Multimedia in the perspective of Mathematical Modelling: Past, Present and Future

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Abstract

This paper discusses the role of Mathematical Modelling in the past, present and future, in shaping the so-called world of Multimedia as it is known today. In this paper, the term "Mathematical Modelling" does not have a precise definition. The term is used to imply problem description in mathematical terms, algorithms and the use of mathematical tools to investigate the given problem. One of such model is the use of differential equations to describe a vast variety of different phenomena in the areas of physics, biology, sociology, etc. The model can be solved analytically; others require numerical methods and the use of a computer that is a necessity to today's mathematical modeller.

This paper looks into the historical timeline on the evolution of multimedia. Stemming from the area of computer graphics, the field of multimedia has been changed drastically from the invention of Cathode Ray Tube in 1885, and then in 1950, Ben Laposky uses oscilloscope to display waveforms that were photographed as artwork. By 1951 “Computer Graphics” was displayed on vector scope on a Whirlwind computer. In 1974, before the invention of pixels, almost all displays were calligraphic, which means the beam needs to be steered around on the screen to trace out lines using some algorithm and a mathematical model. Today raster graphic is being used but the role of mathematical modelling continues in a new form and algorithms.

The evolution of hardware and the increase of computing power with the decline in cost per MIPS has made computer graphic more accessible to a lot more people. Mathematical modelling tools are now widely available and less complex to use but the tools and the models used are becoming more complex than ever .The platforms used have moved from mainframes or mini to workstations and then to desktop machines and now even hand held machines are capable to do graphics display which was only possible by mini computers before.

Due to the limitation of computing power the algorithms and mathematical models used before were more clever and precise the one which skips few iterations wherever possible. Nowadays, computers are fast enough which leads to a more crude and brute force type of algorithms being used. The more profound change is not in the actual modelling but in the use of mathematical modelling and computer graphics. It used to be used for computer-aided design and data analysis, which was the original intention. Now, most of the applications are in special effects, image processing, graphic arts, telemedicine, etc. Above all mathematical modelling is the fundamental reason to the existence of the world of multimedia from the past, present and in the future.

Introduction

Mathematical Modelling role in the evolution of the world of Multimedia today from the early years of computer graphics has been remarkable. When Digital Equipment Corporation (DEC) opened in August 1957 and later in November 1960 introduced the PDP-1 (Programmed Data Processor) the world's first small, interactive computer there was no competition. As Digital grows, it has been playing an important role in the progress of computer graphics. In 1959 the first computer drawing system, DAC-1 (Design Augmented by Computers) was created by General Motors and IBM. It allowed the user to input a 3D description of an automobile and then rotate it and view it from different directions. It was unveiled at the Joint Computer Conference in Detroit in 1964. [2]

Graphic computers were first used in the movie animation industry as a substitute for pencil testing. In the early days the quality of output was not good enough to integrate into a film but good enough to illustrate a scene from an idea. Today images from the computers themselves are being used more and seamlessly being integrated in films. The use of computer graphics in films has spawned great interest in Virtual Reality, where computer graphics help create believable worlds. Today, Mathematical Modelling is not in the limelight, but its produce, namely Virtual Reality, Interactive Multimedia, Multimedia System are common features in any systems.

Definition

John Hayward from university of Glamorgan in his paper on Mathematical modelling define Mathematical Modelling as "*A model of any real-world object or situation is an attempt to describe that object or situation by certain key features of interest, whilst discarding those features which are not of interest. A mathematical model is such a model described using mathematics, usually with the purpose of explaining why something behaves the way it does, discovering some laws or patterns, and maybe making predictions. Thus a model has a purpose and mathematics is merely the language that enables the understanding and purpose to be expressed quantitatively and precisely. Purpose is essential for modelling*" [1]. However, in this paper, the term "Mathematical Modelling" does not have a precise definition. The term is used to imply problem description in mathematical terms, some algorithms and the use of mathematical tools to investigate the given problem particularly in the field of computer graphics and multimedia.

Simply, computer graphic is the transfer of pictorial data into and out of a computer. Using Analog-to-Digital Conversion techniques, a variety of devices such as curve tracers, digitizers, and light pens connected to graphic computer terminals can be used to store pictorial data in a digital computer. By reversing the process through Digital-to-Analog Conversion techniques, the stored data can be output on a mechanical plotting board, or plotter, or on a television like graphic display terminal. Raster graphics stores and displays images as a bit map, a series of closely spaced dots (or pixels) arranged in rows and columns. **Vector**, or object-oriented, graphics stores the images as mathematical formulas. Images are displayed by calculating the coordinates of the end points and then drawing lines between them.

Computer graphics capabilities range from the simple display of digital tabulations as line graphs and pie charts to complex animation and elaborate special effects for television and motion pictures. Computer graphics are used in architecture, art, Computer-Aided Design, electronic games, flight simulators for pilot training, and molecular modelling.

Combined with interactive features, special effects, sounds and other effects, the term multimedia is often used to refer to the more sophisticated computer graphics.

Where and when it all began

It is rather hard to contemplate that actually the cathode ray tube (CRT), and integral part for monitors, was invented in 1885. It was not until the 50's the initial start of the modern day multimedia or computer graphics started. It was in 1950, artist Ben Laposky uses analog computers to help him create oscilloscope artwork and in 1951 the first "computer graphics" was displayed on a Vectorscope-type graphics display on the Whirlwind computer at MIT. In 1960, the term "Computer graphics" was coined by William Felter. [2, 23]

The leap in computer graphics was to come from MIT, when one MIT student in 1961, Ivan Sutherland created a computer drawing program called *Sketchpad*. Sketchpad allowed simple computer images to be drawn with a light pen on a computer screen, save them and even recall them later. Even today, many standards of computer graphics interfaces got their start with this early Sketchpad program. One example of this is in **drawing constraints**. If one wants to draw a square for example, the software will construct a perfect box, with the right dimensions and at the right location. Another example is that Sutherland's software modelled objects - not just a picture of objects. In other words, with a model of a car, one could change the size of the tires without affecting the rest of the car.

These early computer graphics were **Vector graphics**, composed of thin lines whereas modern day graphics are **Raster** based using pixels. Vector graphics use pure mathematics to draw shapes on a computer monitor, or on an output device such as a printer. The disadvantages to vector files are that they cannot represent continuous tone images and they are limited in the number of colours available. Raster formats on the other hand work well for continuous tone images and can reproduce as many colours as needed. However, there are two main advantages of vector graphics. First it uses minimal amount of information to draw an object say a circle which translates to a much smaller file size. Second, depending on the variables used in the mathematical formula (e.g. *r* as the radius of a circle to be drawn) the object can resize accordingly. This means that vector graphics can scale (be resized) without any loss of quality. Due to this reasons we are seeing a coming back of vector graphics as **Scaleable Vector graphics** (SVG) [12]

Also in 1961, Steve Russell, another student at MIT created the first video game called, *Spacewar*, written for the DEC PDP-1. It was a great success and even the engineers at DEC used it as a diagnostic program on every new PDP-1. At the same time, E. E. Zajac, a scientist at Bell Telephone Laboratory (BTL), created the first computer-animated film.

In a short span of time major corporations like BTL and Boeing started taking an interest in computer graphics. Lockheed-Georgia, General Electric and Sperry Rand are among the many companies that were getting started in computer graphics by the mid 1960's. IBM was quick to respond to this interest by releasing the IBM 2250 graphics terminal, the first commercially available graphics computer. Ralph Baer, a supervising engineer at Sanders Associates, came up with a home video game in 1966 that was later licensed to Magnavox and called the *Odyssey*. While very simplistic, and requiring fairly inexpensive electronic parts, it allowed the player to move points of light around on a screen. It was the first consumer computer graphics product.

Also in 1966, Sutherland at MIT invented the first computer controlled head-mounted display (HMD). It displayed two separate wireframe images, one for each eye that allowed the viewer to see the computer scene in stereoscopic 3D. In 1968 the University of Utah recruited Dave Evans to form a computer science program, and computer graphics quickly became his primary interest. This new department would become the world's primary research centre for computer graphics.

Sutherland was recruited by Evans to join the computer science program at the University of Utah. There he perfected his HMD. Twenty years later, NASA would re-discover his techniques in their virtual reality research. At Utah, Sutherland and Evans were highly sought after consultants by large companies but they were frustrated at the lack of graphics hardware available at the time so they started formulating a plan to start their own company. In the same year, **ray tracing** was invented by Appel [3]. A student by the name of Ed Catmull got started at the University of Utah in 1970 and signed up for Sutherland's computer graphics class. The first animation that Catmull saw was his own, an animation of his hand opening and closing. It became one of his goals to produce a feature length motion picture using computer graphics. Because of Evan and Sutherland's presence, UU was gaining quite a reputation as the place to be for computer graphics research.

As the UU computer graphics laboratory was attracting people from all over, John Warnock [4] was one of those early pioneers; he would later found Adobe Systems and create a revolution in the publishing world with his PostScript page description language. Tom Stockham led the image-processing group at UU that worked closely with the computer graphics lab. Jim Clark was also there; he would later found Silicon Graphics, Inc. The first major advance in 3D computer graphics was created at UU by these early pioneers by the invention of **hidden-surface algorithm** [5, 6, 7] and the development of **area subdivision algorithm** [8]

From 2D to 3D

In 1970s computer graphics was introduced in the world of television. Bell Telephone and CBS Sports were among the many who made use of the new computer graphics. While flat shading can make an object look as if it is solid, the sharp edges of the polygons can detract from the realism of the image. To solve this, a Henri Gouraud in 1971 presented a method for creating the appearance of a curved surface by interpolating the colour across the polygons. This method of shading a 3D object has since come to be known as **Gouraud shading** [15]. One of the most impressive aspects of Gouraud shading is that it hardly takes any more computations than Flat shading yet provides a dramatic increase in rendering quality. However, Gouraud shading still could not solve the visible edge of the object. The original flat polygons making up the torus are still visible along the edges of the object.

One of the most important advancements to computer graphics appeared on the scene in 1971, the microprocessor. Using Integrated Circuit technology developed in 1959, the electronics of a computer processor were miniaturized down to a single chip, the microprocessor. One of the first desktop microcomputers designed for personal use was the Altair 8800 from Micro Instrumentation Telemetry Systems (MITS).

In that same year, Nolan Kay Bushnell along with a friend formed Atari. He would go on to create an arcade video game called *Pong* in 1972 and start an industry that continues even today to be one

of the largest users of computer graphics technology. In the 1970's a number of animation houses were formed. Atari was fond of vectors, creating more than 20 games that used the technology between 1979 and 1985. Its first game was *Lunar Lander*, a simulation of landing a ship on the moon's surface. Then came *Asteroids*, the smash hit of 1979. The year after that, *Battlezone* was released.

In Culver City, California, Information International Incorporated (III or Triple I) formed a motion picture computer graphics department. In San Rafael, California, George Lucas formed Lucasfilm. In Los Angeles, Robert Abel & Associates and Digital Effects were formed. In London, England, Systems Simulation Ltd. was formed. There are a lot of other companies were form but almost none of them would still be in business ten years later.

Founded in 1962, Triple I was in the business of creating digital scanners and other image processing equipment. They developed another frame buffer that used 1000 lines; they also built, image accelerators and the software to run it. This development led to the first use of computer graphics for motion pictures in 1973 when Whitney and Demos worked on the motion picture "West world". They used a technique called **pixellization** which is a computerized mosaic created by breaking up a picture into large colour blocks.

In 1973 the Association of Computing Machinery's (ACM) Special Interest Group on Computer Graphics (SIGGRAPH) held its first conference. Solely devoted to computer graphics, the convention attracted about 1,200 people. Since the 1960's the University of Utah had been the focal point for research on 3D computer graphics and algorithms. For the research, the classes set up various 3D models, the most popular, a teapot. It was in 1975 that a M. Newell developed the Utah teapot, and throughout the history of 3D computer graphics it has served as a benchmark, and today it's almost an icon for 3D computer graphics. The original teapot that Newell based his computer model on can be seen at the Boston Computer Museum displayed next to a computer rendering of it. Ed Catmull received his Ph. D. in computer science in 1974 and his thesis [8] covered **Texture Mapping**, **Z-Buffe**r and **rendering curved surfaces**. Texture mapping brought computer graphics to a new level of realism.

Today high-performance graphics workstations have a z-buffer built-in. While Gouraud shading was a great improvement over Flat shading, it still had a few problems as to its realism. This was corrected however by Phong Bui-Toung, a programmer at the UU. Bui-Toung arrived at UU in 1971 and in 1974 he developed a new shading method that came to be known as **Phong shading** [9]. His shading method accurately interpolates the colours over a polygonal surface giving accurate reflective highlights and shading. The drawback to this is that Phong shading can be up to 100 times slower than Gouraud shading. As with Gouraud shading, Phong shading cannot smooth over the outer edges of 3D objects.

In 1974, Sutherland and Hodgman developed a **polygon-clipping algorithm** [10]. In 1975, another major breakthrough in simulating realism began when the French mathematician, *Dr. Benoit Mandelbrot* published a paper called *"A Theory of Fractal Sets."* After some 20 years of research he published his findings and named them *Fractal Geometry*. Mandelbrot followed up his paper with a book entitled *"The Fractal Geometry of Nature."* [19] This showed how his fractal principles could be applied to computer imagery to create realistic simulations of natural phenomena such as mountains, coastlines, wood grain, etc.

Due to funding reasons and movement of few important personalities, the leading centre for computer graphics research soon switched from UU to New York Institute of Technology (NYIT). Dr. Richard Shoup then became a resident scientist at PARC (Xeroc Palo Alto Research Centre) and began working on a program he called "*SuperPaint*." It used one of the first colour frame buffers ever built. At the same time Ken Knowlton at Bell Labs was creating his own paint program. In NYIT, Alvy Ray Smith wrote a full colour (24-bit) paint program, the first of its kind. Later many others joined NYIT's computer graphics lab including Tom Duff and Paul Heckbert. In all, the computer graphics lab of NYIT would eventually be home to more than 60 employees.

Steve Jobs help Wozniak develop his computer into the very first Apple computer, which was built in a garage. In the same year William Gates III at the age of 19 dropped out of Harvard and Paul Allen, founded a company called Microsoft. They rewrote 86-DOS, named it DOS and licensed it to IBM as the operating system for their first personal computer.

Back in NYIT, the first computer graphics application was to create 2D animation tools to assist traditional animators. One of the tools that Catmull built was "*Tween*," a tool that interpolated in between frames from one line drawing to another. They also developed a **scan-and-paint** system for scanning and then painting pencil drawn artwork. NYIT also branched out into 3D. A lot of time and resources were spent in creating 3D models and rendering test animations. However, none of the people in the Computer Graphics Lab understood the scope of making a motion picture. Gradually over a period of time, people became discouraged and left for other places.

With the success of *Star Wars*, George Lucas was interested in using computer graphics on his next movie, "The Empire Strikes Back". However due to financial aspects Lucas dropped it and go back to hand-made models. The experience however showed that photorealistic computer imagery was a possibility, so Lucas decided to assemble his own Computer Graphics department within his special effects company, Lucasfilm. He found NYIT and slowly the computer graphics lab started to fall apart and ceased to be the centre of computer graphics research.

The focus had shifted to Lucasfilm and a new graphics department at Cornell University. Over the next 15 years, Lucasfilm would be nominated for over 20 Academy Awards, winning 12 Oscars, five Technical Achievement Awards and two Emmys. In 1979 George Lucas formed the new computer graphics division of Lucasfilm to create computer imagery for motion pictures. Catmull became vice president and during the next six years, this new group would assemble one of the most talented teams of artists and programmers in the computer graphics industry. The advent of Lucasfilm's computer graphics department is viewed by many as another major milestone in the history of computer graphics. Here the researchers had access to funds, but at the same time they were working under a serious moviemaker with real, definite goals.

In 1976, Triple I developed some custom film scanners and recorders for working on films in high resolutions, up to2,500 lines. Also in that same year at the Jet Propulsion Laboratory in Pasadena, California, James Blinn developed a new technique similar to **Texture Mapping** [16]. However, instead of simply mapping the colours from a 2D image onto a 3D object, the colours were used to make the surface appear as if it had a dent or a bulge. To do this, a monochrome image is used where the white areas of the image will appear as bulges and the black areas of the image will appear as dents. Any shades of grey are treated as smaller bumps or bulges depending on how dark

or how light the shade of grey is. This form of mapping is called **Bump Mapping** [17, 18]. Bump maps can add a new level of realism to 3D graphics by simulating a rough surface. When both a texture map and a bump map are applied at the same time, the result can be very convincing. Blinn also published a paper in that same year on creating surfaces that reflect their surroundings. This is accomplished by rendering six different views from the location of the object (top, bottom, front, back, left and right). Those views are then applied to the outside of the object in a way similar to standard texture mapping. The result is that an object appears to reflect its surroundings. This type of mapping is called **environment mapping**.

In 1977, a frame buffer with a resolution of 512x512 and 8 bits of colour depth cost 65,000 dollars. Today, a video adapter with better capabilities cost less than 100 dollars. During the late 1970's Don Greenberg at Cornell University created a computer graphics lab that produced new methods of simulating realistic surfaces. Rob Cook at Cornell realized that the lighting model everyone had been using best approximated plastic. Cook wanted to create a new **lighting model** that allowed computers to simulate objects like polished metal. This new model takes into account the energy of the light source rather than the light's intensity or brightness. As the second decade of computer graphics drew to a close the industry was showing tremendous growth. By 1980, the entire value of all the computer graphics systems, hardware, and services would reach a billion dollars.

Computer Graphics to Multimedia

A programmer by the name of Loren Carpenter from Boeing studied the research of Mandelbrot and then modified it to simulate realistic fractal mountains. Carpenter developed various **rendering algorithms** and published papers on them. He wanted some scenery to go with his airplanes. By reading Mandelbrot's book and he had an idea about how to create fractal terrain in animation. After solving the technical difficulties, Carpenter made a movie, wrote a paper to describe it and made a collection of still images. It was a hit of SIGGRAPH 1980 and got him hired by Lucasfilm. During the early 1980's SIGGRAPH was starting to really take off

Later, in 1981 Carpenter wrote the first renderer for Lucasfilm, called ***REYES*** **(Renders Everything You Ever Saw**). REYES would eventually turn into the *Renderman* rendering engine. Turner Whitted published a paper in 1980 about a new rendering method for simulating highly reflective surfaces. Known today as **Ray Tracing**, it makes the computer trace every ray of light, starting from the viewer's perspective back into the 3D scene to the objects. Ray tracing is extremely computational intensive. So much so that some 3D animation programmers repudiate to put ray tracing into their software. On the other hand, the realism that can be achieved with ray tracing is spectacular.

Carl Rosendahl launched a computer graphics studio in Sunnyvale, California in 1980 called Pacific Data Images (PDI). A year later Richard Chuang, one of the partners, wrote some **anti-aliasing rendering** code, and the resulting images allowed PDI's client base to increase. While other computer graphics studios were focusing on film, PDI focused solely on television network ID's, such as the openings for movie-of-the-week programs. This allowed them to carve a niche for themselves.

In 1981, IBM introduced their first personal computer, the IBM PC. From then on, PCs became serious business tools. With this new attitude toward PCs came tremendous sales as PCs spread

across the country into practically every business. In the games sector, with the development of polygon graphics and the crash of 1984, vector-based games fell out of favour and soon disappeared entirely. In 1985, Atari released the last vector game, which was *The Empire Strikes Back*. Polygon graphics first appeared in arcades way back in 1984, in a rare Atari-produced game called *I, Robot*. Like most ahead-of-their-time ideas, it was doomed to failure. Throughout the '80s, Atari had proved to be an innovator in the arcades, but it would take a game from Sega to usher in the new era of 3D gaming.

Another major milestone in the 1980's for computer graphics was the founding of *Silicon Graphics* Inc. (SGI) by Jim Clark in 1982. SGI focused its resources on creating the highest performance graphics computers with built-in 3D graphics capabilities, high-speed RISC (Reduced Instruction Set Chip) processors and symmetrical (multiple processor) architectures. In the same year, John Walker and Dan Drake along with eleven other programmers established *Autodesk* Inc. They released AutoCAD version 1 for S-100 and Z-80 based computers at COMDEX (Computer Dealers Exposition) that year. They helped move computer graphics to the world of personal computers.

In 1985,Tom Brigham, a programmer and animator at NYIT, astounded the audience at the 1982 SIGGRAPH conference by creating a video sequence showing a woman distort and transform herself into the shape of a lynx. Hence a new technique called "**Morphing**" was born.

Jaron Lanier, working for Atari as a programmer in 1983, developed the **DataGlove** that detect and transmit to the computer any movements your hand makes. The computer interprets the data and allows you to manipulate objects in 3D space within a computer simulation. In Santa Barbara, California a new company was formed called *Wavefront*. Wavefront produced the very first commercially available 3D animation system to run on off-the-shelf hardware. Wavefront started a revolution that would shape the future of all computer graphics studios.

Also at the same time, Thomson Digital Image (TDI) was founded. To solve incidental lighting problem, a new rendering method was needed. In 1984, Cindy Goral, Don Greenberg and others at Cornell University published a paper called, "Modelling the Interaction of Light Between Diffuse Surfaces." The paper described a new method called **Radiosity** [22] that uses the same formulas that simulate the way heat is dispersed throughout a room to determine how light reflects between surfaces. By determining the exchange of radiant energy between 3D surfaces very realistic results are possible.

In January of 1984, Apple Computer released the first Macintosh computer. It was the first personal computer to use a graphical interface. Around 1985, **multimedia** started to make its big entrance. The International Standards Organization (ISO) created the first standard for Compact Discs with Read Only Memory (CD-ROM). Today multimedia is a major marketplace for personal computer 3D animation. Daniel Langlois in Montreal, Canada founded a company called *Softimage* in 1986 whose software later became the animation standard in Europe.

In 1986, computer graphics makes its way into the courtroom as **Forensic Animation**. It started by using computer graphics to help jurors visualize court cases. Pixar continued to develop their renderer, putting a lot of resources into it and eventually turning it into *Renderman*. Created in 1988, Renderman is a standard for describing 3D scenes. The standard describes everything the computer needs to know before rendering your 3D scene. Once a scene is converted to a

Renderman file, it can be rendered on a variety of systems, from Macs to PCs to Silicon Graphics Workstations. This opened up many possibilities for 3D computer graphics software developers.

An integral part of Renderman is the use of 'shaders' or small pieces of programming code for describing surfaces, lighting effects and atmospheric effects. Surface shaders are small programs that algorithmically generate textures based on mathematical formulas. These algorithmic textures are sometimes called procedural textures or spatial textures. Not only does the computer generate the texture, but it is also generated in 3D space. Most texture mapping techniques map the texture to the outside 'skin' of the object, procedural textures run completely through the object in 3D.

In 1987 GIF format (CompuServe) was born and IBM invented VGA (Video Graphics Array). In December of 1988, Ed Catmull became chairman of Pixar when Steve Jobs stepped down. Pixar made history on March 29, 1989 by winning an Oscar at the Academy Awards for their animated short film, "Tin Toy." The film was created completely with 3D computer graphics using Pixar's Renderman. At the 1989 SIGGRAPH in Boston, Autodesk unveiled a new PC based animation package called *Autodesk Animator*. As a full featured 2D animation and painting package, Animator was Autodesk's first step into the **multimedia tools realm**. The software-only animation playback capabilities achieved very impressive speeds and became a standard for playing animation on PCs.

Multimedia to Virtual Reality becoming real

In 1990, Microsoft shipped Windows 3.0, a GUI similar to the Apple Macintosh, and laid the foundation for a future growth in multimedia. Today Microsoft dominates the PC software industry and it has moved into the field of 3D computer graphics. Also in 1990, AutoDesk shipped their first 3D Computer animation product, *3D Studio*. 3D Studio has risen to the lead position in PC based 3D computer animation software.

Disney and Pixar announced in 1991 an agreement to create the first computer animated full-length feature film, called "*Toy Story*," within two to three years. This project came as a fulfilment to those early NYIT'ers who had the dream of producing a feature length film. Pixar had the confidence that they could pull off the project on time and on budget. The JPEG/MPEG formats were created in the same year and a year later QuickTime was introduced by Apple [24]. In 1993, Wavefront acquired Thomson Digital Image (TDI), which increased Wavefront's market share in the high-end computer graphics market.

Nintendo announced an agreement with Silicon Graphics, Inc. to produce a 64-bit 3D Nintendo platform for home use. Their first product, *Ultra64* will be an arcade game to be released in 1994, while a home version will follow in late 1995. In February 1994, Microsoft acquired Softimage. Microsoft's initial use of TDI technology will be internal, to enhance their multimedia CD-ROM products and interactive TV programs. Microsoft also plans to port the Softimage software over to its Windows may be the first move in starting a trend for the shifting of high-end graphics software from workstations to personal computers.

Today featured blockbusters films are full of computer graphics. The effects are so photorealistic that the computer's role was undetectable. In 1997 the DVD (Digital Video Disc) technology was unveiled and followed by the MPEG-4 format a year later. Full motion picture is now delivered across the internet. Considering the quality and realism that we see in computer graphics today, it's

hard to imagine that the field didn't even exist just 30 years ago. Yet even today new development continues to excite the computer graphics community with new graphics techniques. And while companies have come and gone over the years, the people and the interest are very much alive. Most of the early pioneers are still active in the industry and just as enthusiastic about the technology as they were when they first started.

The future

With the growth of the IT world as a whole it is expected the future of Mathematical modelling would be even more challenging and demanding. With the introduction of new Multimedia Services such as the Multimedia Messaging System on mobile phone would liberate even further the type of multimedia applications on various platforms. Even though initially only one bit bitmap images were used on WAP phones, the introduction of full colour LCD screens on mobile phone would increase users expectation on the type of multimedia images scrolling across their mobile screens.

With super computers is now becoming even more powerful, back end calculation and simulation has moved to a new level. In some cases the business needs has overcome the scientific needs. In the latest development the NEC-built Earth Simulator was reported to be faster than all 15 of the biggest supercomputers in the United States combined. The machine will be used in climate and earthquake studies. It performs an astounding 35.9 trillion calculations a second with all its 5,104 processors. [25]

On the end user and normal household front, the use of personal computers and microprocessor-based devices is still expanding. It was reported the billionth computer was sold this year somewhere around the globe. “Moore’s Law” as the press called it in 1965 still holds true today and perhaps for years to come [11]. Gordon Moores observed an exponential growth in the number of transistors per integrated circuit. The development and competition in the microprocessor industry has enable powerful computers to land on our desktop capable of delivering millions of instructions or calculations a second. Rendering that use to take days on a “super computer” then is done in a matter of minutes on a decent workstation today. Task that used to done as an overnight processes is now done “on the fly”.

As the technology continue to develop such as the Hewlett-Packard effort in creating a 64-bit memory using molecular technology that fits in a square micron, what was then thought impossible is now possible. As the microprocessor impacted on computer graphics in 1971, materialisation of nanotechnology would definitely have a great effect to the world of computing. The reintroduction of vector graphics which was thought no longer relevant in this multimedia age as SVG [12] to make the size of web pages smaller shows Mathematical modelling continues to play an important role in enabling technology expansion in the world of Multimedia.

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