Unit 1
Introduction

Computer Graphics

Introduction

Computer Graphics is a field related to the generation of graphics using computers. It includes the creation, storage, and manipulation of images of objects. These objects come from diverse fields such as physical, mathematical, engineering, architectural, abstract structures and natural phenomenon. Computer graphics today is largely interactive, i.e. the user controls the contents, structure, and appearance of images of the objects by using input devices, such as keyboard, mouse, or touch-sensitive panel on the screen.

In short, Computer graphics refer different things in different contexts:

- **Pictures**, scenes that are generated by a computer.
- **Tools** used to make such pictures, software and hardware, input/output devices.
- The **whole field of study** that involves these tools and the pictures they produce.

Until the early 1980's, computer graphics was a small, specialized field, largely because the hardware was expensive and graphics-based application programs that were easy to use and cost-effective were few. Then, personal computers with built-in raster graphics displays-such as the Xerox Star, Apple Macintosh and the IBM PC popularized the use of bitmap graphics for user-computer interaction. A bitmap is a 1s and 0s representation of the rectangular array points on the screen. Each point is called a pixel, short for "Picture Elements". Once bitmap graphics became affordable, and explosion of easy-to-use and inexpensive graphics-based applications soon followed. Graphics-based user interfaces allowed millions of new users to control simple, low-cost application programs, such as word-processors, spreadsheets, and drawing programs.

The concepts of a "desktop" now became a popular for organizing screen space. By means of a window manager, the user could create position and resize rectangular screen areas called windows. This allowed user to switch among multiple activities just by pointing and clicking at the desired window, typically with a mouse. Besides windows, icons which represent data files, application program, file cabinets, mailboxes, printers, recycle bin and so on, made the user-computer interaction more effective. By pointing and clicking the icons, users could activate the corresponding programs or objects, which replaced much of the typing of the commands used in earlier operating systems and computer applications.

Today, almost all interactive application programs, even those for manipulating text (e.g. word processor) or numerical data (e.g. spreadsheet programs), use graphics extensively in the user interface and for visualizing and manipulating the application-specific objects.

Even people who do not use computers encounter computer graphics in TV commercials and as cinematic special effects. Computer graphics is no longer a rarity. It is an integral part of all computer user interfaces, and is indispensable for visualizing 2D, 3D objects in diverse areas such as education, science, engineering, medicine, commerce, the military, advertising, and entertainment.

Historical Background

Guys, it's quite descriptive but interesting one, read thoroughly.

Prehistory

The foundations of computer graphics can be traced to artistic and mathematical ``inventions," for example,

- Euclid (circa 300 - 250 BC) who's formulation of geometry provides a basis for graphics concepts.
- Filippo Brunelleschi (1377 - 1446) architect, goldsmith, and sculptor who is noted for his use of perspective.
- Rene Descartes' (1596-1650) who developed analytic geometry, in particular coordinate systems which provide a foundation for describing the location and shape of objects in space.
- Gottfried Wilhelm Leibniz (1646 - 1716) and Isaac Newton (1642 - 1727) who co-invented calculus that allow us to describe dynamical systems.
- James Joseph Sylvester (1814 - 1897) who invented matrix notation. A lot of graphics can be done with matrices.
- I. Schoenberg who discovered splines, a fundamental type of curve.
- J. Presper Mauchly (1919 - 1995) and John William Mauchly (1907 - 1980) who build the ENIAC computer.

Early History

History of computer graphics dates from the Whirlwind Project and the SAGE computer system, which were designed to support military preparedness. The Whirlwind Project started as an effort to build a flight simulator and SAGE was to provide a air defense system in the United States to guard against the threat of a nuclear attack. The SAGE workstation had a vector display and light pens that operators would use pinpoint planes flying over regions of the United States. We can see a SAGE workstation at the Boston Computer Museum.

Besides the being the age of the first vacuum tube computers, the 1940's were when the transistor was invented at Bell Labs (1947). In 1956, the first transistorized computer was built at MIT.

The Age of Sutherland

In the early 1960's IBM, Sperry-Rand, Burroughs and a few other computer companies existed. The computers of the day had a few kilobytes of memory, no operating systems to speak of and no graphical display monitors. The peripherals were Hollerith punch cards, line printers, and roll-paper plotters. The only programming languages supported were assembler, FORTRAN, and Algol. Function graphs and "Snoopy" calendars were about the only graphics done.

In 1963 Ivan Sutherland presented his paper *Sketchpad* at the Summer Joint Computer Conference. Sketchpad allowed interactive design on a vector graphics display monitor with a light pen input device. Most people mark this event as the origins of computer graphics.

The Middle to Late '60's

Software and Algorithms

Jack Bresenham theorized line drawing algorithm on a raster device. He later extended this to circles. Anti-aliased lines and curve drawing is a major topic in computer graphics. Larry Roberts pointed out the usefulness of homogeneous coordinates, 4x4 matrices and hidden line detection algorithms. Steve Coons introduced parametric surfaces and developed early computer aided geometric design concepts. The earlier work of Pierre Bezier on parametric curves and surfaces also became public. Author Appel at IBM developed hidden surface and shadow

algorithms that were pre-cursors to ray tracing. The fast Fourier transform was discovered by Cooley and Tukey. This algorithm allows us to better understand signals and is fundamental for developing antialiasing techniques. It is also a precursor to wavelets.

Hardware and Technology

Doug Englebart invented the mouse at Xerox PARC. The Evans & Sutherland Corporation and General Electric started building flight simulators with real-time raster graphics. The floppy disk was invented at IBM and the microprocessor was invented at Intel. The concept of a research network, the ARPANET, was developed.

The Early '70's

The state of the art in computing was an IBM 360 computer with about 64 KB of memory, a Tektronix 4014 storage tube, or a vector display with a light pen (but these were very expensive).

Software and Algorithms

Rendering (shading) were discovered by Gouraud and Phong at the University of Utah. Phong also introduced a reflection model that included specular highlights. Keyframe based animation for 3-D graphics was demonstrated. Xerox PARC developed a ``paint'' program. Ed Catmull introduced parametric patch rendering, the *z*-buffer algorithm, and texture mapping. BASIC, C, and UNIX were developed at Dartmouth and Bell Labs.

Hardware and Technology

An Evans & Sutherland Picture System was the high-end graphics computer. It was a vector display with hardware support for clipping and perspective. Xerox PARC introduced the Altos personal computer, and an 8 bit computer was invented at Intel.

The Middle to Late '70's

Software and Algorithms

Turned Whitted developed recursive ray tracing and it became the standard for photorealism, living in a pristine world. Pascal was the programming language everyone learned.

Hardware and Technology

The Apple I and II computers became the first commercial successes for personal computing. The DEC VAX computer was the mainframe (mini) computer of choice. Arcade games such as Pong and Pac Mac became popular. Laser printers were invented at Xerox PARC.

The Early '80's

Software and Algorithms

No notable progress.

Hardware and Technology

The IBM PC was marketed in 1981 The Apple MacIntosh started production in 1984, and microprocessors began to take off, with the Intel x86 chipset, but these were still toys. Computers with a mouse, bitmapped (raster) display, and Ethernet became the standard in academic and science and engineering settings.

The Middle to Late '80's

Software and Algorithms

Jim Blinn introduces blobby models and texture mapping concepts. Binary space partitioning (BSP) trees were introduced as a data structure, but not many realized how useful they would become. Loren Carpenter started exploring fractals in computer graphics. Postscript was

developed by John Warnock and Adobe was formed. Steve Cook introduced stochastic sampling to ray tracing. Character animation became the goal for animators. Radiosity was introduced by the Greenberg and folks at Cornell. Photoshop was marketed by Adobe. Video arcade games took off, many people/organizations started publishing on the desktop. UNIX and X windows were the platforms of choice with programming in C and C++, but MS-DOS was starting to rise. Remarkably, the PHIGS (programmers hierarchical Interactive Graphics System) standard came into play, which is later dominated by openGL in 90's.

Hardware and Technology

Sun workstations, with the Motorola 680x0 chipset became popular as advanced workstation a in the mid 80's. The Video Graphics Array (VGA) card was invented at IBM. Silicon Graphics (SGI) workstations that supported real-time raster line drawing and later polygons became the computer graphicists desired. The data glove, a precursor to virtual reality, was invented at NASA. VLSI for special purpose graphics processors and parallel processing became hot research areas.

The Early '90's

The computer to have now was an SGI workstation with at least 16 MB of memory, at 24-bit raster display with hardware support for Gouraud shading and *z*-buffering for hidden surface removal. Laser printers and single frame video recorders were standard. UNIX, X and Silicon Graphics GL were the operating systems, window system and application programming interface (API) that graphicist used. Shaded raster graphics were starting to be introduced in motion pictures. PCs started to get decent, but still they could not support 3-D graphics, so most programmer's wrote software for scan conversion (rasterization) used the painter's algorithm for hidden surface removal, and developed ``tricks'' for real-time animation.

Software and Algorithms

Mosaic, the first graphical Internet browser was written by Marc Andreessen and Eric Bina at the University of Illinois, National Center for Scientific Applications (NCSA). MPEG standards for compressed video began to be promulgated. Dynamical systems (physically based modeling) that allowed animation with collisions, gravity, friction, and cause and effects were introduced. In 1992 OpenGL (Open Graphics Library) became the standard for graphics APIs In 1993; the World Wide Web took off. Surface subdivision algorithms were rediscovered. Wavelets begin to be used in computer graphics.

Hardware and Technology

Hand-held computers were invented at Hewlett-Packard about 1991. Zip drives were invented at Iomega. The Intel 486 chip set allowed PC to get reasonable floating point performance. In 1994, Silicon Graphics produced the Reality Engine: It had hardware for real-time texture mapping. The Ninetendo 64 game console hit the market providing Reality Engine-like graphics for the masses of games players. Scanners were introduced.

The Middle to Late '90's

The PC market erupts and supercomputers begin to wane. Microsoft grows, Apple collapses, but begins to come back, SGI collapses, and lots of new startups enter the graphics field.

Software and Algorithms

Image based rendering became the area for research in photo-realistic graphics. Linux and open source software become popular.

Hardware and Technology

PC graphics cards, for example 3dfx and Nvidia, were introduced. Laptops were introduced to the market. The Pentium chipset makes PCs almost as powerful as workstations. Motion capture, begun with the data glove, becomes a primary method for generating animation sequences. 3-D video games become very popular: DOOM (which uses BSP trees), Quake, Mario Brothers, etc. Graphics effects in movies become pervasive: Terminator 2, Jurassic Park, Toy Story, Titanic, Star Wars I. Virtual reality and the Virtual Reality Meta (Markup) Language (VRML) become hot areas for research. PDA's, the Palm Pilot, and flat panel displays hit the market.

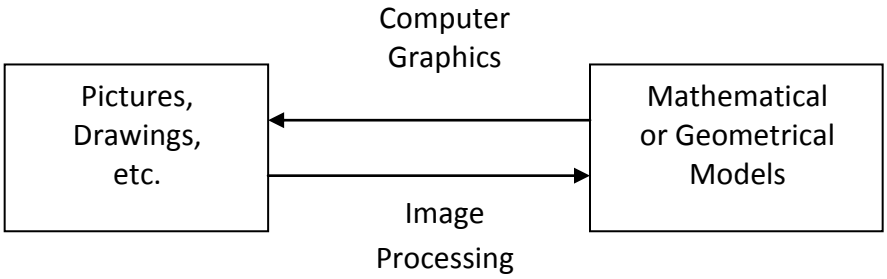
The '00's

Today most graphicist want an Intel PC with at least 256 MB of memory and a 10 GB hard drive. Their display should have graphics board that supports real-time texture mapping. A flatbed scanner, color laser printer, digital video camera, DVD, and MPEG encoder/decoder are the peripherals one wants. The environment for program development is most likely Windows and Linux, with Direct 3D and OpenGL, but Java 3D might become more important. Programs would typically be written in C++ or Java.

What will happen in the near future -- difficult to say, but high definition TV (HDTV) is poised to take off (after years of hype). Ubiquitous wireless computing should become widespread, and audio and gestural input devices should replace some of the functionality of the keyboard and mouse.

You should expect 3-D modeling and video editing for the masses, computer vision for robotic devices and capture facial expressions, and realistic rendering of difficult things like a human face, hair, and water. With any luck C++ will fall out of favor.

The Difference between Computer Graphics and Image Processing:



Computer Graphics: Synthesize pictures from mathematical or geometrical models.

- ***Image Processing***: analyze pictures to derive descriptions (often in mathematical or geometrical forms) of objects appeared in the pictures.

Applications of Computer Graphics

Computer graphics is used today in many different areas of science, engineering, industry, business, education, entertainment, medicine, art and training. All of these are included in the following categories.

1. User interfaces

Most applications have user interfaces that rely on desktop windows systems to manage multiple simultaneous activities, and on point-and click facilities to allow users to select menu items, icons and objects on the screen. These activities fall under computer graphics. Typing is necessary only to input text to be stored and manipulated. For example, Word processing,

spreadsheet, and desktop-publishing programs are the typical examples where user-interface techniques are implemented.

2. Plotting

Plotting 2D and 3D graphs of mathematical, physical, and economic functions use computer graphics extensively. The histograms, bar, and pie charts; the task-scheduling charts are the most commonly used plotting. These all are used to present meaningfully and concisely the trends and patterns of complex data.

3. Office automation and electronic publishing

Computer graphics has facilitated the office automation and electronic publishing which is also popularly known as desktop publishing, giving more power to the organizations to print the meaningful materials in-house. Office automation and electronic publishing can produce both traditional printed (Hardcopy) documents and electronic (softcopy) documents that contain text, tables, graphs, and other forms of drawn or scanned-in graphics.

4. Computer Aided Drafting and Design

One of the major uses of computer graphics is to design components and systems of mechanical, electrical, electrochemical, and electronic devices, including structures such as buildings, automobile bodies, airplane and ship hulls, very large scale integrated (VLSI) chips, optical systems and telephone and computer networks. These designs are more frequently used to test the structural, electrical, and thermal properties of the systems.

5. Scientific and business Visualization

Generating computer graphics for scientific, engineering, and medical data sets is termed as scientific visualization whereas business visualization is related with the non scientific data sets such as those obtained in economics. Visualization makes easier to understand the trends and patterns inherent in the huge amount of data sets. It would, otherwise, be almost impossible to analyze those data numerically.

6. Simulation and modeling

Simulation is the imitation of the conditions like those, which is encountered in real life. Simulation thus helps to learn or to feel the conditions one might have to face in near future without being in danger at the beginning of the course. For example, astronauts can exercise the feeling of weightlessness in a simulator; similarly a pilot training can be conducted in flight simulator. The military tank simulator, the naval simulator, driving simulator, air traffic control simulator, heavy-duty vehicle simulator, and so on are some of the mostly used simulator in practice. Simulators are also used to optimize the system, for example the vehicle, observing the reactions of the driver during the operation of the simulator.

7. Entertainment

Disney movies such as Lion Kings and The Beauty of Beast, and other scientific movies like Jurassic Park, The lost world etc are the best example of the application of computer graphics in the field of entertainment. Instead of drawing all necessary frames with slightly changing scenes for the production of cartoon-film, only the key frames are sufficient for such cartoon-film where the in between frames are interpolated by the graphics system dramatically decreasing the cost of production while maintaining the quality. Computer and video games such FIFA, Doom, Pools are few to name where graphics is used extensively.

8. **Art and commerce**

Here computer graphics is used to produce pictures that express a message and attract attention such as a new model of a car moving along the ring of the Saturn. These pictures are frequently seen at transportation terminals supermarkets, hotels etc. The slide production for commercial,

scientific, or educational presentations is another cost effective use of computer graphics. One of such graphics packages is a PowerPoint.

9. Cartography

Cartography is a subject, which deals with the making of maps and charts. Computer graphics is used to produce both accurate and schematic representations of geographical and other natural phenomena from measurement data. Examples include geographic maps, oceanographic charts, weather maps, contour maps and population-density maps. Surfer is one of such graphics packages, which is extensively used for cartography.