

In the late ninteenth century scientists began to employ Chronophotography (the recording of photographs at regular intervals) to study movement. The English photographer Eadweard Maybridge used Chronophotography in the study of human and anumal movement, with the aid of a battery of cameras exposing in rapid succession. Between I878 and I890 he made major contributions both to the science of movement and to the development of the moving picture through his published photographs and lectures.

Professor E.J. Marey, the French scientist, investigating animal movements, devised the first motion picture camera as we know it. It consisted of a photographic gun in which twelve pictures could be recorded on a circular plate in about one second. The American scientist and inventor, Thomas Alva Edison, was working towards the simultaneous recording of sound and motion during the I890's. His Kinetoscope was shown publicly in I893 and was the first commercially successful motion picture system.

The Lumière Brothers in France added a stop motion device to the camera which permitted the projection of films by a light beam onto a screen at a rate of twenty four frames per second. They created some films which were shown in Paris during the I890's and called cinématographe. The age of the motion picture had begun.

George Melies, a French theatre owner, opened the first movie theatre and also the first motion-picture production studio where he developed effects like dissolves, stop-motion animation and scale models. He even produced the first film to be lightened with electric light. His films became longer and more adventerous and in 1902 he produced his most successful film "A Trip to the Moon". Cinema soon broke away from its theatre restraints and successful actors soon became film stars. As technology became available, the cinema exploited it - the zoom lens, the carbon arc lamp, sound phonographs, sound-on-film, magnetic recording, stencil colouring, toning and tinting etc. All of these plus the development of a cinematic language and innovative use of camera movements by directors (panning, tracking, close-ups etc.) led to the situation where, by the mid-1930's, cinema was the most popular mass entertainment medium ever. Technical advances made the written word popular with the invention of printing and now it has done the same for the moving picture.

As our society got more sophisticated and the public more demanding, costumes, masks and theatrical settings were not enough to create visual illusions. New tricks had to be devised to stimulate greater reality - a collection of these is known as effects.

Space and science-fiction, monster, fantasy and disaster films rely heavily on complicated techniques to create scenes that would not be found in real life. These effects could include: optical printing (it made Christopher Reeve fly across the urban sky of New York City in "Superman- The Movie" 1978), Stop-motion photography (brought the model of a giant beast to life in the film "King Kong" 1933), Rear and front projection (the blending of a human actor in an ape suit with images of real apes in "2001: A Space Odyssey" 1968), cel animation (superimposed to live action sequences in "The Birds" 1963), Make-up (Planet of the Apes" 1968), Mechanical Effects (brought the great white shark to life in "Jaws" 1975), Live Effects (recreating the fire in "The Towering Inferno" 1974), Motion Control Systems (The computer-controlled camera system used for shooting the special effects in "Star Trek, The Motion Picture" 1980).

Developments In Animation Techniques:

The cartoon or animated film was first created on devices that preceeded the film camera and projector. The Phenatistoscope, Zoetrope and Praxinoscope, among others, made use of animated drawn images.

Among the earliest true cartoon films were those of Emil Cohl, the French cartoonist and photographer. "La Fantoche", which was made in I908, was the first cartoon film. His films were very simple in style and animation, just like his contemporaries the American artist J. Stuart-Blackton and Windsor Mc Cay. This was necessary because sixteen pictures had to be drawn for each second of screen time. A technical advance came with the patenting, by the American cartoonist Earl Hard and J.R. Bray in I9I4, of processes using celluloid sheets (cels) to portray only those parts of the subject that were to move - the background and other non-moving subjects were thus painted only once for each scene. This simplification of the process brought about an increased use of the cartoon. Live action was also included, along with stop-motion photography which amazed audiences of that time. This type of early animation inherited the use of tricks from magical theatrical performances.

In I9I7, Max Fleischer, creator of 'Popeye', made his first cartoon. Felix, the first of a long line of cartoon cats, was introduced by Pat Sullivan; Walt Disney entered the field with 'Laugh-O-Groans" in I92I; the first "Silly Symphony" with sound appeared in I929; the first three-colour Technicolour cartoon was "Flowers and Trees" in I932; and a number of feature-length productions followed from I937.

These technical advances always seem to follow,one after the other, from the early discoveries. History is constantly repeating itself. Printing, photography and film-making all developed over a period of time, from a scientific invention to a highly advanced art-form. In the middle thirties, cel animation was at the same stage that computer animation finds itself at today - the door open to a potentially great future. Among the major technical developments pioneered by the Disney Studios was the multiplane animation cartoon with which complex animation effects of great realism could be produced

In the late 1940's, the realistic image characteristics ofmany of the Disney feature cartoons gave way to a simplified style, sometimes approaching the abstract. A change pioneered by United Productions of America (U.P.A.) and developed as many sponsored cartoons (especially for television), encouraged new styles of drawing. In addition to the cartoon, other forms of animation have been developed - puppets, silhouettes, abstract forms etc. Many of the most recent experimental animators - John Stehura, John Whitney, Peter Foldes, Stan Van der Beck, Ed Emshwiller, work with computer-aided systems.

Today, the cost of live action film making is rising so high that animation has become competitive, especially in the area of television commercials. The future of animation at the beginning of the 1980's looks brighter than it has since the early 1930's, with numerous feature movies and television specials in production around the world; new studios being established, specializing in every area of animation; computer and conventional animation growing more sophisticated,and audience attendance at animated features and festivals steadily increasing. The film producer/ director Ron Stark refers to it as the beginning of a new 'Golden Age'.

Television: A New Member In The Family:

In Marshall McLuhan and Quentin Fiore's book "The Medium is the Message: An Inventory of Effects" (New York: Banton Books, 1967) they refer to the fact that Jules Verne, the famous science fiction writer of the late 1800 's predicted that television would be invented in the twent-eighth century. The date of his prophecy was proven wrong long before the 1970's, a decade when over one hundred million T.V. sets were built. In fact television has a greater effect on modern human life than any other form of media. The power of the networks and the effect of advertising in human behaviour, the manipulation of information and the shaping of a collective image are the effects of T.V., effects which totally mystify the human intellect. It is such a versatile medium that it opens a window to human culture, myths and knowledge and provides the viewer with an intense visual experience. While the information it provides is less analytical and has less coverage than printed media, it selects key events and provides immediate information on an emotional level.

One of the basic conditions for the existence of T.V. the transformation of light into electrical signals, was discovered in I873 by F.R. Carey, using a mosaic of selenium cells and a mosaic of electronic light to transmit images on a wire. Various scanning methods to produce master images were devised during the last two decades of the nineteenth century. In I929 Vladimir Zworykin came up with the Kinescope an improved version of the cathode ray tube, which provided the necessary elements for the operation of an all electronic television system. The first public deomonstrations of wireless T.V. systems were organised during I925 by C.F. Jenkins in the United States and J.L.Bairdin, England. These events caught the attention of the big radio companies which rushed to acquire the new technology. In I929 the BBC began regular daily black and white broadcastings, CBS in the U.S. became the first network to broadcast a commercial colour programme in I957 and at the time black and white T.C. became profitable. In I956 Ampex introduced the quadruple videotape which made possible the recording of shows and events. During the fifties also, television affected the movie-making industry for the first time.

With the advent of integrated circuits and micro processing all T.V. equipment and cameras became smaller and portable. Today satellite transmissions and digital techniques are changing the style and operations of the T.V. industry. The T.V. monitor has become the preferred output element for inter-active computer systems. It was the first technological advance to have a direct effect on the mechanical or hardware parts of the computer. It can be regarded as another step towards the realization of computer-generated images

From the Abacus To The Microprocessor:

Computer technology in general has evolved tremendously in the last ten years, but the search for more automated calculating devices can be traced back a long way. Computers are still thought of as large and daunting devices, even by those people who have programmable pocket calculators containing all the essential features of a computer.

Where, when and how did these wonders of modern-day science come about? For some of the answers, let us take a closer look at their evolutionary process.
The earliest users of calculating machines were the Chinese with their abacus in the sixth century. During

the seventeenth century, because of the increasingly complex calculations involved in astronomy, more sophisticated calculating devices were needed.

The German mathematician and philosopher, Gottfried Wilhelm Leibnitz, started working with binary numerial systems (systems which are able to represent any number using string of only two symbols), and called it "universal calculus". He was followed in I822 by Charles Babbage, an English mathematician and engineer who attempted to build an automtic calculator using decimal counting wheels. His device was capable of completing an addition operation in one second. Three years later, another English mathematician, George Boole published "The Laws of Thought", a paper that took up the search for a binary universal calculus from where Leibnite had left off one hundred and fifty years before. But it was not until the I930's that both Boolean logic and electronic circuits were linked together, Claude Shanon, an electrical engineer at the Massachusetts Institute of Technology realised that the overall behaviour of electrical circuits could be exposed in a form of mathematical logic.

The coming of World War Two revealed the need to optimise calculations, not only for number-crunchers but also for powerful code-breechers. The Colossus" built by Alan Turing in England was capable of reproducing the function of any other computer machine and helped Allied Intelligence to gain full control over Nazi code systems. This was followed in I943 by the Mark I in the United States, but was soon attached by the ENIAC, designed by John W. Mauchly and J. Presper Eckert Jr. The ENIAC relied on the more efficient vacuum tubes that could switch states more quickly thus electronagnetic relays. In the I950's a few big companies started to get interested in purchasing computer systems. But in I948 Walter Brattaim and John Bardein, working at Bell Laboratories in the U.S., announced the creation of a new switching device that would replace all the dial methods and totally revolutionise the electronics industry, and the world. It was called the transistor and because it was solidstate, it did not need a vacuum equipment to operate. Developments were made by William Shokley with the "P-N-P Junction" germanium transistor in I950, and GordonTeal, with the silicon junction transistor in I954. As manufacturing technologies evolved, the production of transistors boomed.

The most logical step in miniaturisation came with the integrated circuit (IC) which also showed a marked decrease in the amount of manual assembly needed. Using silicon (the second most abundant element on the earch) as the basis, all the elements of a circuit were built up together and could operate independently with no electrical interference. The semi-conducting layers were formed on the surface of the silicon'chip'by a chemical process. This allowed the information to be stored in 'memory' as the presence or absence of electronics in microscopic locations. The American researchers who developed this 'phaser bi-polar process' were Robert Noyce of Fairchild Semiconductor and Jack Kirby of Texas Instruments.

In the early seventies the U.S. was number one in the development of microelectronics. The Intel Corporation put all the arithmetic and logic processing circuits on one chip, taking advantage of the integrated circuits 'miniaturisation capabilities'. Those circuits constitute the Central Progressing Unit (CPU) of the computer. By putting them together on a single chip they created a microprocessor. It holds hundreds of thousands of microscopic elements such as transistors, resistors and capacitors. It can perform logical and arithmetic operations on strings of binary data and can do it very fast. Some of them can perforn one million calculations per second. The smaller they are, the cheaper and better performers they are.

It can be concluded from the last few sections of this chapter that human evolution is closely bound up with technological change (i.e. with the introduction of ever more efficient machines and machine-like systems). Technical progress proceeds through series of phases. These are: handcrafts, mechanical mechanization, classical physical technology, electro-technology and finally electronic automation. The increase in technical developments which follow on invention and discovery proves that there undoubtedly exists a trend toward the fullest possible mechanization of all activities that can be taken over by machines.

Photography was the most significant stage as the path to the mechanisation of art and design. In the final years before computer art became known, numerous attempts were made at mechanical pictorial compositions: these were largely based on photography in conjunction with mechanical aids.

Another development which lead logically to computer graphics was the discovery of the beauty of scientific structures. The artist or scientist has an active involvement with aesthetic concepts and values,but does not create anything. A milestone in this development was the book"Foto-auge"by Franz Roh in 1930. He was the first to see photographs of medical diagnostics, astronomy, aerial photography etc. as aesthetic objects. His book includes examples of scientific photographs regarded as purely aesthetic images.

The First Applications Of Computer Graphics:

Early computer graphics were produced by a rather primitive arrangement in which the computer drove a plotter working on a rotating drum, something like the devices which record changes in barometric pressure. The American artist, Ben F. Laposky provided the first major initiative in generating graphic images by means of electronic machines and computer installations. His work, which commenced in 1950, was based on the super-imposition of electrical oscillations of varying time functions. He called the results "oscallons" or "electronic abstractions" and usually took the form of sine-waves, sawtooth curves, or square waves, similar to some of the examples on Slide 81 by John Whitney Sr. In 1960 Kurd Alsleben in collaboration with Cord Passow started to make drawings by means of an analogue system and a mechanical drawing installation. But the first aesthetic computer graphics was made with the help of large digital computers in 1963. They were pioneered by the periodical "Computers and Automation" which, at the same time, announced the first competition for computer graphic works.

In the early 1960's computer graphics were developed to visualise objects and situations that were too costly or impossible to represent otherwise. Flight simulators , CAD/CAM systems and CAT scanners were among the pioneering computer graphic systems. The first computer to use cathode ray tubes (CRT) as output channels was the Massachusetts Institute of Technology's Whirlwind computer in 1950. The Sage Air Dispense System in the middle 1950's was the first to use ' command and control' CRT display consoles, on which operators identified targets by pointing at them with light pens (an interactive device).

The beginnings of modern interactive computer graphics can be found in Ivan Sutherland's work on the 'sketchpad' drawing system in the early sixties. This system made use of several new interaction techniques and data structures for dealing with visual information. It had all the capabilities for the manipulation and display of two and three dimensional wire frame objects, and provided "a vision that sustained the fields of computer graphics for over a decade while techniques and hardware matured" (from the Association of Computing Machinery's Special Interest Group on Computer Graphics, SIGGRAPH.)

Slide I7 shows a spatial plane which in its three dimensional form is distinguished by hatching or net representation. You may notice that all hidden lines are removed.

Sutherland started the first laboratory for computer graphics at Harvard University, where he concentrated on the display of 3D objects and the requirements of user feedback. As a co-founder of Evans and Sutherland, he was instrumental in the development of LDS-I, which provided the first real time display that incorporated clipping and perspective transformations. It also allowed for real time simulations and the modelling of moving objects within a well defined environment. (See Chapter 2 on Image Generation)

At this time also, the enormous potential for partially automating drafting and other drawing-intensive activities in computer-aided design (CAD) and computer aided manufacturers (CAM) was clear to the manufacturing in the computer, automobile and aerospace industries. By the mid-sixties a number of research projects and commercial products began to appear. Prominent among these was General Motors who produced various time-sharing graphic stations for car design. Other companies which developed similar systems include: Boeing, IBM, McDonnell Douglas: General Electric and Lockheed. The U.S. also produced the first examples of figurative computer graphics. William A. Fetter, who was the first person to use the term "computer graphics" in I960 created an extensive series of experimental works for the Boeing company in Washington. His aim was to work out the most efficient layout of an airplane cockpit. He designed a program with which plotter drawings of people in various positions were generated.

Slide 86 show a pilot in one such position. Notice the simple, three dimensional form of the figure. The wire-frame construction is a major advance from the totally two dimensional, abstract shapes of earlier computer graphics.

He also produced drawings to represent different views of an airport as seen by a pilot about to land. The same principle is now being widely applied to every field of construction, manufacture and operation - space shuttle pilots practice manoeuvres in simulators for years before their maiden voyage; an architect can provide a computer with all the dimensions of a room or building and can then instruct the computer to provide a drawing of the proposed structure viewed from any position inside or outside.

Slides 33, 37 and 67 show just how advanced in technical and aesthetic realism the computer is at this stage in its development. The three dimensional, wire-framed, tennis stadium in Slide 6 can be viewed from any angle the observer wishes. Just imagine how many photographs that would take without the cababilities of computer animation.

Although these works had strictly scientific purposes in the firstplace, their aesthetic aspects were so striking that they have always been seen in the context of computer art.

Computer graphics got international public attention in 1965, when the first exhibitions were held in Stuttgart (in Germany) and New York (in the U.S.) The more prominent artists involved in these included: Frieder Nake, George Nees. (Slide 87 shows a computer sculpture of Nees, made up from wooden blocks, whose size and positions were resolved by a random program). A.Michael Noll and Bela Julesz. Computer Art Exhibitions have always been associated with lectures and discussions to a much greater extent than more traditional art events. The first exhibitions were held in rather modest settings, in isolation of other exhibitions. But by the beginning of the seventies public interest had grown enormously and computer graphics and computer music were presented side by side with works produced by traditional methods.

'Cybernetic serendipity', which took place in London in I968 was the first of such exhibitions. It aroused world-wide interest in computer graphics which continues today, especially with the two premier computer shows in the United States - the National Computer Graphics Association (NCGA) Conference and Exhibition,and the Siggraph Conference and Exhibition. (Slide 4I is just one example of the work shown at the I983 Exhibition). Another important event in the development of computer graphics was the publicising of Herbert W. Franke's book "Computer Graphics Computer Art" in I97I. His collection of illustrations from all sources and his study of their aesthetic values opened many eyes to this new phenonomon. An example of his own work can be seen on slide 74. - an abstract but quite colourful and dazzling display.

C H A P T E R   T W O

A TECHNICAL OVERVIEW OF THE COMPUTER

Hardware: The Basic Elements:

All computers regardless of their size or purpose share a similar basic structure that performs all the basic functions. The term 'hardware' refers to the 'hard-wired' circuits or the physical components, both electrical and mechanical. The computer is thus a collective noun used for a group of devices - the Central Processing Unit, Memory, Input and Output.

The Central Processing Unit (CPU) is that part of the system which can perform operations as a result of instructions. It is the 'central brain of the computer and, in large machines, consists of a series of circuit boards. In smaller machines the CPU is usually contained entirely in a micro processor. They accept'data' in strings or 'words' of binary digits (bits)*, and the length of those strings can vary. In the case of microprocessors (the increase in their processing power is proof of the explosive development of micro-computer technology in the past few years.

Memory is the section of the computer where all the information is stored. This information is encoded in a binary form for distribution and storage in a huge array of 'compartments'. These compartments are numbered and addressed for recall when needed. There are three basic types of memory: Randon Access Memory (RAM), Read Only Memory (ROM) and Peripheral Memory. RAM is dynamic memory where information can be continuously changed. ROM has fixed contents and can be only read but not altered. It included the basic instructions for the computer to operate properly. Peripheral Memory allows large amounts of information to be cheaply stored in a more permanent way than in RAM. This was formerly punched type, but today it is usually magnetic disks or tapes.

Input encompasses all the circuits and peripherals used to enter information into a computer - the keyboard (alpha-numeric); the graphics tablet (an electronic drawing pad or digitising tablet), the light pen (a touch-sensitive instrument), control dials, joysticks and scanning cameras.

* Digital technology consists of the analysis of continuous (analog) range of information into a series of discrete numerical sequences (digital information - made up of positive/negative (+/- or I/O) binary elements.

The input devices could be called the computer's ears and eyes, and the output devices the computer's mouth. The computer communicates with us, and with the rest of the world through its output channels When dealing with visual communication, the choice of one output device or the other can bring very different results.

Output technologies become a significant factor when dealing with images. The quality of an image can be measured among other things, in terms of its resolution'. This term is used for the number of 'pixels' which can be displayed in a computer generated image on a cathode ray tube (on raster displays it is usually a matrix of horizontal pixels and vertical scan lines). A pixel is a minuscule dot, a single picture element, somewhat like halftones in printing. Output technology affects the definition of images by its ability to produce grids of dots. The smaller and tighter the dots are, the better the resolution will be. Hard copy output comes in a few forms; these are printers which use a dot matrix or in some cases, overprinting alphanumeric characters to produce shading and intensity values: plotters which can actually draw continuous lines with pens; and electrostatic charges, which can distribute tones on paper like the photocopy technique. The camera used to photograph an image displayed on a cathrode ray tube, could also be considered another hard-copy output device.

The CRY is the most popular choice for the display of high quality images, and for the interactive creative process which allows images to be changed dynamically and quickly. There are two basic types of computer displays - calligraphic or vector displays, and video raster displays. The image we see on the screen is created by the glow emitted by a phosphorous coating when bombarded by a beam of electrons. Because it decays within a very short period of time, a picture must be 'refreshed' by redrawing it may times per second so that it appears to the viewer as a constant unflickering image.

Vector displays allow lines to be drawn between selected positions on the screen. The video raster displays trace an image line by line in sequence to a predetermined time base. It has wider possibilities of application than vector displays since it can deal with halftone and colour as well as other vector images.

Software: Programs And Languages:

Without the use of software, hardware is almost useless. Software refers to the entire organised set of instructions, programs, procedures and documentation that are related to a computer system. It contains coded information necessary for the hardware to operate. It injects the circuits with knowledge and makes them perform different operations. Computer programs are coded into binary language and are usually stored on a magnetic medium. They are made up of a series of structured instructions and rules for logical operations that instruct the computer to perforn different actions.

Software can be divided into two main categories according to the functions that they perform. Systems programs perform operations related to the computer system in general and application programs are designed to solve a particular set of problems related to a particular area (graphics programs are in this category). There are several programming languages, each suited for a specific area or problem. Some of these have been designed to create manipulate and display visual images, including ASAS, SYNTHAVISION, GRAMPS, PICTUREBALM, GPAC, DATA PLOT ETC. ASAS for example, is a language that provides functions for controlling elaborate animation sequences.

Graphic software has been developed for a great variety of applications including those programs which are designed to operate with a specific hardware. In the case of seal time, complex animation there is always a need for a special purpose display system to aid production.

In the early days of computer graphics, the equipment and expertise limited any development of the graphic systems. Also limited was the software needed to drive them. These small volumns of expertise and equipment could hardly deal very quickly with complex problems of storing graphics data and producing images from it.

The production of portable and structured software is becoming popular at present. A program (or set of programs) that contains the basic graphic functions and is device-independent, is called a 'general-purpose graphics package'. This kind of software makes possible the use of device-independent subroutries that can be adapted to different graphic systems with minimal changes, and provide the programmer and user with high level access to the graphic input/output hardware. It makes possible greater user-computer interface which provides elements such as: a conversation language, interaction techniques, a set of routines that perform the basic graphic manipulations, feedback and plenty of back-up. The basic drawing and graphic functions, for both vector and raster graphics, include full polygonal areas, colour and intensity specifications, display of patterns, limited three dimensional (3D) hidden surface removal, raster bit-pad manipulation, perspective, and several colour models.

Graphics software is designed to be used as a creative tool. Good software provides the user with commands and interactive routines as well as a compact language suited to express visual operations It means that programs which are easy to use and stimulate creativity will result from taking human factors into account during the design process. A computer graphics system 'imitates' the way we handle visual information and contain several functions that we use to transform ideas into images etc. drawing, colouring, composing and image processing.

Image Generation:

Computer generated images exist in a synthetic environment. They represent the world with precise formulas. In their visible form they are only optical illusions. They are generated in a different world and made from shapes that we have never seen before. Programming realism into a computer is not only a technological problem but also a 'game' with perception - on one scale we have to progress our computer generated model in the same way that illuminated objects are perceived by the human eye (Slide 53) as the other, we have to recognise computer generated world and shapes that we have never seen before (Slide 77). We have to refine our ability to perceive what we can see. We are capable of seeing and recognising any new environments by accepting them and integrating them into our experience. It must always be remembered that the human brain can generate knowledge and be far more complex than any computer. The designs of computer graphic systems should take into account the need of effective co-ordination of hand-eye-brain. The user needs tools to perform most of the actions which are needed in the creative process, without being overloaded with information. For example, the knowledge of how an image is captured on photographic paper may be useful to a photographer, but it is far from a necessity.

In order to create synthetic images with a computer system, several procedures are necessary. These procedures are performed by specialised parts in both hardware and software.

Today's mini and microcomputers are close to performing tasks that yesterday were reserved for mainframe computers. Take the two slides, numbers 8I and 83 for example. The first slide shows a sequence from the film 'per-mu-ta-tions' by John Whitney. It was formulated on quite a large main-frame computer, the IBM 360, in I966. The second slide is a plotter drawing "Skew B" made in I983 by the artist Mark Wilson. He used an IBM Personal Computer which is a lot smaller and just as powerful as the older machine. A few years can make an enormous difference to a fast developing industry. Storing and refreshing images is looked after by a refresh memory called the 'frame buffer' which is included with most graphic systems. It is arranged in a two dimensional array where each location corresponds to a location on the screen.

At present the program needed to create realistic images must be complex and computationally intensive (especially for the images like those shown in Slides 42 and 43). Most systems share the basic operations needed to create fully symbolic images. In all cases the object is first defined (numerically or interactively) and located in three dimensional mathematical space. Next a camera location (viewer's angle) and field of view (area being observed) are defined, and the three dimensional numerical description is transformed into a two dimensional perspective image. All hidden lines on surface are removed. In rendering the scene the necessary illuminations, texturing and colour are added. Slides 6I and 62 show two steps in the process of rendering a sphere; in Slide 6I its surface is wire framed by a series of lines around the circumference; the polygons or areas created within this grid can be filled in and shaded with reference to a specific light source as shown in Slide 62. A more complex sphere with alot more polygons like those on Slide 46, can allow for more complex lighting environments stimulating shadows, reflections and refractions of light through surfaces etc.

From a designer's point of view, creating a three dimensional (3D) image, like the examples shown in Slides 7, 49 and 52, is more like sculpting than painting. He is creating a complete model of a shape which can be viewed (or even photographed) from various angles, but exists independently from the observer. In fact in the world of computer aided designs (CAD) the model itself is the ultimate product - the images made up of it are just to ensure that the model is correct.

The technique of modelling textured surfaces and the use of reflective maps (the reflective properties of a surface when a certain amount of light falls on it) was introduced by James F. Blinn and Martin Maxwell in 1977 while they were at the University of Utah. Their method of modelling light reflection from opaque surfaces is now the standard. Any non-transparent or opaque surface reflects a certain amount of light depending on its texture. The only reason why we can see the surface of the moon is because it reflects the light of the sun. The smooth white body of the snowman in Slide 12 will reflect much more light than the complex and colourful surface of the globe in Slide 13. To create this 3D effect the designer must specify the lighting environment. Simulated light sources may be placed at any desired location in space and their colour and brightness specified. Different systems simulate lighting environments at different amounts of detail and accuracy.

Blinn devised what is called "a scan-line algorithim for directly displaying bi-cubic surfaces" as well as a number of other useful mathematical techniques for manipulating 3D objects. He worked as a consultant for the Compter Graphics Laboratory of New York Institute of Technology (NYIT) and for the Motion Picture Project at III before moving to the Jet Propulsion Laboratory of the Californian Institute of Technology.

If a model appears in two dimensions then two numbers are required to define the location of a point as its surface, i.e. the horizontal and vertical distances. In the case of 3D models, one needs three numbers to describe a point on its surface, i.e. the horizontal, the vertical and the depth distances. These numbers can be used by the computer to define shapes in several ways.

The simplest type of 3D computer model is called a ' wire-frame' model and is the earliest type of computer modelling (it has been in use since the late sixties). It is very common today, especially in television commercials. The co-ordinates necessary can be input into the computer by keyboard or by electronic pen (a digitizing device which transfers data to the computer by touching an electronically sensitive drawing surface at certain points). The wire framed,Minolta photocopier (Slide 9) and simplified tennis stadium (Slide 6) for CBS Sports were created in this manner. Both slides are frames from animation sequences which allow the viewer to move around and over the images with amazing and accurate results.

After the basic shape of an object has been designed, the computer can make certain geometric changes in the design, merely by doing some arithmetic on the co-ordinates. These alterations are called transformations. The simplest types are moving the object to a new location, making the object a different size, rotating the object and viewing the object in perspective. In addition to the descriptions of the points and outlines of an object, the computer must be given information about where solid surfaces lie.

The simplest solid modelling technique is to describe the surface of the solid as a collection of flat polygonal surfaces. Each such polygon can be described by giving the co-ordinates of each point around the perimeter. Polygons are simple for programmers to manipulate and programs which deal with them can be quite fast. The city, shown in Slides 3 and 4 for a television commercial by Ohio Bell Telephone Company was created using a plan and elevation of the buildings. When these dimensions were input, the computer could produce an accurate, wire-framed image of the city. Each building was a collection of polygons (or simple geometric shapes in this case) as shown in the motion test on Slide 3. The finished piece of animation (Slide 4) was fully modelled or rendered by giving a texture and colour to all the polygons. Implicit surfaces, like curved surfaces, can be described mathematically in several ways. Basic shapes can be simply transformed to suit the designer's need. For more arbitrary curved surfaces, such as car bodies or airplane surfaces, one may use 'patches' which can be stretched by mathematical means to cover a shape. Slide 52,showing the complex surface of part of a spine is a good example of this. It began as a contoured shape (as demonstrated in Slide IO) after having its co-ordinates input into the computer. The designer could now stretch the patches over the shape, giving it a fully three dimensional appearance.

When a designer has a collection of shapes in defined locations and directions in space with a desired viewing angle, he can begin to render the scene using line drawing (Slide 2) or shading (Slide 8). The image which a designer renders reflects a certain amount of light from its surface. The amount of light reflected to the eye will depend on the properties of the surface - colour, gloss, transparency. These properties might change from polygon to polygon. The process which does this is called image mapping.

The designer must also specify the lighting environment which can result in shadows and reflections/refractions of light as in Slide II. Now the animation can work with real models rather than drawings.

With all these amazing effects in the hands of an animator/designer/artist, he is for the first time capable of manufacturing a look and feel that has never been possible before. Further advances in software and hardware will serve to speed up and enhance all these processes, allowing the designer/animator more freedom.

Image processing techniques (which I referred to earlier) are used in many fields, and one of its main applications is the improvement of pictorial information for human interpretation. These techniques started in the I920's with the first digitized images being transmitted through the first transatlantic submarine cable. They were further developed for the transmission and reception of images generated during the missions of NASA's space program of the I960's. It can be used for improving the visual quality of images for their manipulation. It does not create them. The computer artists Kenneth C. Knowlton and Leon D. Harmon published a definition of it in "Science" magazine of the early sixties;

"By picture processing we mean either the transformation of graphical material or the generation of pictures from data or abstract rules alone, or combinations of these operations"

An image to be processed is first digitised by sampling its brightness levels, and translating them into a digital array of pixels. A digitizer, usually a television camera, converts the image into a numerical representation which can be subjected to different types of enhancement. The processed image can be output in several devices, such as: CRT's, T.V. Screens, printers ans plotters.

The examples illustrated by Slides 21, 22 and 23 show clearly some of the results of this process. In the first case individual pixels are enlarged enormously and coloured;in the second and third they are enlarged almost to the point of abstraction. Slide 85 "Mural" by Kenneth C. Knowlton, is an early example of picture processing. The picture, which was created in 1966, was produced through the scanning of a photograph and the resultant tone values represented by micropatterns. It is obvious that the more modern examples have allowed for much more interaction with the artist/designer.

The computer graphics and image processing techniques which I have described in this chapter are the basis of all computer based image systems. Systems like this, which began operations in scientific and technical areas, are finding their way into other areas such as entertainment and business. It is almost like history repeating itself - the same happened with photography and film-making. In the next chapter I will look at some of its uses, especially in the animation and film world of today.

C H A P T E R   T H R E E

Synthetic Images in Movement

The Development of Computer Animation:

Computer film which is closely related to computer graphics, finds its origins at the Bell Telephone Laboratory in I963 and the Boeing Company with William A. Fetter about the same time. Film machinery that could produce its own images was explored as early as I942 by John and James Whitney. They were followed in the fifties by Mary Ellen Bute, Norman McLaren and Marc Adrian.

At the beginning of I965 the Bell Laboratories, under the guidance of Dr. Edward Zajac and Dr. Kenneth Knowlton, began experiments which led to the production of what are now regarded as computer animated film. The first one produced was Edward Zajac's simulation of the motion of a communications satellite in I963. The others included - K.C. Knowlton's "A Computer Technique from the Production of Animated Movies"(I965). F.W. Sindon's "Force" and "Mass and Motion"(I966), A.M. Noll's "Four-Dimensional Hypercube" and "Computer-generated Ballet" (I966-67), E.E. Zajac's "Two-Gyro gravity Gradient Altitude Control System"(I966) and K.C. Knowlton's "Man and His World"(I967). These films, as their titles imply, range from hard scientific instruction in space research to pure experiments in the visual arts.

> "Movies made by computer are seen to be a significant adjunct to education and scientific investigation, particularly in the areas amenable to mathematical and logical treatment and where results can or should be visualised"
> (Kenneth C. Knowlton from 'Celebrity Serendipity'I968)

In I967 Charles Csuri, a professor, and James Shaffer, a programmer, both working at Ohio State University produced a ten minute film "Humming Bird"(Slide 84) which became famous for the varied graphic manipulations with the image of a small bird in flight.

The best known creater of computer films in the late sixties was the American scientist John Whitney Sr. He is regarded by many people as the "father of computer graphics". With the use of computers he could express by abstract means the "intrinsic harmonies of calculated dynamic motion". Some of his discoveries in the technological field quickly found commercial applications. His slit-screen camera was used to create the effect of "spatial motion in dept" in the 'Star Gate' sequence of

Kubrick's film "200I-A Space Odyssey' and was also the forerunner of today's motion control photography. Slide 8I shows sequence from his film "per-mu-ta-tions". The rosettes illustrated are an indication of the multiplicity of the variations of results captured in the program.

The production of computer made films spread fast, and by I970, well over one hundred companies were involved in this work in the United States alone. These included General Electric, Westinghouse Co., IBM, and most of the space research units along with certain prominent universities. Over ten million dollars was being invested in the development of this new medium at the beginning of the seventies. At this time also the analog systems of the Computer Image Corporation, Scanimate and Caesar, were very popular because of their suitability to television advertising.

In I974 only about one tenth of the world's animation output was carried out on computer. This consisted of approximately three hundred and fifty science fiction films, two hundred television commercials and some twenty experimental abstract films. With the enormous boom in the late seventies and early eighties, it could be estimated that four billion dollars was spent on motion pictures and eleven billion on television in I982 alone. That is quite a rise by any standards.

Animators were willing to try out all media and techniques in the seventies. The results of their efforts can be seen in feature films like "American Pop", Heavy Metal", "The Fox and the Hound" and "Xanadu" as well as various T.V. commercials and station I.D.'s.

Some Techniques Used in Computer Animation:

"For all its accuracy and versatility,modern colour photography is essentially a lifeless, inaccurate thing when compared with the possibilities of a computer system. Drawing on the computer's processing power, information captured in the memory can represent not just an image but a comprehensive model from which an infinite variety of images can be produced on demand"
(Edward Rosenfeld from 'Computer Images: State of the Art" I983).

Before looking at how computer techniques have been used to assist animation in the production of images for films, T.V. programs and T.V. commercials, I would like to briefly review the methods and techniques generally involved in animation.

There are a number of processes involved in creating animation by the conventional methods: initial design or storyboard, indicating the films key scenes, the significant parts of movement or key frames, the frames between the parts of movement (twenty four or twenty five per second), pencil tests to test the quality of movement; introducing colour or painting and filming with sound tracks added. It is possible to use the computer to automate much of this conventional animation process, but the greatest growth has been in the computer production of key frames and inbetweens. When it comes to complex three dimensional objects and complex movements, conventional techniques often prove inadequate or inappropriate. Even animators who generally use only manual techniques must turn to computers for assistance. There are three basic steps that need to be followed in order to use a computer to help in animation.

First images have to be put in a form that the computer can understand and use. (i.e. digitised, which can be the most difficult, time consuming and error-prone of tasks). Input can be acquired from a number of sources - the data or digitising tablet being the most popular. Artwork can be drawn directly or traced onto the computer via the data tablet. A video camera can digitise pictorial information if the artwork, objects or scenes are put before it, and the resultant video signal passed onto the computer. The second test is to program the machine to perform the manipulations of the images (translations, rotations, zooms, etc.) and the final task is to display what has been prepared.

Computer generated animation could be more correctly referred to as computer scene simulation or digital scene simulation. Animation refers to manual frame-by-frame manipulation where every frame is drawn. But digital scene simulation is based on the process of leaving in or encoding information once, and then directing the computer to generate its results frame-by frame.

"Imaging" is the generic term for the electronic generation and manipulation of imagery. It has a visually limitless variety of techniques, which could be broken down into three main categories - Analog control, Digital control, Machine control.

The Analog computer is capable of distorting and changing a video signal and creating flips, slides, bends, oscillating shapes, etc. Machine control or motion control is the manipulation of artwork, models, animation stands, optical printers, and the working of the camera by computer. Popular techniques like 'slit-scan' and 'glowing trails' can be accomplished through the control of the camera shutter. Look at slides I and 5 for examples of this.

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Digital control held true for all familiar computer applications. Digital computers are made up of different functional units that perform specific tasks (which I have already dealt with). Memory which is one of these parts, has an additional important function in digital computer animation. The programs which are held in memory are necessary for inbetweening speed, movement, modelling and storage. The frame buffer is an important element in the making of raster animation (which is digital pictures made up from pixels as in Slide 20 for example) as it stores information for individual video pictures. It is also capable of transferring the information of each raster point of video speeds.

Another important difference between filmcel interpolation (character and area movements) and computer interpolation is the fact that the artist/animator has no need for pencil tests to determine whether the speed is correct. He has the results immediately and can make changes in a matter of seconds.

Computer Simulation:

"Computers really allow you to do anything you want and anything you can imagine. You can take actors and stick them in a totally synthetic environment, make walls move through each other or give the audience the ability to see through solid objects. The only limitations are the imagination itself"

These powerful words from Robert Abel of 'Abel and Associates' (a commercial computer graphic company in California) lead one to question the effects that computers are having and will have on the world of art and design. Since its invention in the 1950's computer animation has come a long way. In the United States and throughout the world, facilities houses are springing up, so that film makers have the opportunity to create dazzling sequences of animation.

"From the copilot's seat, I can see the runway lights of Honolulu's airport as we move steadily downward in the dark. Instead of landing, however, my pilot holds our altitude at five hundred feet and heads for the city across the bay. Before I can grab the controls, we are heading directly at a tall building on the water front. Seconds later, we ram it. Only at the moment before impact, when we could clearly see that the building was actually a column of pin-point lights, did our flight look like anything but the real thing. Everything in our nightmare landscape - even the dark of the night itself - animated from the memory of a computer. One flight never in fact took

place. A computer hooked up to a large curved T.V. projection screen had created and displayed the images of Honolulu we saw through the windows of the mockup of a cockpit."
(from 'Computer Pictures Magazine' May/June 1980)
These are the experiences the American writer Dave Fleisher, and also the same experiences of many trainee pilots throughout the world who begin their training in the safety of flight simulators. These computer animated flight simulations are the best reality 'cheaters' one could find. Take Slides 37 and 38 as good examples. To mimic reality as well as they do, they must be able to create complex scenes consisting of thousands of polygons in what animators call 'real-time' speed (as little as one thirtieth of a second, the rate at which the average T.V. set displays its images). It is the high-speed circuitboards which work in nanoseconds (billionths of a second), that allow the thousands of necessary drawings to appear on the simulator's T.V. screen before the allocated one thirtieth of a second has run out. It is very important that the difference between reality and simulation is as slim as possible.

The New York Institute of Technology:

In the United States, the government has long been interested in computer graphics especially computer animation, In fact, all of the early projects in this field, that later led to the development of the first flight simulators were founded by the Department of Defence and NASA. The five million dollars which Dave Evans and Ivan Sutherland got from the Defence Department's Advanced Research Projects Agency (ARPA) in the late sixties and early seventies was the back-up that was necessary for the flight simulation program. This led to the development of their E and S system; the first commercial system for computer aided design and manufacturing (CAD/CAM) as well as computer animation for advertising. Slide 72 has an example by the Industrial Light and Magic Company which used Evans and Sutherland's Digistar Digital Planetarium Projection system to create the starship for the movie "Star Trek II: The Wrath of Khan."

The government also funds many Institutes of Technonoly, giving them the resources, not only to buy up hardware, but also the freedon, time and money to write computer animation software. The New York Institute of Technology (NYIT) at Old Westbury, Long Island, is deeply involved in a great many aspects of animation. It has become the most famous facility for furthering research into computer graphics animation techniques. It was founded in I974 under the direction of Dr. Edwin Catmull. Their pioneering research led to the development of special software and hardware systems. In I98I the commercial area of the NYIT came into being under the name of the Computer Graphics Laboratory Inc. (CGL). Their two dimensional animation system was designed to assist in conventional cartooning and traditional character-style animation. They also developed interactive two dimensional paint-systems (AVA and IMAGES), three dimensional modelling (soids and polygons), animation, image processing, digital sound synthesis, texture mapping and much more.

All the programs for the type of work were originally written by Alvy Ray Smith and Ed Catmull. These two have since moved on to head a special research group at George Lucas's 'Lucasfilm' facility to see how computer-created effects could be integrated into films. In between they spent a short time at the Jet Propulsion Laboratory of the Californian Institute of Technology.

For the past five years the NYIT have been working on what eventually should be the first totally computer animated full-length feature called "The Works"(Slide 50) under the direction of Lance Williams. Progress has been notoriously slow, but it is a film that has become "an exercise in testing the very intricate problems of making extraordinary complex 3D imagery" (according to Dr. Alexander Schure, Chancellor at NYIT)

Commercial Companies Involved in Computer Graphics:

The first commercial company to get involved in computer graphics and computer animation was the General Electric Company in Syracuse, New York State. As well as building the first real-time full colour interactive system in I967 for flight simulation, they also produced colour computer animated films,and founded the Genegraphics system for the Audio Visual market and animation market. Slide 53 gives an example of what they can produce in terms of 'super-realism'. It also proves that some computer graphic techniques must be getting quite close to their limitations. But it is such a versatile and young medium that the future can only mean a growth in many more areas.

The second company to produce full colour computer graphics, was the Mathematical Applications Group Inc. (MAGI) of Elmsford, New York State, MAGI, under the direction of Dr. Philip Mittelman has spent much of its time since its foundation in the mid-sixties researching and developing its software, producing a particular identifiable style. Its synthavision system is a digital animation system which began as a government sponsored contract and is now used for T.V. advertising and films. All its 3D models and architectural scenes are constructed out of geometric solid perimitives. They have a solid, fully shaded appearance with accurate light sources, shadows and hidden surfaces. After they build an environment their 'directors language' allows the artist/animator to move, turn, scale, explore,etc. an object within this environment. They specify the number of frames, the distance and the direction an object should travel within a scene, allowing for acceleration and deacceleration. The computer will automatically determine where they are located, what they look like and how they are shaded and framed. Colours need only be assigned to the objects - by combining percentages of blue, green and red a virtually infantile colour spectrum is available.

MAGI have completed many high-tech commercials and video games (Twentieth Century Fox's home video game 'Worm War I' for example), but their greatest work can be seen in their contribution to the motion picture 'Tron' which was released in the summer of I982. Tron is the first motion picture to use computer generated imagery on a large scale. It also marks a milestone in film optical and light effects. It is the story of a youngman whose knowledge of computers leads him into an adventure within an electronic fantasy world. The computer-generated landscapes, buildings and vehicles provide settings for the line action characters to move about in. The futuristic vehicles, shown in Slide 68 were created by numbers at MAGI-Synthavision for the film.

Four different animated houses were used to create a back for TRON - Information International Inc. (III) of California, Digital Effects Inc. of New York and Robert Abel and Associates of California, along with MAGI. Donal Kushner was the producer. Stephen Lisberger the director and Richard Taylor/Harrison Ellenshaw, the special effects supervisors.

Digital Effects Inc. in New York City are one of the world leaders in the fields of computer animation, graphics, illustration and special effects. They are quite a young company, founded by their President, Judson Rosebush, in I978. They have concentrated on developing software programes rather than massive hardware. With their vision system they can define, manipulate, render and display two dimensional or three dimensional spatial environments. The frames of animation in Slides 2 and 7 illustrate the variety of their work in television advertising.

The client comes to Digital Effects with a project that has either been designed at an advertising agency or is to be designed in house. The next phase involves computer or data input through scanning, (as in Slide 20 for the'Scientific American'magazine), digitising, (as in Slide 9 for 'Minolta' photocopiers) or the use of predefined graphics primatives (squares, circles, cubes, etc.) which are already programmed into the software (as in Slide 3 for the 'Ohio Bell' telephone company). With this information the animator can render the object in the key frames, taking note of colour, texture, extremes of action and environment as well as camera angles and views, light sources, shadows etc. Motion can be defined by the use of viewing parameters which involve an objects change in size position, speed of rotation, camera moves, type of lens and rates of change. When everybody is satisfied with the rendering and the motion tests, both are combined and the entire animation is computed and later transferred to digital magnetic tape, and then thirty five millimeter film. (Slides 3 and 4 show this process clearly).

In the post-production of their jobs, Digital Effects combine the computer animation with other elements such as live action, audio, type, logos, etc. The series of Slides, I3 to I6, show the title sequence for a television programme "NBC Nightly News". The sequence involved the scanning of some photographs which were transferred onto a globe. This globe has been modelled and light sourced. The title itself zooms in past the viewer and stops in the middle distance. The large golden letters are fully three dimensional, after being input by digitizing tablet. The sequence only lasts about twenty seconds but contains plenty of clear and concise information. The resolution of their film recorder is as high as four thousand by four thousand points. But as Judson Rosebush says:

"High technology is not a substitute for creating. You must have a strong underlying concept and a true role for high technology to use it successfully in advertising"

Today corporate advertising needs to put abstract concepts and complex 'products' to the fore front. Hence it is well suited to animated visual treatments in television commercials. This new object of attention is often technical and directed towards a product's design, durability, the way in which it functions and how it is made. (For example Slides 65 and 69, illustrating a commercial for 'Schithz Razors'. Given the expanding capabilities of computer-generated animation or imagery, modern animation is well suited to the kind of advertising treatment because it can depict products of, and in, every shape, numerous form, and do it relatively quickly. What's more, it has a direct sytlistic relationship to the idea of technology - something which advertisers recently discovered and are now relying on. In fact some of the best designed animation sequences can be found among the multitude of logos and names that streak, zoom or explode across our television screens both day and night. They are bold, exciting and memorable. Some enter a world of fantasy far beyond the bounds of conventional and visible reality. Some of the more effective advertising on RTE, BBC and ITV, which use computer animation, include the complex "Ulster Bank" commercial which uses plenty of wire-framed images to symbolize their variety of services, and the 'Michelin MX" Tyre commercial with its highly modelled surfaces (the world of Electronic Arts of London). One of the most exciting animated logos on our television screens at present must be the Channel 4 sequence in which the three dimensional, multi-coloured, number 4 begins to form together from lots of moving parts.

Perhaps the most recognisable technique used over the past few years has been the wire-frame model of something (car, camera, stereo, etc.) They are usually shown on some form of grid (as in Slide 89). Such 3D visualisation of objects do have that 'look of high technology and remind one of video display screens and perspective grids that industrial designers use. Video games, which are immensely popular at the moment, have opened up a new 'galaxy' of their own in television advertising, and are always much more pleasing to look at than the games themselves.

It must be said that advertising is an industry in which everybody seems to jump on the bandwagon at least once - an effective advertising campaign always fixes its imitators. About three or four years ago, it seemed that there were as many commercials shot on location in space as there were situated on our humble boring earth. Slide 63 (for an amusement park in Florida) and Slide 75 (for a Japanese television programme) are good examples of this trend.

The only company whose work more than anybody else, pioneered the special effects revolution of modern television advertising, is Robert Abel and Associates of California. Set up in I97I, they were the first to inject new life into old products by the ingenious application of computer-driven cameras. They were also the first to take advantage of the capabilities of computer graphics systems to make unusual and exciting images. Then Evans and Sutherland Picture System II used vector graphics to produce their three dimensional images in real time, which they often combine with line action. Their 'Bubbles' commercial for 7-Up in I974, 'Brand-Name' for Levi Strauss in I976 (Slide 76) and many television title sequences helped to establish the company. With Bill Kovacs as their technical director, they have now become one of the longest and most inventive production houses in the U.S.

Other major companies in the States include Digital Productions Inc. in Los Angeles and R. Greenberg Associates in New York. Digital Productions have invested in one of the most powerful computers available, the twelve and a half million dollar CRAY X-MPI/22 Super Computer. (Slide 55 shows what it looks like). Its co-owners, John Whitney Jr. and Gary Demos have assembled a facility that can make full use of the most advanced graphic software available. It can create pictures with a total of twenty four million pixels per frame, and because the CRAY is a general purpose machine they are not locked into any one style of imagery. Their first-major job was the feature film 'Star Fighters' made in I982. Their efforts towards very highly realistic images can be seen in Slides 54 and 56. Notice how fine the resolution is, and the delicate use of lighting.

R. Greenberg and Associates, founded in I978, have in-house facilities for computerised animation, aerial projection, horizontal tracking for motion control and optical and live action control. They have completed successful television advertising campaigns for such clients as American Airlines, General Motors and Atari, and also some feature film projects.

Other production houses, notably Dolphins in New York and Image West in Los Angeles, use Scanimate Systems in their work. Scanimate can manipulate raster generated images by video input equipment and can create the effect of type and figures moving in space.

America's long technological,financial and artistic leadership has made life a little difficult for companies in other countries to try to get involved in the computer animation business. The Japanese, who have for a long time studied the American advances in this area, are now quite close to becoming one of the world's largest producers of computer-generated animation. Some of the primary companies involved in this tremendous growth are Japan Computer Graphics Lab. (JCGL), Toyo Links / Osaka University, The Animation Staff Room and MTI. Examples of their work can be seen on slides 49,58,67 and 75. In England, the first companies to venture into this field were Electronic Arts, Digital Pictures and The Moving Picture Company. Most of their work is for television companies and commercial advertising.

The Future For Computer Animation:

Though at the present time a major'revolution'is well under way in the amination industry, two major questions will have to be answered: Will the powerful new tools of electronic animation act as a threat or a blessing to animators? and will animators be able to accept and use the potential of this new medium, or will they be replaced by it? There is no simple answer. Computers have evolved from being an aid to being a tool - a creative tool which ben be used by'non-computer people'. But it must be said that nothing can replace a strong imagination and nothing can match a good design sense

As the equipment and machinery gets cheaper and more efficient, many people like inkers and opaquers will lose their jobs - computers are designed to eliminate the more expensive time-consuming work. The old saying "If you can't beat them, join them" will probably be quite relevant in this case. Those accepting electronic assistance will have a whole new world of style and creative freedom opened up to them. Certain techniques requiring the human touch are of course irreplacable. The brand of quality that Disney established as a standard in animation is still years away from the grasp of computers.

The most important factor in good animation is the quality of movement. In the case of figure animation, it is not only the smoothness of motion that lends feeling, but the 'naturalism' in that motion. The poor resolution of some computer drawn figures detracts a lot from the finished result, but as the limitations of computer assisted animation are rapidly disappearing, these problems are getting fewer and fewer. Stephen Lisburger, the director of TRON, points out this fact: "People are going to have to come to grips with how they will utilize this, and then we'll be looking at whole environments where things are completely different from what we're used to seeing. I think we'll even see interactive movies with audience participation, eventually".

Alvy Ray Smith of Lucasfilm has a comparison to make on this point:

"The camera was an incredible development in its day, but now nobody gives a second thought to picking up a camera. And it's going to be the same with computer graphics, I suspect. First there will be a love affair and then everybody will settle down to making artistic use of the new language of images that are provided."

But Richard Taylor, also of Lucasfilm, has quite an original view of advertising and like the new technologies: "Computer commercials remind you of something you have never seen before"

Constant stimulation of the right kind is essential in order to keep an audience's interest alive. This means that the creative artist must take advantage of every effect which is offered by the visual facilities of the new technology. It could be said that film and television techniques are practices which originate from the invention of moveable type in the fifteenth century (which I have referred to earlier). Its aim was to impart more information, education and entertainment to greater number of people, more efficiently. It never seems to age - every time you look at animated spot there is something new to see, something which you might have missed the first time around.

Ever since the first computer film in I963 by E.E.Zajac, computer animation and art has grown so fast that it presently stands as a forty million dollar industry. It is vital to the survival of the animation industry that it always contains the added dimension of illusion and magic. It should also be noted that many animators have returned to the more traditional techniques to rediscover what was considered to be a forgotten skill. Halas and Bacherlor Films Limited in England and Zagreb Films in Yugoslavia are two such companies - open to all areas of creative thinking and animation techniques.

C H A P T E R   F O U R

ART VERSUS TECHNOLOGY

Technology And Tradition:

"The eye carries people to different parts of the world it is the prince of mathematics, its sciences are most certain, it has measured the heights and dimensions of the stars, it has created architecture and perspective and divine painting"
(From Leonardo da Vinci's Treatise on Painting)

In Leonardo's time no medium could satisfy the creative impulses set in motion by his eyes and intellect. When he was young he concentrated on two dimensional world of painting. But it was that same keen mind that enriched the art world with insights from optics, human anatomy and expressive psychology which uncovered the limits inherent in painting. The cameras would never be a mirror, as it could not for example, capture the beautiful dynamic geometry of a bird in flight, no matter how artistic and scientific eyes might perceive it. Hence Leonardo turned more and more to the "paradise of mathematical sciences", hoping to find a medium where an artist might create as widely as the scope of human vision and intellect.

Five hundred years later, in the form of computer image support systems, that medium has finally been realised. With this new tool artists and scientists are able to extend the dimensions of human sight and launch their own creations into visual flight.

The 'society of information' or 'age of electronics' in which we live, has created a new culture, based on technology, which is constantly changing the features of our everyday lives. Development in computer image generation has given rise to unlimited possibilities. Now with the aid of powerful programs, an untrained person can create images without any technical knowledge.

Originally art had a close relationship to science, and theories were often deeply connected with one's senses. Artists like Leonardo da Vinci succeeded in bringing both fields together. We live in an age where we are surrounded (or maybe 'bombarded') by information from television, radio and other mass media. This has led to a style where we must ask ourselves the meaning of our relationship to the natural world and its position in a universal culture. Hence the big question of whether or not computer generated art works can truly be called 'art'.

The usual objection to computer art originate from the fear that somehow the computer, like Hal in the film 2001 or the MCP in the film TRON, will take control, eliminating the role of the artist. Another fear is the absence of hand-work which would make art 'easy' requiring less skill than the more traditional forms. These same objections were raised when photography was discovered. In 1859 Charles Baucelaire considered photography to be a major threat to the entire fine art tradition. He wrote in "The Salon of 1859: The Modern Public and Photography":

"It is nonetheless obvious that this industry (Photography) by invading the territories of art, has become art's most mortal enemy, and that the confusion of their several functions prevents any of them from being properly fulfilled.... If photography is allowed to supplement art in some of its functions, it will soon have supplemented or corrupted it altogether".

According to the photography critic and theorist, David Jacob, this rejection of photography stemmed from the fact that, since the Industrial Revolution, the machine has become more and more important, while man has had to take second place. Accordingly, certain values were attributed to each:

"Man was construed in romantic terms, with emphasis placed on inspiration and the God-like qualities of creativity. Cameras were mechanistic, without feeling or bias. Depending on how one looked at it, the photography - as - art question opposed subjectivity to objectivity, art to science, humanism to technology, or God to Satan". (from his 'Of Cretans and Critics: In Search of Photographic Theory" Afterimage, Vol.10 No.7 Feb.1983)

Computer artists claim that their medium is where photography was one hundred years ago. Rather than the camera, it is the computer that has come to represent the mechanistic objective and scientific sphere. People agree that it is incapable of producing art because it is a machine, contracting the myth of the artist who stands poised with the paint brush in hand. Of course, there are those who say that the computer brings out the artist in everyone. The error in both of these attitudes is the underlying assumption that technology is a force unto itself, rather than a series of inventions and technical advances by humans who are responsible for their use and abuse. Since technology of any sort cannot function of its own, it is illogical to say that a computer can threaten the creative process; or a computer can be the actual creator.

Computers offer artists promises on two levels. Firstly, as a tool that, like a compass or ruler, help and extend the capabilities of the hand. And, secondly as an extension of the brain, making complex procedures possible. Procedures that would not otherwise be undertaken, or only from the considerations of the time available in an artist's lifetime.

Too Much or Too Little?

The traditional painter or printmaker worked on one image for a long time and therefore an abundance of images was out of the question. The technological artist, on the other hand, usually accumulates plenty of images, due to the ease in which they can be created and modified. This establishes an entirely unique means of image creation, and can be traced back to the experimental work of the Impressionist painters in the last century. Albert Aurier wrote in 1856 (about impressionism):

"The aim is still the imitation of the subject matter, perhaps no longer in its own form, but in its perceived form, its perceived colour. It is the transition of the instantaneous sensation with all the distortions of a rapid and subjective synthesis."

With this position of image abundance, the next process for the artist includes the selection and disposal of created and viewed pictures from extremely large collections.

Problems can arise where one might not expect them. Time saved in an images construction, can be lost in choosing from an enormous selection. Also, the images created may no longer represent the artist's true expression, but only his interaction with the machine, and image complexity or resolution may not be adequate (this brings in the question of system costs and capability). At present gaining access to already developed systems can be very difficult and expensive and the artist can also find himself/herself in the situation of having a limited understanding of a system developed by somebody else - limiting creative possibilities.

One of the major pitfalls in the design of interactive graphic systems and image manipulation systems must be the fact that every time a system is operational, additional requirements become readily obvious. In other words, development seems to take over from image generation. As James Blinn of the Jet Propulsion Laboratory (JPL) stated in his 'Computer Graphics Tutorial" at Siggraph, Atlanta 1978:

> "We are always in the same place needing just one more option to make it really work and whenever we get that option we realise that we need still yet another option"

Ken Garland, a prominent English designer, is very wary and sceptical of the new technologies. The advent of cheap, compact computers and the greater availability of computer peripherals (auxiliary hardware) has, in his view only allowed the designer to get swamped with cost limits, engineering constraints and impatient clients. Also, as he says in his article, 'Battle ground or Seedbed" from the Online Publication on the Computer Graphics Conference '82':

> "...that part of graphic designs which is concerned with speculation, innovation and synthesis as opposed to information gathering and analysis, is, I suspect, not only poorly served by the employment of computer-based graphic systems, but may even be harmed by them...Graphic design - or any other design, for that matter - is an austere and painful process, in which success can by no means be assured; one that is now as it has always been, in danger of being stopped by too much assistance rather than too little, by too many choices instead of too few"

John Aston, a prominent designer with the BBC, is also aware of some of the dangers, as he points out in the Online Publication 1982:

> "...today we are in danger of conniving at the equally mindless over-production and over employment of electronic information arts and regardless of the real applicability to all the functions claimed by their progenitors....no good design comes easy no matter what magic apparatise is brought to bear"

Attitudes like this do not just apply to English designers and artists. Lou Dorfsman, senior Vice-President at CBS and Creative Director for the network's advertising and design and also one of the United States' most influential designers, does not like the attitudes he sees among many young graphic designers in regard to the new technology. As he says:

"I see young designers who think there is some magical way to fame and fortune, because the machine does all the work for you. It's lesser talented students who are gravitating towards the computer thing. Those who have a sensitivity to design and drawing stay away from it"

Lou is one of those people who readily concede that the computer aided designer is here to stay, but he doesn't want the machines to strip graphic design of its human warmth. The computer artist and illustrator J.C. Chartrand has his own warning towards computer graphics:

"Given the difficulty of entering the computer graphics profession, artists who make the transition may be disappointed to find that they have not escaped the creative paradoxes and compromises that were inherent in commercial production. The use of computers just adds a few new twists. For instance, the phenomonal speed of computer assistance does not provide the artist with endless creative leisure. Instead, it tends merely to tighten his or her deadlines."
(From 'The artist's graphic vision of the future'. in Computer Graphics News, Mar./Apr. 1983)

Computer Art:

Two groups, artists and technologists, which are usually segregated, come together to use the computer as a tool. They have different sensibilities and priorities to their work. For some computer imaging is a problem solving exercise - once a particular medium is mastered, the programmer tackles another one. Others are interested in how those techniques might be used to implement an idea or generate a meaning. That lies beyond the more obvious technical problems at hand. Another development has been the separations of the conception of visual artwork from its actual execution.

One finds that through history, art has always been independent of the medium through which it is practised. It is a process of exploration and enquiry and gives humans the potential for an aesthetic perception that has little to do with the properties or techniques by which it is produced. In other words, it is not the paint that makes a painting, art - even if the subject of the painting is the painting itself. The surrealist artist Andre Breton put it this way:

"The work of art is valuable in so far as it is vibrated by the reflexes of the future"

And the American computer scientist, Peter Kugel, gives a word of warning:

"Those applying computers to the understanding of artworks have imposed on themselves an unnecessary limitation that must be removed or else the understanding will lead to artworks computers produce that are flat and lifeless"

Today draughtmanship can be replaced by programming skills and this shows a shift in the visual arts to something having the characteristics of the performing arts based on a composition or script. The fact that images produced on a cathode ray tube are impermanent, also adds to this theory. It is only limited in artistic possibilities by the capacities of the computer and by the ingenuity of an artist-programmer.

The programes themselves can, through their actual formulation, help one to understand the final result in very much the same way that teaching somebody to do something helps one to have a better understanding of what is being taught. The conscious or unconscious elements that affect an artist in his artmaking process are to be found in his brains. At present no way has been discovered which might allow one to inspect the thought making process. Only information input into the brain and the human response on input can be inspected. In the case of a program for an artwork which is written on a piece of paper, there is no problem inspecting and testing it. Computers are not yet capable of using trial and error procedures like humans can.

Computer art has much the same frames of reference as those relied upon by those artists who do not use computers. What we understand as computer art today is a representation of the computer in the service of those very same visual art traditions which the new technology is supposed to hold absolute. The computer artist, Gene Youngblood, refers to this fact in his essay "The Myth of Computer Art" for Siggraph '83".
"The idea of computer art - of an art unique to the computer - remains after twenty years an unrealised myth, its horizons barely in view, its forms still to be manifest."

They give it names like realism and figurative art, exploit and copy the techniques and results of the traditional manual styles, rather than exploiting its untried possibilities.

It might be that there is still an unclosed gap in the system that consists of an artist-programmer, program, computer and output device. The technological achievement of a piece of work becomes secondary when one attempts to place it in the context of a broader visual history. As John Berger has pointed out in his book 'Ways of Seeing' (1972):

> "When an image is presented as a work of art, the way people look at it is affected by a whole sense of learnt assumptions about art"

These learnt assumptions or culturally, determined ideas about what is good art and what is bad art- are not only held by the observer,but also by the maker and are rooted in one's background. Therefore, what an artist sees as interesting may be technologically simple;on the other hand, what is impressive technologically may not be so impressive in relation to contemporary art and design. Different criteria are used in different contexts, and art must be examined in the context of the conventions of art, typography in context of the contentions of typography, animation in context of the conventions of animation and so on. The art critic, Lucinda Furlong, wrote in the Siggraph '83' Art Exhibition Catalogue about the fact of computer artists finding acceptability for their work:

> "It should be kept in mind that 'acceptable' is usually synonymous with marketability. For example, all talk of whether photography was 'art' or not subsided when that medium was assimilated into the art-print market around 1978. Similarly, it is the reality of the marketplace that will play a bigger role in the computer's acceptance - not rhetorical debates over its merits and deficiencies as an artistic tool"

The annual SIGGRAPH Exhibition of Computer Art (which I have mentioned a few times already) is the world's major exhibition in this field. It brings together artists and technologists and their 'State of the Art' creations. Some of the examples which accompany this thesis show the variety of results. In Slide 82 a computer-aided sculpture by David Morris stretches the boundaries of this art to three dimensional forms. Ron McNeill, a faculty member at the Massachusetts Institute of Technology's Visual Language Workshop, uses the computer as an extension of his work in photography and electronic imaging

(Slide 78 - right). The ability of the computer to take on the characteristics of other media is shown by Harve Huitrics "Souvenir de Vacances" (Slide 80) which looks very like a pointilist landscape, and Frank Dietrich's 'Softly 3'(Slide 78-Left) which has the same formal idea as modern abstract painting. Among the graphics work on show at the last year's exhibition were Joe Pasquale's 'Hello Plugs' (Slide 57) and Neel Greene's "Mondo Condo" - quite futuristic and amazingly realistic illustrations.

The Electronic Future:

Today many people involved in the world of art believe that the computer will reveal the way to unlimited new aesthetic horizons and produce totally new art forms.

One of these new art forms, which is already with us, is three dimensional animation (or simulation) which I have already detailed. Its effect on every aspect of modern life through its aesthetic and philosophical implications is staggering and will be more so in the future. It is unprecedented in a visual sense, combining elements of photography, painting and animation.

However, if a particular piece of three dimensional animation is to be examined in an historical context, it need not and should not have the medium through which it was produced, taken into account. The artist should have no restrictions in his desire to explore the uniqueness of the computer, regardless of whether the results are 'art-like' or not or whether the art would acknowledge it. What is most unique about the computer is its interactivity and this leads back to the word 'tool'. (Computer art has more to do with the process of being in the world (ontology) than it has with aesthetics. Understanding a computer means using it rather than looking at it.

> "...the special effects of computer images can be as commonplace and immediate as television. But the ultimate special effect is far from commonplace and is in fact far from being fully realised. For by creating a visual language in the active medium of computers, image makers have moved us across a human threshold comparable to the moment when some unknown ancestor first created writing by pressing figures into clay"
> (From'Computer Images': 'Sale of the Art'by Joseph Deken 1983)

The ultimate computer art form could constitute a combination of 3D simulation and interactivity, allowing the artist to create with all his senses. The reason for this is because, the more interactive a system is, the more it becomes what you sense and what you experience.

The first of this type of interaction to be made was the interactive movie, based on computer-controlled optical video disc systems. For example, the Aspen Movie Map (examples of which can be seen on Slide 88) produced by the Architectural Machine Group at M.I.T., which allows the viewer to travel down any street in the city and even into buildings to examine their contents. All the information for this simulated movie has already been gathered and processed, so it is there in the computer to be revealed. Where can scene simulation like this lead to in the future? How will it affect our lives and what are its commercial possibilities?

Gery Demos of Digital Productions in Los Angeles believes that the proper software will make remote interactive scene simulation over cable T.V. channels a commercial possibility within this decade.

> "...you must tune in and connect your home computer to the central computer by phone modem and you become part of the movie. The Image Utility presents the generic possibilities and you make variations based on your own personality and abilities. You control things, create a custom movie that will never be seen by anybody else"

Dr. Alexander Schure, the Chancellor of the New York Institute of Technology realises that, in this age of information, computer graphics systems will make major inroads into the workplace and become an absolute necessity in our lives. The application of the new technologies are staggering and within the next twenty five years we will find ourselves in a totally new era - the Industrial Revolution will pale in comparison. As he says in his article "What lies in the future for the management of Computer Graphics" from Computer Pictures November/December 1983:

> "In the 1980's and 1990's sophisticated computer graphics power will be a corporate requirement, as fundamental to corporations' economical survival as reading, writing, calculations and visual skills are essential to present day communications channels ....Never before in human existence has so much information been generated to be coded, systemised, categorized, and stored for the race to utilize ..... Simply put, there are no aspects of business or industry that will remain immune to the changes brought on by

the developments in these fields. They bring new problems. They also bring incredible new opportunities".

He realises that the office of the future may not be an office at all. With the aid of computer graphics, managers will be able to keep track of their records, tasks, time organization and communication needs. It will lead to major changes in job professional profiles within a company and willbe the key to the successful management of the future.

Computer Graphics And The Graphic Designer:

One of the major challenges in the designer world of today is the merging of the separate moulds of computer graphics and graphic design. The graphic designer is an artist who works in the commercial end of the business and fears that computer graphics is coming close to the stage where it could take their place or limit their creativity.

This will not happen if computer systems are designed to meet the artist's needs. For the sake of the industry's future growth, technologists must be able to meet the concerns of the graphic artist and aim towards user-friendly hardware and software. In computer assisted graphics, the artist/designer makes all the decisions relating to shape, colour and other graphic elements. Hence, the right type of system should make better use of his abilities. These abilities or skills can be broken down into roughly two categories: judgmental and mechanical. The artist must first make the decisions as to how something should look, and then perform the mechanical functions to produce it.

Computer assisted graphic design stations can take over many of the mechanical tasks that eat up the artist's time. Now he has been given increased control of the job by producing more elements and faster. Size, shape, relationships of graphic elements, typesetting, dimensions, line thickness, curves, junctions, colour accuracy, etc., are all there to aid the graphic designer; but not take away his ability to make graphic decisions.

If computer graphics means the loss of some jobs in the short term, it will be more likely to create even more in the long term. Normally when computer graphic systems are installed the demand for graphics rises dramatically. It finds itself being increasingly used in functions such as business meetings, sales presentations and training programmes. These are areas where time, cost and quality were not adequate in the past.

Presentation graphics, which is an irregular activity with most companies and information graphics, which is rooted in the system and written word, will be developed with a much greater emphasis on graphic literacy. The well-prepared designer, aided by the new tools, will fit into the communications systems of the eighties and nineties with ease. They will become the new professional graphic designers of the future.

The Cost Of New Technology:

On a few occasions in the past chapters, I touched on the financial aspect in regard to computer technology. It is an area which more than any other will affect the artist, the designer and the animator. Fortunately, the trend is towards cheaper software and hardware which must be a great benefit to the spread of the technology.

It has been figured out that if the automobile industry had paralleled the computer industry since World War Two, today we could buy a car for two pounds and twenty five pence which could get three million miles to the gallon. The microporcessor has, of course, led to a substantial reduction in the cost and a substantial increase in the sophistication of interactive graphic terminals in recent years - that which was impossible a few years ago is now an inexpensive reality.

Systems which cost over fifty thousand pounds ten years ago, can cost less than eight thousand pounds nowadays. You can buy a high resolution system for the same price as a basic storage tube terminal cost seven years ago, approximately five thousand pounds. In the future, as more and more applications software becomes firmware (hard software, or software stored permanently in hardware), fewer and fewer computer graphics users will need programmers.

The compounded annual growth of the industry is put at more than twenty percent. The leading earners are Electronic Design, three thousand and sixty million pounds; Mechanical Design, three thousand and twenty five million; Drafting and Cartography, two hundred million; Scientific, one hundred and twenty million; Business Graphics, one hundred million; and Art/Animation applications, forty million. By the year 1985 the market value for desktop computers (plays a key role in the rise of computer graphics) is predicted to hit one thousand, eight hundred and fifty million pounds. In the five years from 1980 to 1985, it is predicted (by a Frost & Sullivan revenue forecast) that the computer graphics market will jump from one point three nine billion pounds to somewhere around six billion pounds.

The computer graphics industry in Europe is about four years behind that in the U.S. and Japan. Still the European market is expected to grow six-fold by 1990. This means that the computer graphics software and services market of three hundred and fifty million pounds in 1982 could be almost one point seven billion 1990. Software accounts for the bulk of this market (eight-five percent) with the other fifteen percent going to services. The U.K. leads the group followed by Germany and France.

There is probably about two hundred thousand graphic devices of all kinds installed worldwide which means that there is a user's community of about the same size. Of that, some forty thousand people are making a living from the industry, a figure which will grow quite large in the future. The people who are coming or of schools now, ir in the next decade from now, will consider the use of keyboard as natural as we consider paper and pencil. This leads me on to the topic of computers in art and design education.

Computers in Art and Design Education:

Most adults are amazed when a fifteen year old becomes a millionaire writing computer games, and when children as young as two years play with small computers. But the fear of machines is practically non-existent in the child. He/she overcomes 'technophobia'(fear of machines) by using the technology, just like the fear of riding a bicycle is overcome by attempting to ride it. "Practice makes perfect", and for the artist/designer it allows him to build up a collection of work and, at the same time, develop as a professional.

When we move into the 1990's we may have a totally different set of problems or opportunities, based on the fact that we will be working with people who have graphics and computer literacy, i.e. the young students of today.

> "When we talk about the future of graphics, I think we have to recognise that the future will deal with a computer literate society"
> (from"Trends in Computer Graphics" by C. Machover. Online Publications of the Computer Graphics Conference 1982).

Children have grown up with T.V. screens and for them, the computer is a screen that responds to them, and can be hooked up to a machine that can be programmed to respond the very way that they want. In the U.S. there are now more than one hundred and fifty thousand computers in the schools, compared with fifty two thousand in 1981.

This growth is also occurring in Ireland, as J.H. Frazer of the Ulster Polytechnic notes in his article "Hardware and Software Techniques for Simplifying Computer Graphics" for the Online Conference Publication in 1982,

> "The Availability of cheap graphic software and hardware will be an immense encouragement to whole groups of children with skills not covered in the traditional literacy and mathematical classroom activities"

and Alan Pleass, the Head of the Design Department at R.T.E.:

> "Graphic designers need time to adapt, particularly to micro-chip technology. However, too much restraint will create a vacuum to be quickly filled by untrained and unqualified technicians who will then be responsible for graphic design standards... This must radically change the teaching of graphic design in colleges of art in order to produce people capable of achieving the highest levels of creativity in the eighties."

Both of these men see a change taking place in schools, away from teaching by instruction towards a more natural process of learning by doing. As the more adaptive and more accessible graphics software becomes available, the change in education will speed up further. Art students, who are provided with the tools of science, could be the first to bridge the gap, between the two 'cultures' of art and science. Therefore the next frontier of the Information Age must be education.

C O N C L U S I O N

"I have landed countless Boeings, driven miles of digitized highways, moved inside crystals and molecules, orbited Venus, rendez-voused in space, not to mention having watched teapots, textured balls, cubes, and semi-transparent glasses, glowing under many a source of light" (C.E.Vandoni from the Procedings of the International Conference and Exhibition in Switzerland 1980).

Today with the aid of an enormous variety of new image creation techniques we can represent almost any fantasy that our imaginations will allow. But we must remember that illusions still cannot be created at the touch of a button. Computer technology opens new doors to creativity but, at the same time, it demands a new attitude, a new system of doing something, a new understanding of the creative process.

It brings us back to our childhood and our first box of paints - splashing the colours around was great fun, but we never worried about what the final product of our efforts might look like. I think it will probably take several years before the majority of the users see computer-based technology more as a tool than as a limitation and feel comfortable creating and designing with it. Computer technology will hardly substitute artists or even replace designers.

As I have pointed out in my historical development of image making technologies, the present situation has its similarities in the past. Today, an artist who offers resistance to the new techniques and technologies could be compared to a Renaissance artist that refuses to use fine brushes and oil paints, because he has already mastered other more ancient techniques. Robots are the threatening symbol of technology but it is very unlikely that they will ever substitute human creativity.

"For good or bad; computing is here to stay. As information designers our clear responsibility is to encourage and help the process of making computers responsive to people, rather than let things slide through confusion or neglect in the other direction"
(From"The Use of Graphics in Computing" Industrial Design Magazine" September/October 1982)

The animator of the future will not be much different fromthe animator of today. He/she will be working with new tools and will probably have added a few technical terms to his/her vocabularly. The main concern will remain the same - to combine a lively imagination and design skills with technique But there is still to be explored the strong imaging potential of the computer itself. It will be the animators who accept the challenge of technology and explore its friendly, though enormous, flexibility who will enjoy and benefit from the magic which machines offer.

To get involved with a computer-based system would mean a big capital investment for most people. But with the fast-decreasing costs, that figure is getting smaller every week. Of course, this means that more people will have more access computer-based imaging systems. This should increase the public awareness of art and design and also increase the user's understanding of technology. The designers with a knowledge of this area, are needed to implement efficient systems for operations on a wider market.

One factor which kept recurring in my research was that, computer graphics tries to imitate older technologies though it can be very innovative also. The search for pictorial realism with computer graphics is a good example of that situation - you might call it 'cultural recycling'.

The birth of new communication channels (video games, videotext, cable T.V. etc.) offers new creative possibilities. It demands the solving of new needs and the creation of new visual styles, new images and typefaces. The artists, without the traditional prejudices on the reation between art and technology, are needed to work under these different circumstances.

As a word of warning, I have to emphasise the fact that, unfortunately, technology has its limitations. It is easy to overestimate all the wonderful things that can be done with computers - our imaginations seem to run wild . But, though, technology tends to be mystified; it is nothing more than a product of human civilization - a set of tools that have different meanings in different times and places.

Tools are nothing by themselves, they acquire their meaning and usefulness with the use that we make of them. We should use the best means available for solving a specific problem - which may or may not be a computer. Technology creates illusions but we must not have illusions about technology.

At this point it is up to us, not the computer, to decide how we want to manage our world. As the computer artist, David Em, put it in his essay "Butterfly Nets Revisited: The Artist in the Lab" for SIGGRAPH '83':

> "And perhaps soon the high tech machines will not be so exclusively applied towards corporate and industrial growth, but for human growth, personal expression, and spiritual enlightenment."

GLOSSARY.

Analog: a representation of values as a continuously variable signal.

Animation: sequential images producing an illusion of motion.

Algorithm: a set of well-defined rules for solving a problem in a finite number of operations.

Binary: a numbering system having only 2 values O and I.

Cathode Ray Tube (CRT): an evacuated glass tube in which a beam of electrons is emitted and focused once a tube surface coated with phosphors. A beam deflected system moves the beam so that the image is drawn on the surface.

Color Mapping: pseudo colorization by which input color values are converted to values stored in a colour look-up table.

Co-ordinates: an ordered set of data values, either absolute or relative, which specifies a location in the model space or device space.

CRT: Cathode Ray Tube.

Data Base: a stored collection of libraries of data.

Data Tablet: a graphic input device which encodes X-Y data from a hand held stylus on the tablet surface.

Digital: numerical representation of values.

Digitizer: a device that codes images or shapes into digital data.

Firmware: hard software, or software stored permanently in hardware.

Frame Buffer: the digital memory of a raster display used to store the bit map.

Graphic System: any collection of hardware and software designed to make it easier to use graphic input and output in computer programs.

Hard Copy: a permanent copy of a display which can be separated from the display device.

Hardware: the actual physical computer, e.g. its circuit boards and peripherals.

Input Device: peripheral to the computer which accepts information and digitizes it.

Interactive: the concept of dialog between user and computer, typically conducted in real-time

Keyframe Animation: animation techniques whereby the user defines the beginning points and end points and the computer calculates the in-betweens.

Machine Language: a language used directly by a computer.

Menu: a list of options on a display allowing the user to select the next program action by indicating one or more choices with an input device.

Monitor: Cathode Ray Tube (CRT) and its housing.

Paint Program: user orientated software based on traditional techniques of drawing and painting.

Periperal: auxiliary hardware to the computer such as monitors, tablets, and disk drives.

Pixel: a single picture element, the smallest displayable area that can be differentiated from its nearest neighbours.

Plotter: a device which draws an image on a removable recording medium (e.g. paper, film, etc.)

RAM: Random Access Memory: hardware memory that can be written to or read from.

Real Time: the concept of interaction between the user and the computer where there is no perceivable delay between user action and computer reaction.

Resolution: the number of pixels which can be displayed.

Software: a set of programs, documents, procedures and routines associated with the operation of a computer system.

Vector: a line drawn between two points in 2 or 3 dimensions.

Video Signal: a continuously varying voltage that specifies the intensity along each scan line of an image; it modulates the beam current and produces a trace of varying intensity.

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