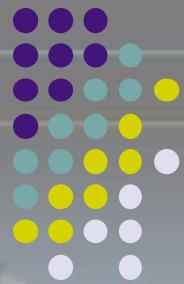
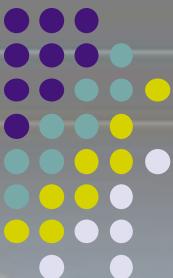


Computer Graphics 1: Introduction

Lecturer :Tim Dawson

Email: tim.dawson@gcd.ie





This module...

- 1) 12 weeks
- 2) 5 ECTS credits
- 3) 30% CA
- 4) 70% examination



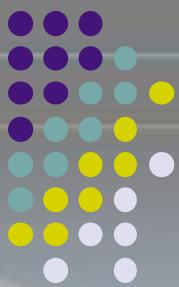
This lecture...

- Course Outline
- Lectures & Labs
- CA assignments
- Books
- Computer Graphics – What's It All About?
- Application Areas
- A brief history

Learning Outcomes

...

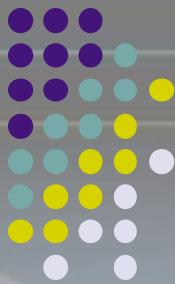
- explain steps in the rendering pipeline.
- mathematically describe object and viewing transformations.
- explain various line drawing, polygon drawing and clipping algorithms.

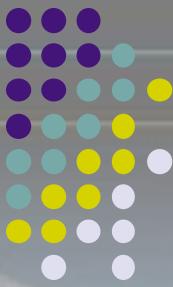


Learning Outcomes

...

- use mathematical techniques and laws of physics to develop lighting and shading models.
- describe ray tracing techniques and analyse ray tracing algorithms.
- write 3D applications using an appropriate graphics API.





What we cover...

- **Rendering pipeline and display technologies**
- Computer Graphics Systems: Geometry creation, Rendering pipeline, frame buffer, display, rasterization
- Display Technologies: Liquid Crystal Displays (LCD), Plasma displays, light emitting diode (LED) displays
- Coordinate Systems: object, world, view and image coordinate systems.



What we cover...

Geometry creation

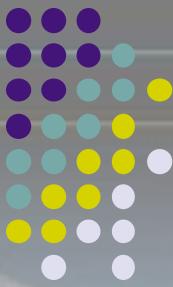
- Line drawing algorithms
- polygon drawing algorithms
- clipping



What we cover...

Transformations

- Object transformations: translation, scaling, rotation, composite transformations, 3D rotations about arbitrary vectors.
- Viewing transformations



What we cover...

- **Lighting, Colour models and shading**
- Lighting
- illumination and shading
- Light sources: point lights, directional lights, ambient lights
- Reflections: diffuse reflections, specular reflections, Phong illumination model
- Colour Models: colour perception, additive colour model RGB, subtractive colour model CMY and CMYK
- Shading: flat shading, Gouraud shading, Phong shading
- Texture mapping



What we cover...

Ray tracing

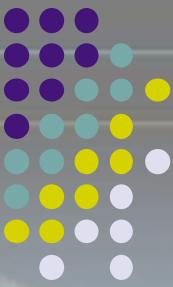
- Ray casting
- Ray tracing
- photo realistic rendering of 3D scenes
- Iterative ray tracing algorithm
- Optimisations of the ray tracing process



What we cover...

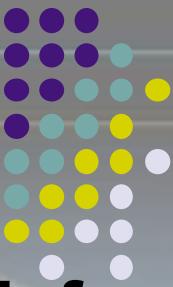
Graphics programming

- Elements of a 3D scene: view point, objects lights
- Using Processing
- 3D graphics APIs: OpenGL

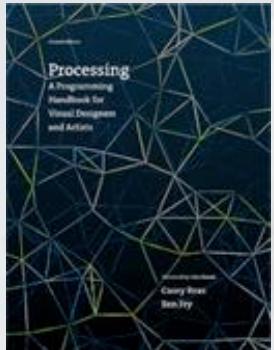


Reading list ...

- **Recommended reading**
- Dunn, F., 3D Math Primer for Graphics and Game Development, 2nd Edition, CRC Press, 2011
- Lengyel, E., Mathematics for 3D Game Programming and Computer Graphics, 3rd Edition, Delmar Cengage Learning, 2011



Secondary Reading

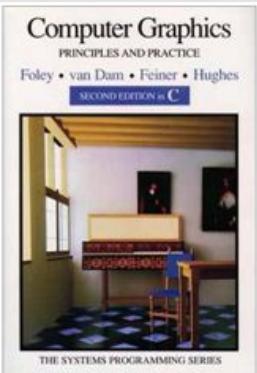


**Processing: A Programming Handbook for Visual Designers
(Second Edition)**

Casey Reas and Ben Fry.

Published December 2014, The MIT Press.
720 pages. Hardcover.

-



“Computer Graphics: Principles and Practice”, J.D. Foley, A. van Dam, S.K. Feiner & J.F. Hughes, Addison Wesley, 1995

Great for really in-depth theory



Lectures and labs

- Lecture 630 -8 pm Wednesdays
- Lab 630 -8 pm Wednesdays
- No Lab the first week!



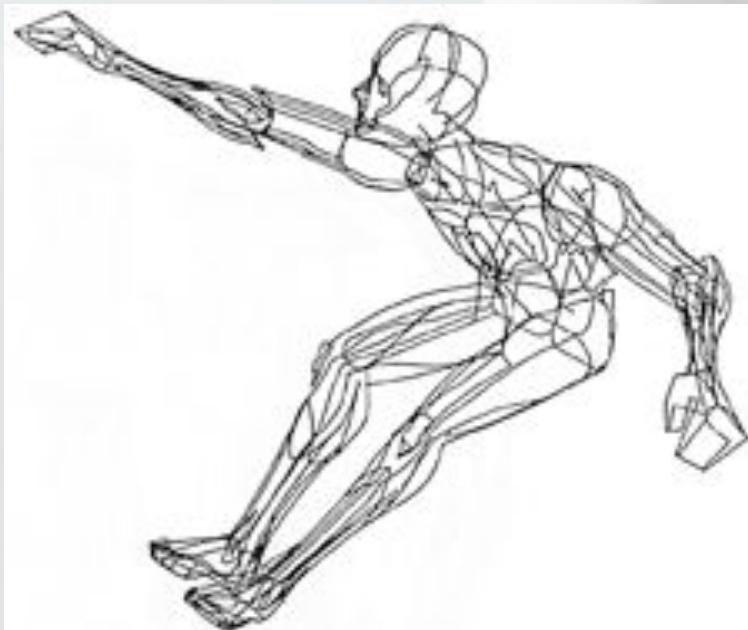
Questions

- Any Questions?



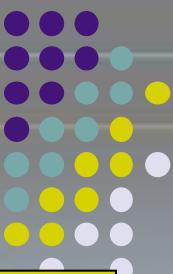
What Is Computer Graphics?

- The term **computer graphics** was coined in 1960 by William Fetter to describe new design methods he was pursuing at Boeing

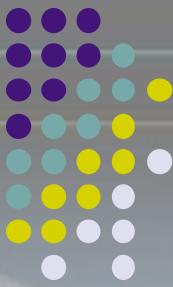


Fetter created a series of widely reproduced images on a pen plotter exploring cockpit design, using a 3D model of a human body

What Is Computer Graphics? (cont...)



- “*Perhaps the best way to define computer graphics is to find out what it is not. It is not a machine. It is not a computer, nor a group of computer programs. It is not the know-how of a graphic designer, a programmer, a writer, a motion picture specialist, or a reproduction specialist.*
- *Computer graphics is all these – a consciously managed and documented technology directed toward communicating information accurately and descriptively.”*
- **Computer Graphics**, by William A. Fetter, 1966



What Is Computer Graphics?

- Simple definition: computer graphics is the use of computers to create images
- Computer graphics is the science and art of communicating visually via a computer's display and its interaction devices
- The visual aspect of the communication is usually in the computer-to-human direction, with the human-to-computer direction being mediated by devices like the mouse, keyboard, joystick, game controller, or touch-sensitive overlay.
- the ultimate consumers of the communications are human, and the ways that humans perceive imagery are critical in the design of graphics programs—features that humans ignore need not be presented (nor computed!).



What Is Computer Graphics?

- CG has come to be the dominant form of content creation for video games, movie special effects, and many other forms of entertainment
- From the standpoint of a naive observer, CG really is magic
- Vision is entwined with our sense of reality, “seeing is believing”
- CG imagery can cross the line between physical experience and imagination

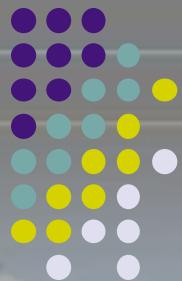


Interactive Computer Graphics

- Takes things a step further by allowing users rapid visual feedback from their actions
- Typically we have the following cycle:



- This area is the focus of this course



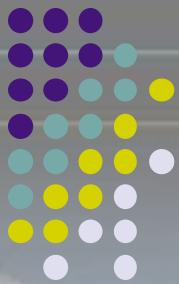
- With interactivity added, Fetter's definition pretty much still holds
- So much of modern computing involves some graphical aspect that computer graphics is now ubiquitous
- So let's say computer graphics encompasses anything achieved visually on computers





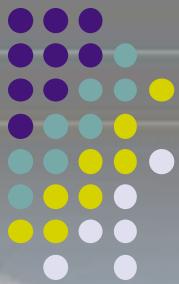
Applications?

Some Applications Of Computer Graphics

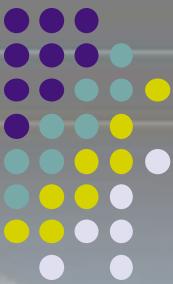


- The applications of computer graphics are many and varied; we can, however, divide them into four major areas:
 1. Display of information
 2. Design
 3. Simulation and animation
 4. User interfaces

Some Applications Of Computer Graphics

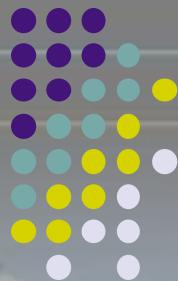


- Some of the application areas these applications are mapped to:
 - i. Computer aided design
 - ii. Scientific visualisation
 - iii. Films
 - iv. Games
 - v. Virtual/Augmented Reality
- **NOTE:** There are lots more and there is huge overlap between these different areas



Display of Information

- Classical graphics techniques developed in antiquity to convey information among people
- spoken and written languages serve a similar purpose, the human visual system is unrivaled both as a processor of data and as a pattern recognizer
- More than 4000 years ago, the Babylonians displayed floor plans of buildings on stones.
- For centuries, cartographers have developed maps to display celestial and geographical information.



Visualisation of Information

- statisticians have explored techniques for generating plots that aid the viewer in determining the information in a set of data.
- Now, we have computer plotting packages that provide a variety of plotting techniques
- tools that can handle multiple large data sets

*Fluid dynamics of the mantle
of the Earth.
Pseudocolor mapping of
temperatures and isotemperature
surface.*





Visualisation of Information

- Modern Medical imaging technologies
 - i. computed tomography (CT)
 - ii. magnetic resonance imaging (MRI)
 - iii. ultrasound
 - iv. positron-emission tomography (PET)
- generate three-dimensional data that must be subjected to algorithmic manipulation provide useful information.



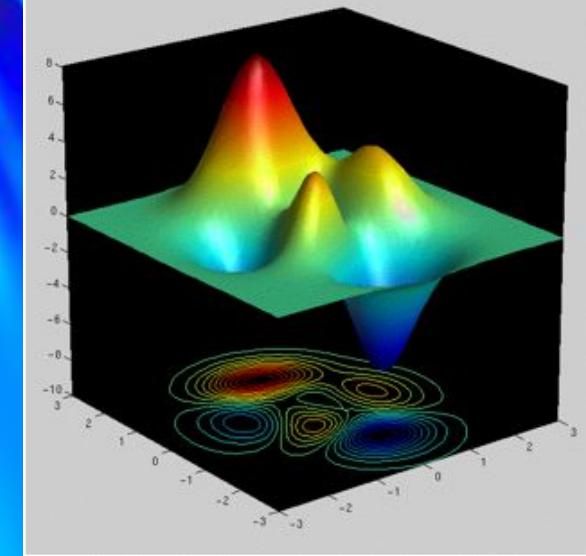
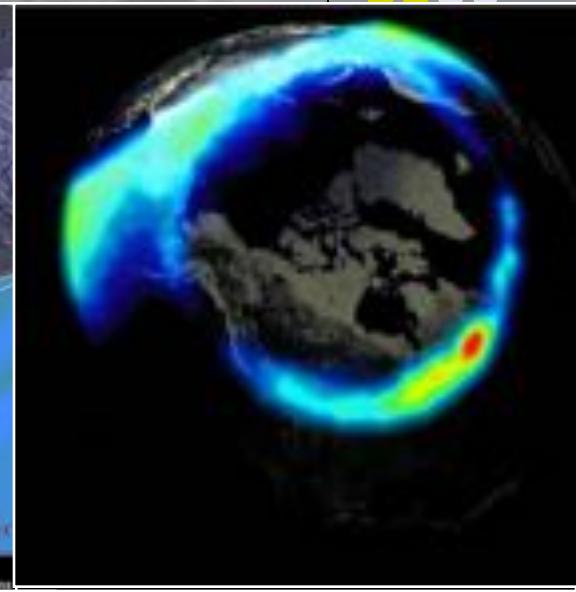
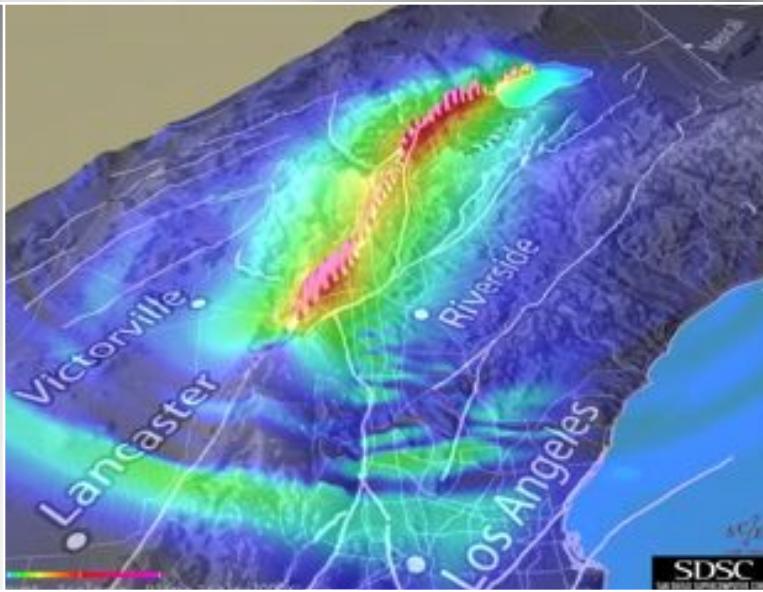
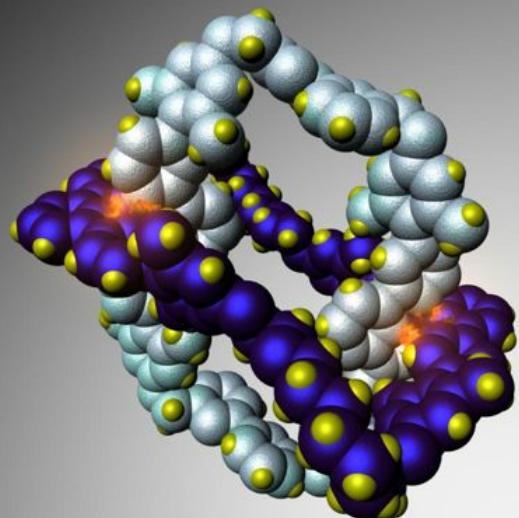
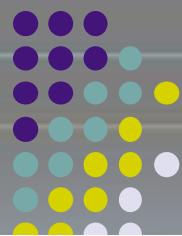


Visualisation of Information

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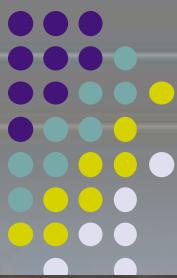
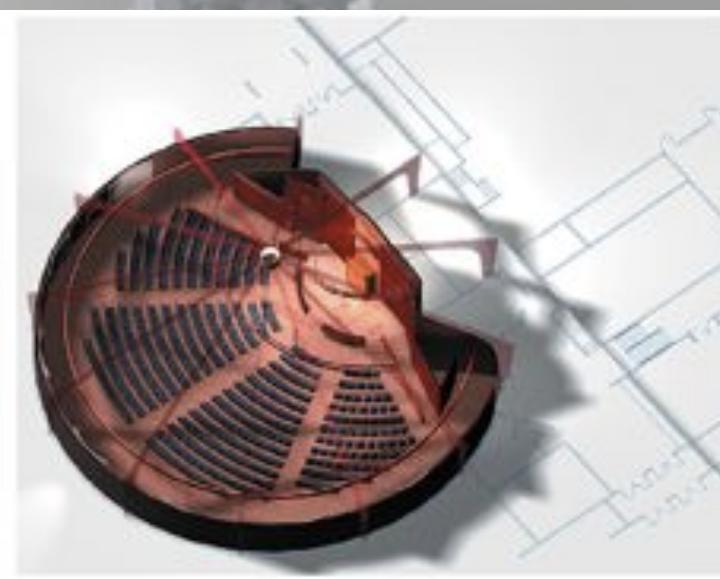


Scientific Visualisation

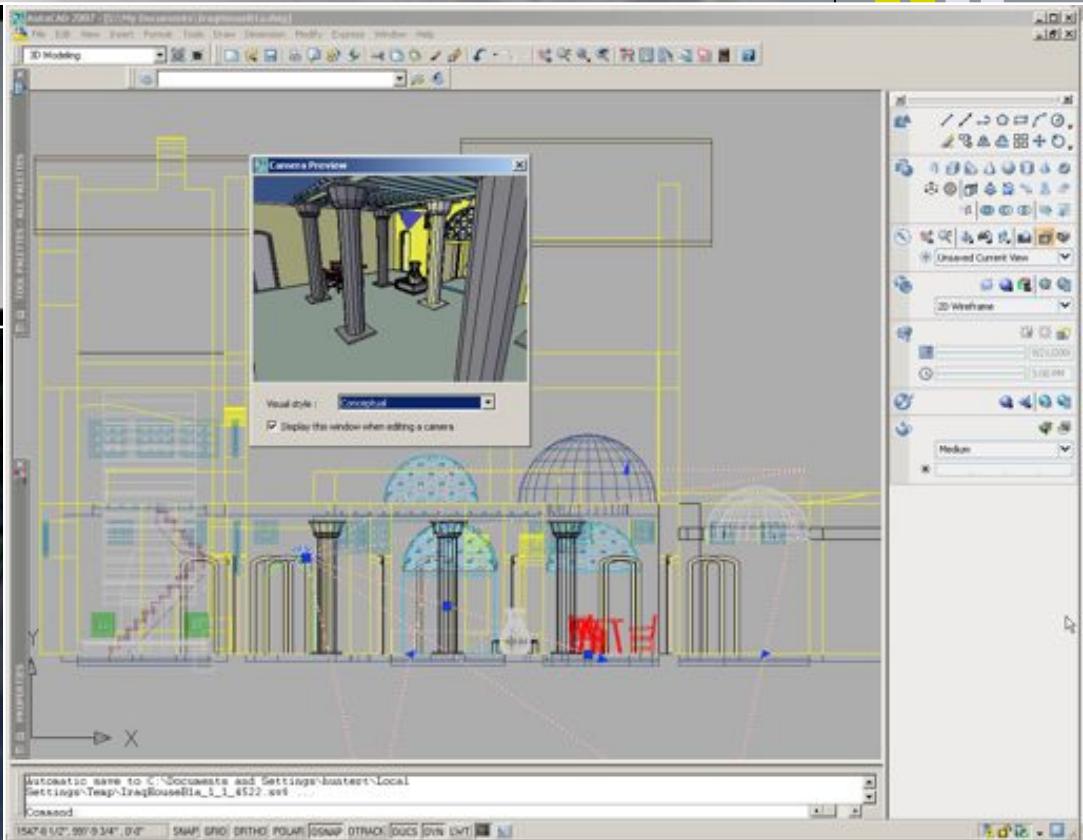
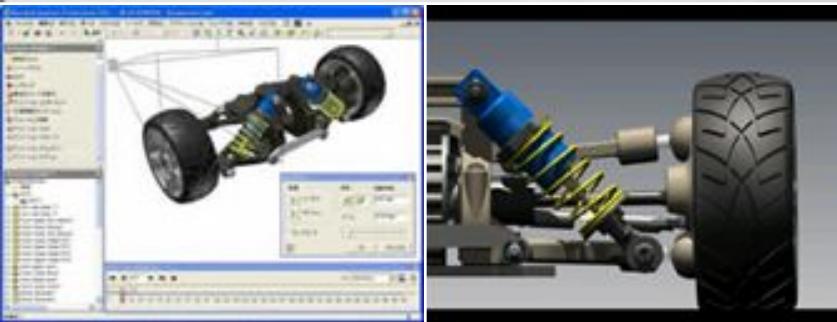
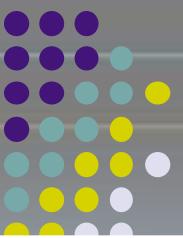


Design

- engineering and architecture professions are concerned with design
- Seeks cost-effective and aesthetic solution that satisfies the starting specifications
- Design is an iterative process
- Basic paradigm of humans interacting with images on the screen of a CRT was recognized by Ivan Sutherland over 40 years ago.



Computer Aided Design





Simulation and Animation

- Once graphics systems evolved to be capable of generating sophisticated images in real time, engineers and researchers began to use them as simulators
- The use of special VLSI chips has led to a generation of arcade games as sophisticated as flight simulators
- Games and educational software for home computers are almost as impressive





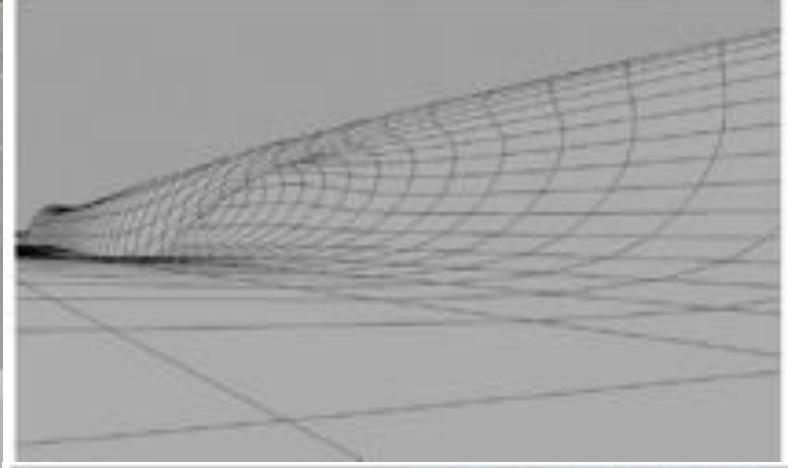
Films

- Leaders in quality and artistry
- Big budgets and tight schedules
- use almost all types of computer graphics technology.
- Almost every modern film uses digital compositing to superimpose backgrounds with separately filmed foregrounds

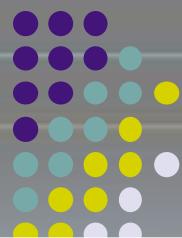


Films

- Sequence of still from Surf's Up



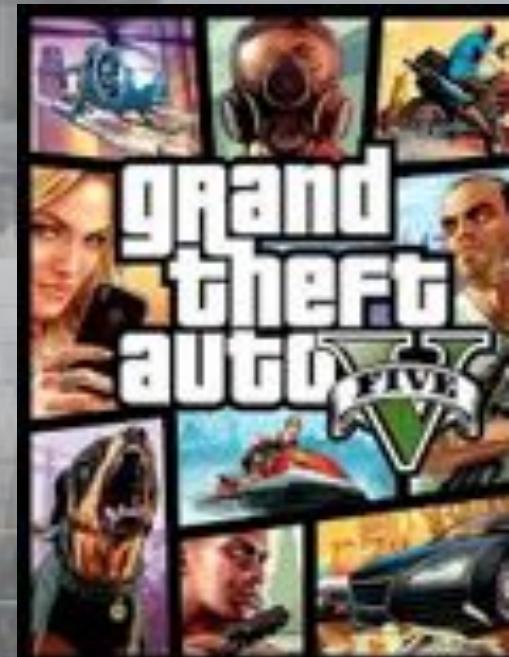
Films





Games

- Video games increasingly use sophisticated 3D models and rendering algorithms
- The newest driving force in CG
- Why? Volume and Profit
- why we have commodity GPUs
- Focus on interactivity
- Cost effective solutions
- Games drive the baseline





Games

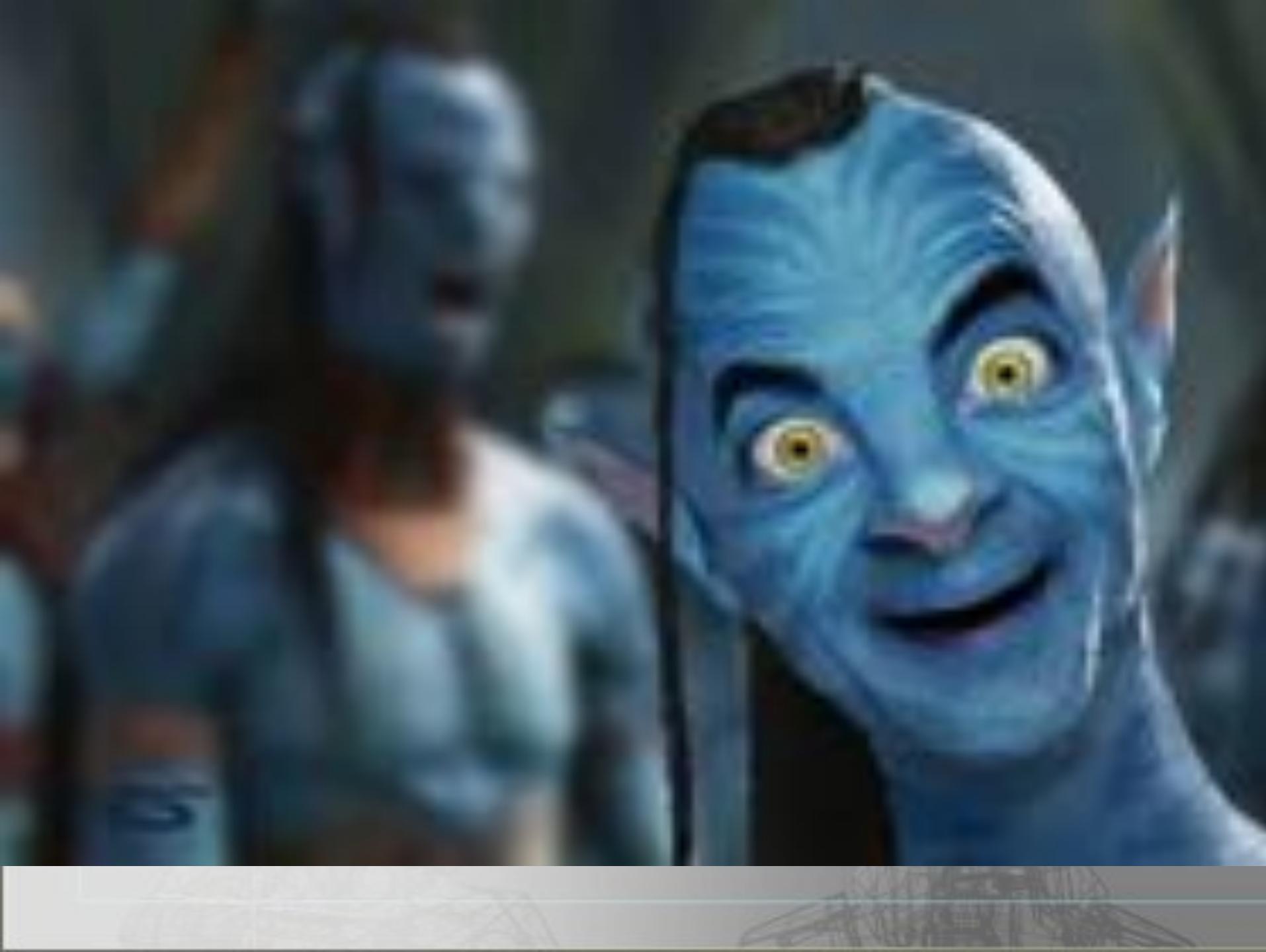




3d stereoscopic films

- 3D films have existed since about a century ago. The technology just didn't really take flight since then due to high costs.
- It is not until In the recent years that we've experienced the revival of 3D technology not only in films like Avatar, but also for gaming screens.

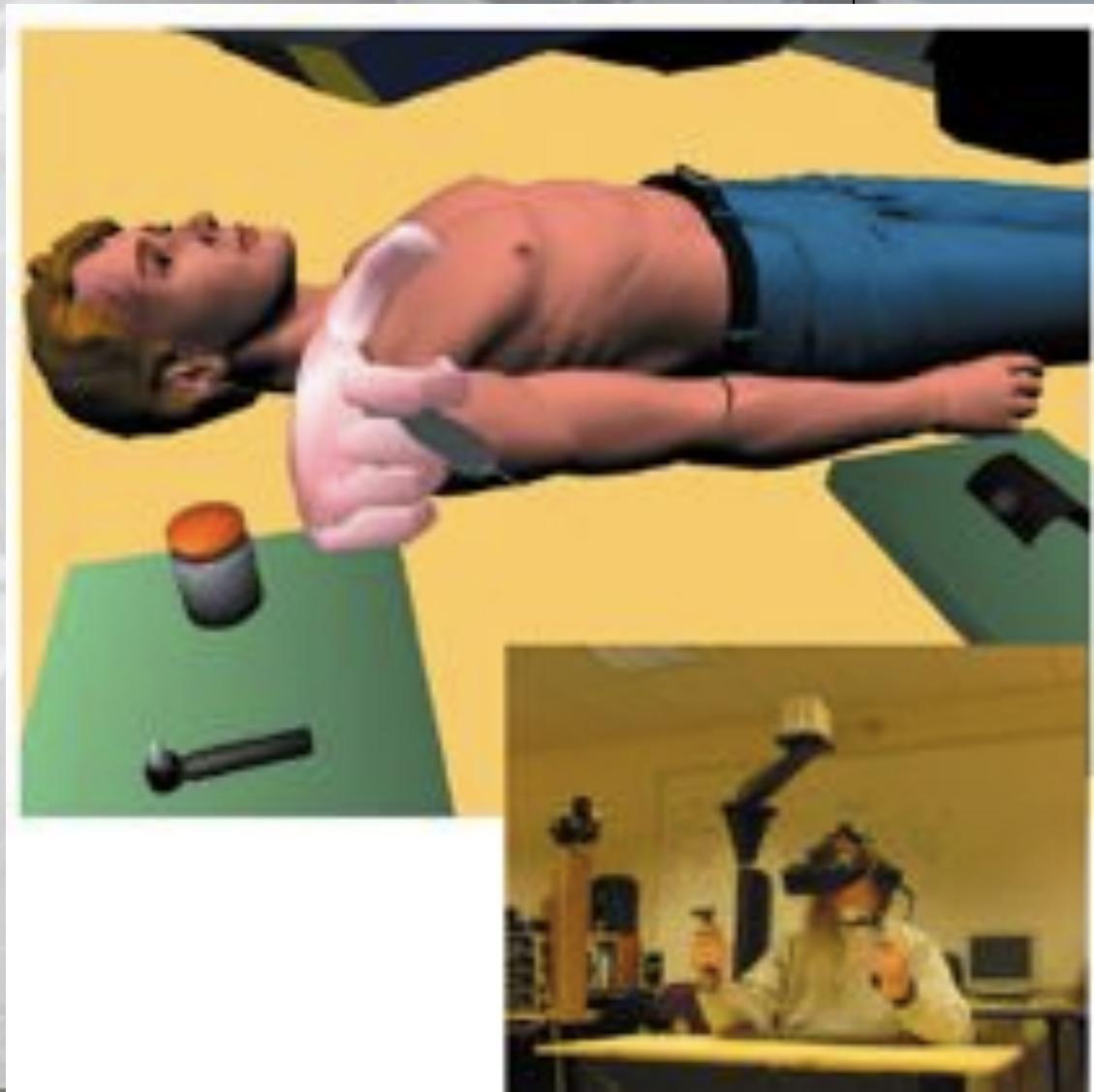


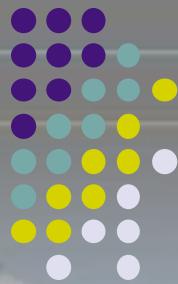




Virtual/Augmented Reality

- The field of virtual reality (VR) has opened up many new horizons.
- A human viewer can be equipped with a display headset that allows her to see separate images with her right eye and her left eye so that she has the effect of stereoscopic vision.

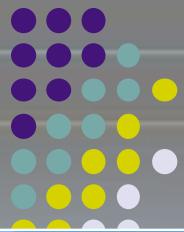




Virtual/Augmented Reality

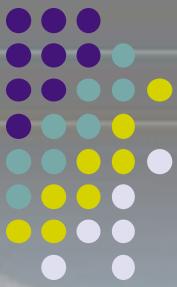
- With major leaps in technology that resulted in improved hardware capabilities, virtual reality (VR) has started to resurface in the gaming industry.
- Of particular note is the Oculus Rift, a VR head-mounted display (HMD) created by Palmer Luckey using financing sourced through crowd sourced funding





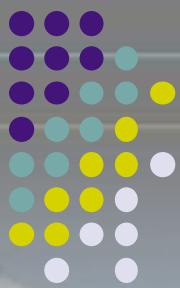
Virtual/Augmented Reality





History of CG

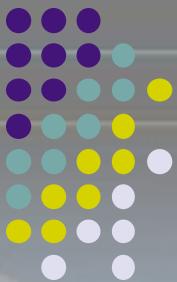
Precursors of computer graphics



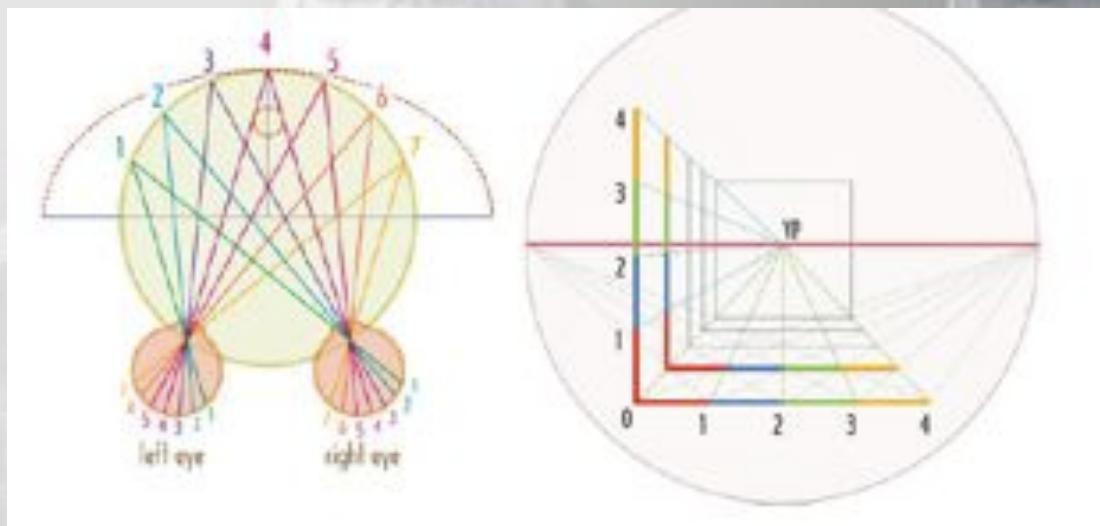
- In 1435, the Italian scholar Leon Battista Alberti wrote a treatise in Latin titled *De Pictura* (on painting). It is the first known publication on the subject of linear perspective
- Linear perspective is a subject very closely related to the heart of modern computer graphics because it establishes a way to artificially construct a realistic representation of 3D objects within a 2D picture space
- The process is called projection
- Alberti's treatise was partly based on observations made by the prominent Florentine sculptor and architect Filippo Brunelleschi , though other artists from the same period were also experimenting with the technique.



Linear perspective



- Linear perspective demonstrated that a realistic representation of a 3D environment could be calculated based on rules that govern how our eyes see the world around us
- Linear perspective stems from the observation that parallel lines seem to converge as they move farther from our eye.
- The reason isn't that they are actually coming together, but that the human eye is nearly spherical in shape



Aerial perspective



- Leonardo da Vinci's observation that colors become less distinct over distance became known as Aerial Perspective
- The phenomenon is caused by many tiny light-occluding particles such as dust and fog suspended in the atmosphere
- At near distances, they do not noticeably affect our vision because there are not as many of these particles between our eye and the object we are observing as when we refocus our eyes on a distant object
- In computer graphics, aerial perspective is known as environmental fog



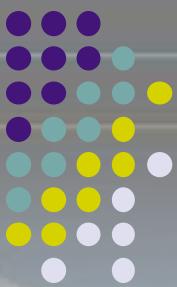
The Influence of Pointillism



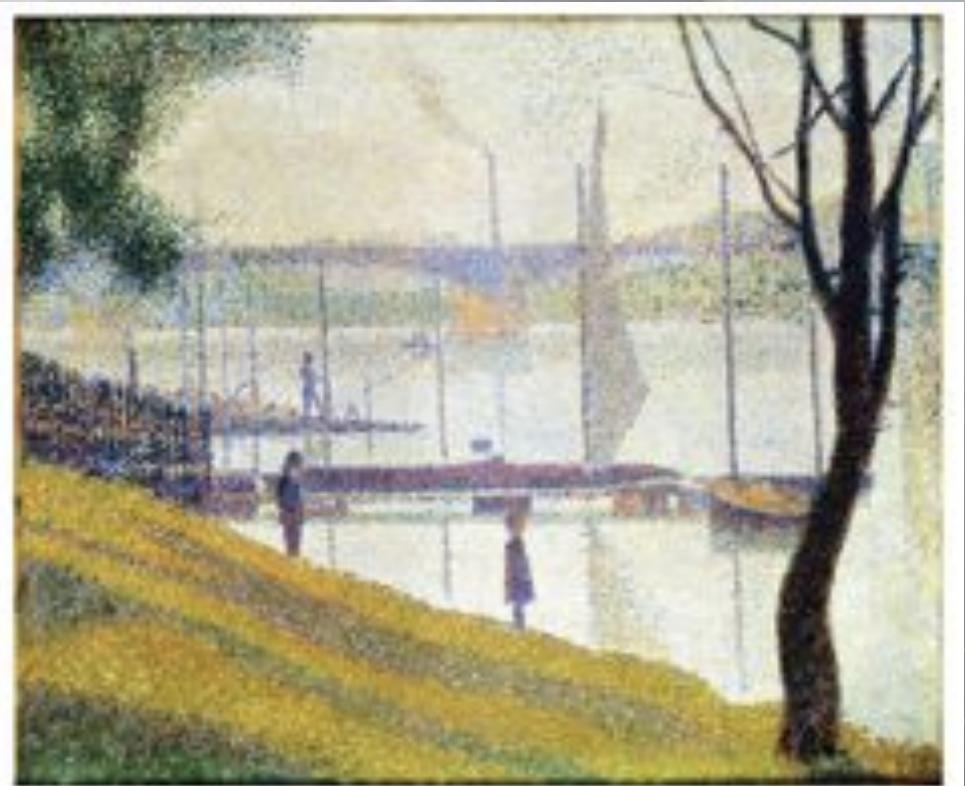
- style of painting invented in the late nineteenth century by the French artist Georges Seurat
- as inspired by the work of Impressionists like Claude Monet or Pierre Auguste Renoir , who discovered that they could make a convincing landscape without mixing their colors in a traditional way
- Monet, Renoir, and others used bright colors that were either unmixed or were not fully mixed, then placed them near other colors that would make them seem as if they were part of the same color.



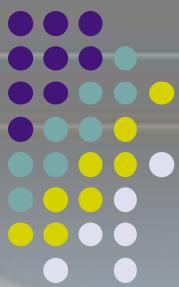
The Influence of Pointillism



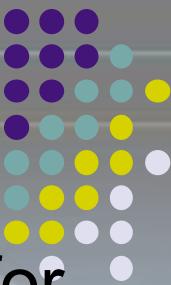
- What these artists discovered was that if they broke a color into its primary components , a full spectrum of visible colors could be created.
- Pointillism using nothing but brightly colored dots, or points.



Early history of computer graphics

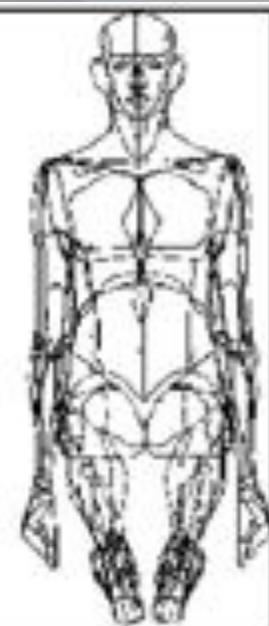


- John Whitney, Sr
- American animator, composer and inventor of motion control photography
- working with brother James made series of experimental films
- modified analogue computer from WW2
- Used it to control the motion of lights
- one of earliest examples of motion control photography Alfred Hitchcock's 1958 film Vertigo,

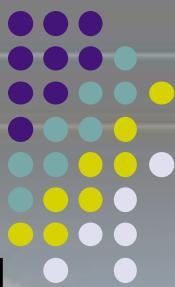


William Fetter

- In 1960, William Fetter was a graphic designer for Boeing at Lawrence Livermore Labs
- credited with coining the phrase "Computer Graphics"
- “The Boeing Man” – 3D representation of human



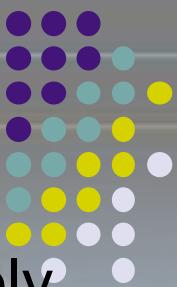
Virtual/Augmented Reality



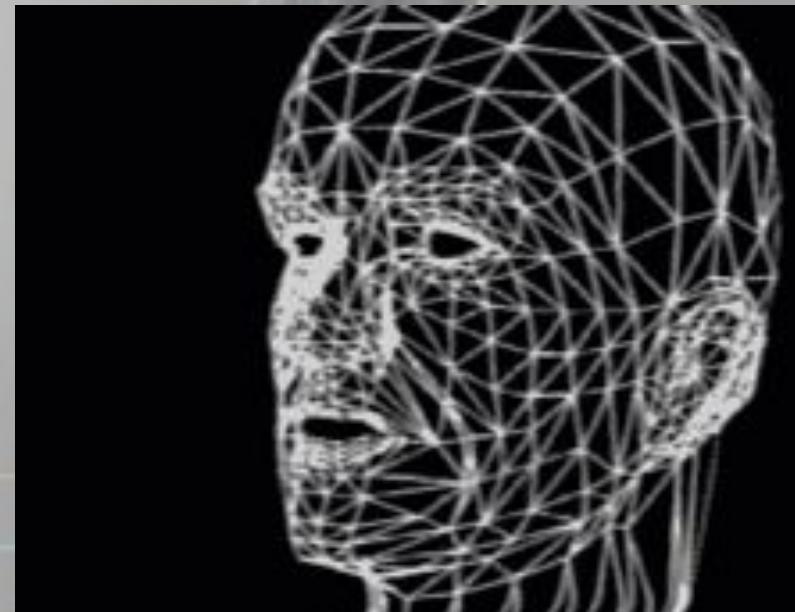
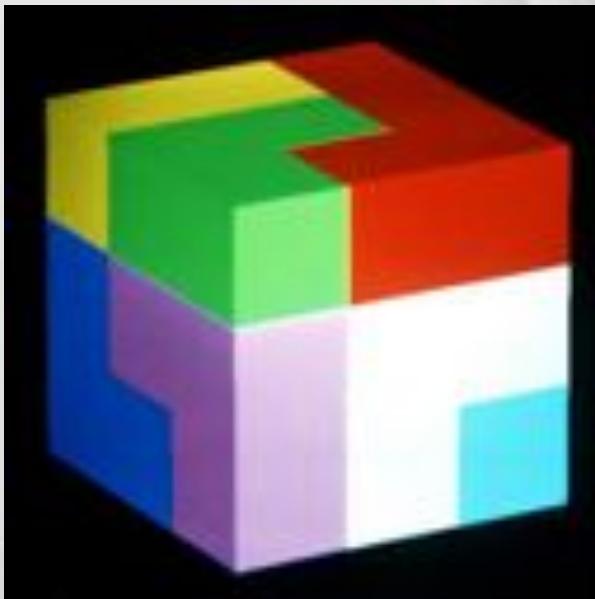
- 1963 One of Fetter's contemporaries, Ivan Sutherland submitted his PhD. thesis, entitled Sketchpad: A Man-machine Graphical Communications System.
- The software enabled a person, for the very first time, to interactively create an image on a computer display
- sketchpad pioneered the concepts of graphical computing, including memory structures to store objects, rubber-banding of lines, the ability to zoom in and out on the display and the ability to make perfect lines, corners, and joints.



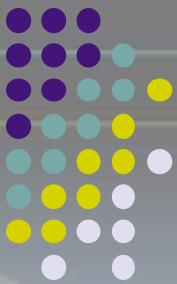
Virtual/Augmented Reality



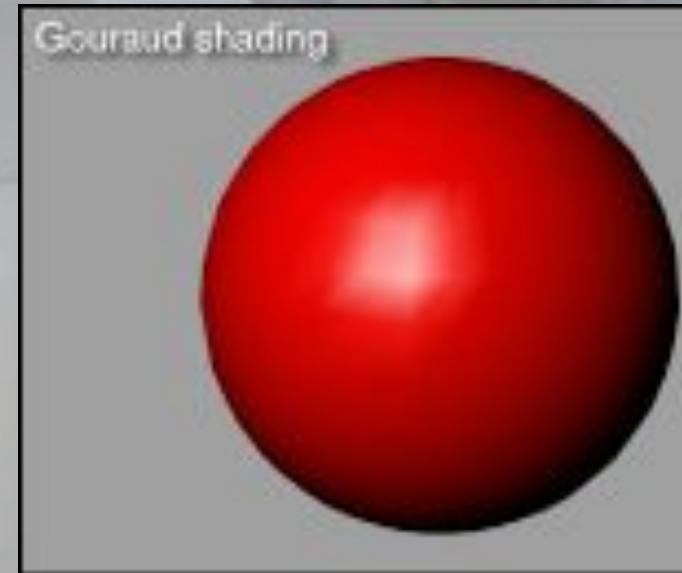
- The very first three-dimensional images were extremely rudimentary by today's standards and consisted of wire frame representations of various geometric shapes.
- Sutherlands colleagues Evans, Wylie, Romney, and Erdahl developed the Scan line HSR (Hidden Surface Removal) algorithm to create renders of solid objects.



Shading: Gouraud and Phong

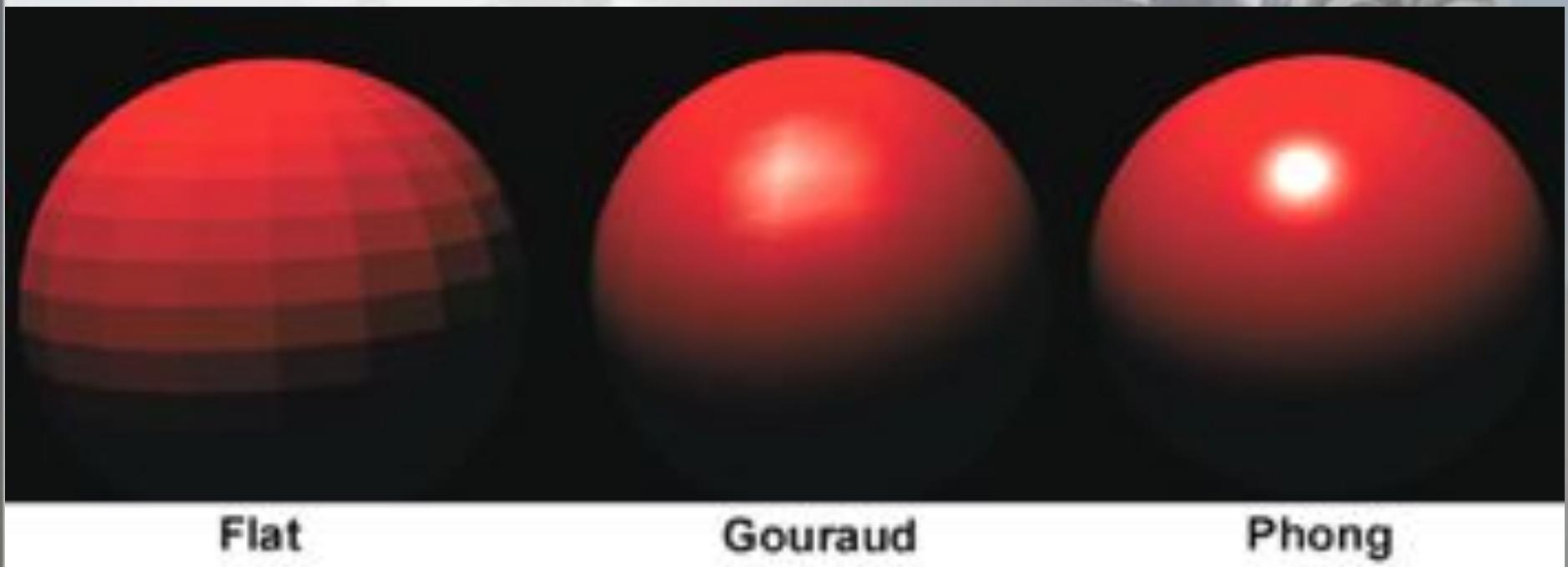


- the next issue for developers was how to increase the apparent complexity of a scene without increasing the amounts of geometry, therefore conserving precious system memory
- the only shading model available to early renderers was the flat shading model, also known as faceted shading.





Shading: Gouraud and Phong





Shading: Gouraud



A



B



C



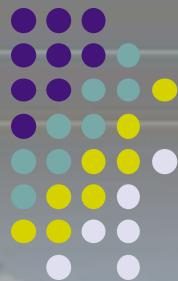
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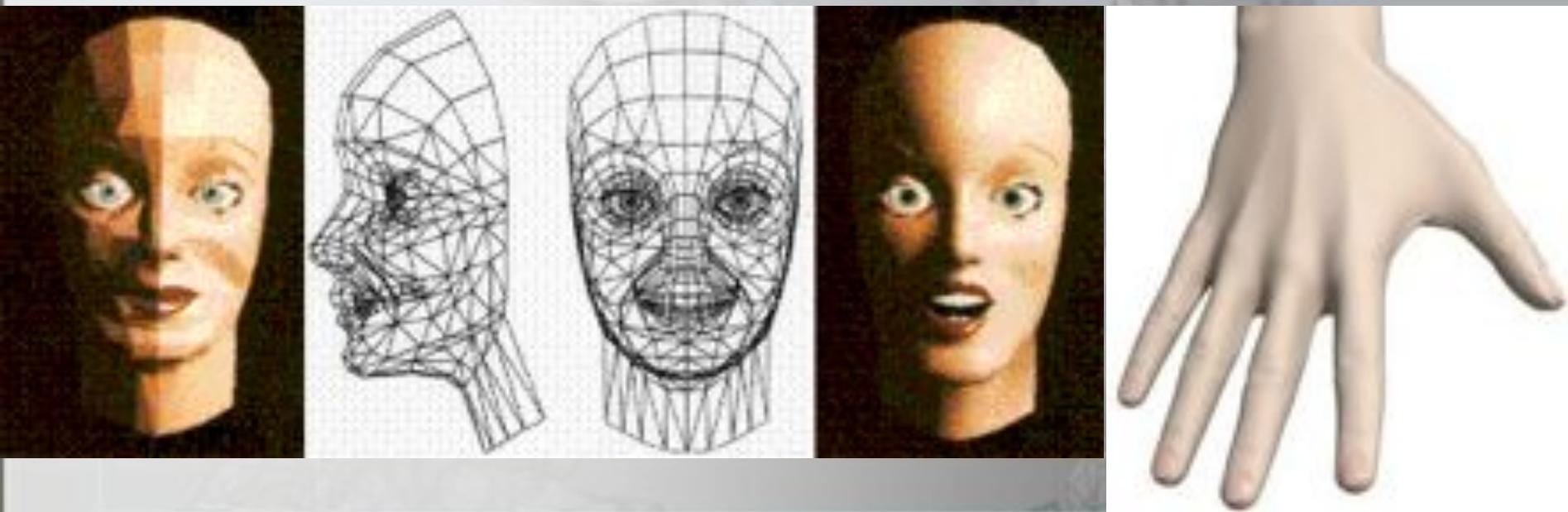


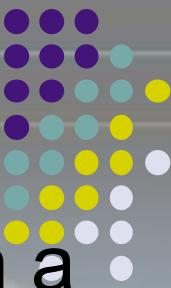
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Animation 3D models

- Frederic Parke created 3D human face model in 1972
- Edwin Catmull created digitized hand in 1973

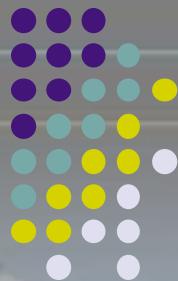




Futureworld

- 1973 First use of 2D computer animation in a significant entertainment feature film.
- Edwin Catmull and Frederic Parke worked on sequel Futureworld in 1976
- First major feature film to use computer generated images (CGI)

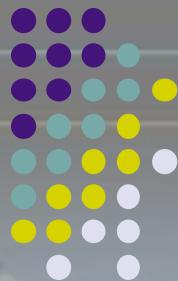




Edwin Catmull

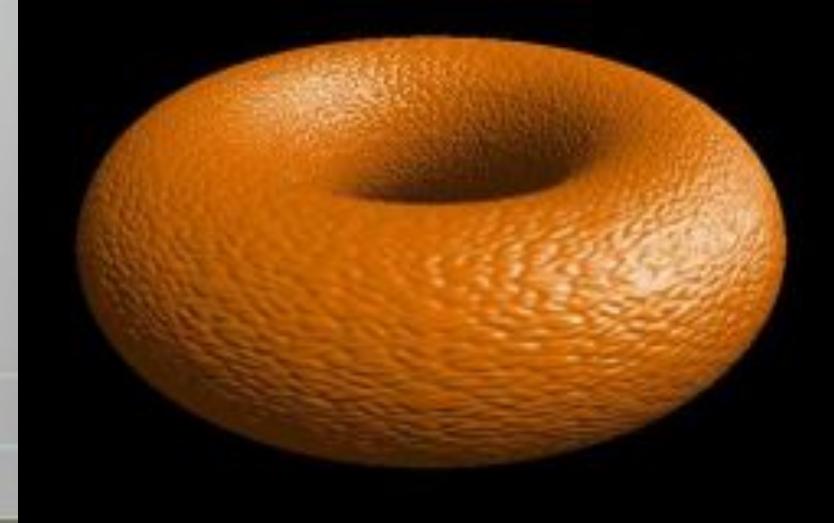
- Computer scientist – pioneering work in area of texture mapping and subdivision surfaces
- 2001 - became president of Walt Disney and Pixar Animation Studios
- One of the founders of Pixar





Jim Blinn

- Computer scientist – PhD from Utah 1978
- Pioneering work on bump mapping and environment mapping
- 1976 Torrance-Sparrow light reflection model, bump mapping

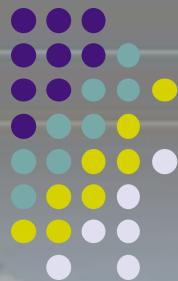




Star Wars

- 1977, Star Wars Episode IV: A New Hope
- George Lucas used 3D graphics to enhance film
- Success of film helped heighten 3D animation in cinema

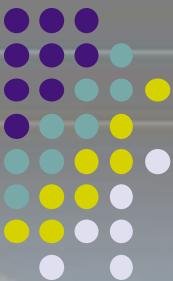




Tron

- Development began in 1976
- Released in 1982, contained live action and computer animation
- Tron one of first movies made extensive use of computer animation

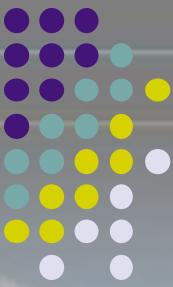




Terminator 2 (1991)

- Revolutionized special effects industry
- Ground-breaking computer graphics and visual images





Jurassic Park (1993)

- Realistic 3D dinosaurs
- George Lucas inspired to work on Star Wars again





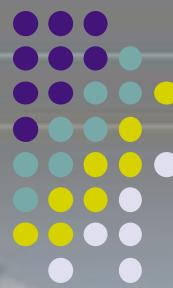
Toy Story

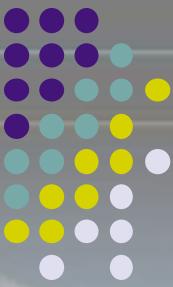
- First feature-length 3D animated movie in 1995
- Considered to be first animated feature generated completely on computers



Toy Story

- From storyboard to final render, the many steps in creation of digital imagery



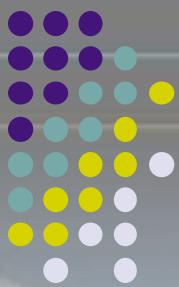


Star Wars

- Star Wars Episode I: The Phantom of the Menace in 1999
- Almost every shot enhanced with 3D animation
- Feature's realistic aliens and backgrounds



Final Fantasy: The Spirits Within



- First animated feature to attempt photorealistic CGI humans

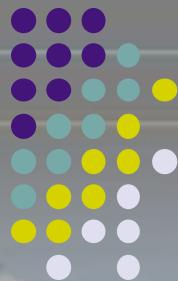




Lord of the Rings: Two Towers

- First photorealistic motion captured for film





3D Today

- 3D animation can be seen everywhere
- Big in movie industry, video games, ads
- Anyone can make it with available software

