

# Introduction to Computer Graphics

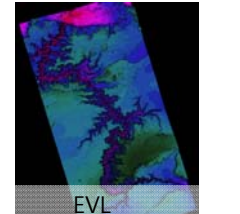
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Fall 2021  
8/31/2021  
Kyoung Shin Park  
Computer Engineering  
Dankook University

## Computer Graphics Applications

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- ❑ Computer Animation, Film
- ❑ CAD/CAM
- ❑ Games
- ❑ VR, AR, MR
- ❑ Medical Imaging
- ❑ Scientific Visualization



## Computer Graphics Main Theme

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- ❑ Imaging
  - Express 2D images effectively
- ❑ Modeling
  - Form real or virtual 3D model objects that can be understood by computers
- ❑ Rendering
  - Render into the 2D image from a 3D model (geometric model, volume rendering, image-based rendering)
- ❑ Animation
  - Express the natural movement of objects, such as humans or anthropomorphic animals and plants, and robots over time

## Modeling

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- ❑ Geometric Modeling
  - Create 3D models using graphics toolkits such as Maya, 3DS Studio Max
- ❑ Physically Based Modeling
  - Realistically reproduce physical phenomena in nature such as water, smoke, fire and explosion through computer graphics
- ❑ 3D Scanning
  - Project a laser or a specific pattern into a subject and resorting a 3D shape from the captured image
- ❑ Image-based Modeling
  - Create 3D model from multiple photos

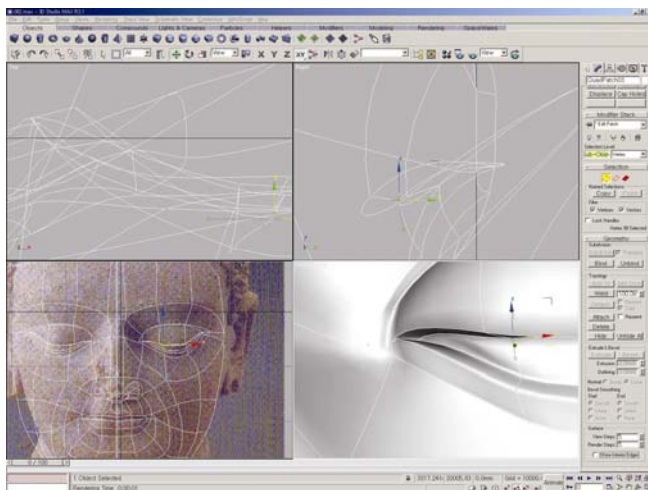
## Rendering

- ❑ Physically Based Rendering
  - Render CG object realistically based on the physical interaction between light and object
  - Ray Tracing, Radiosity
- ❑ Volume Rendering
  - Render 3D representation of large volumes of data
- ❑ Image-based Rendering
  - Render the image generated at one point of view from the images at other points of view
- ❑ Non-Photorealistic Rendering
  - Contrary to photorealistic rendering, render the image generated by human hands
  - Cartoon, Pencil drawing, Watercolor painting, Oil painting, mosaic, Oriental ink-and-wash painting
- ❑ Real-Time Rendering
  - Interactive graphics, Game, GPU

## Animation

- ❑ Keyframe Animation
  - An experienced keyframe animator sets keyframes for important object movement and then smoothly interpolates keyframes
  - It is manually done by cell animation; automatically done by computer animation
- ❑ Motion Capture
  - Directly capture joint motion using optical camera, magnetic sensor, mechanical sensor, etc.
  - It is widely applied to movie industries because it is possible to create the most realistic motion, but it is difficult to edit capture motion
- ❑ Physically Based Animation
  - Create realistic interaction and animations through physically based animation
- ❑ AI-based Behavior Animation
  - Automatically create natural behaviors like real humans by giving the character intelligence and behavior

## Geometric Modeling



3D Studio Max

## Physically Based Modeling and Animation

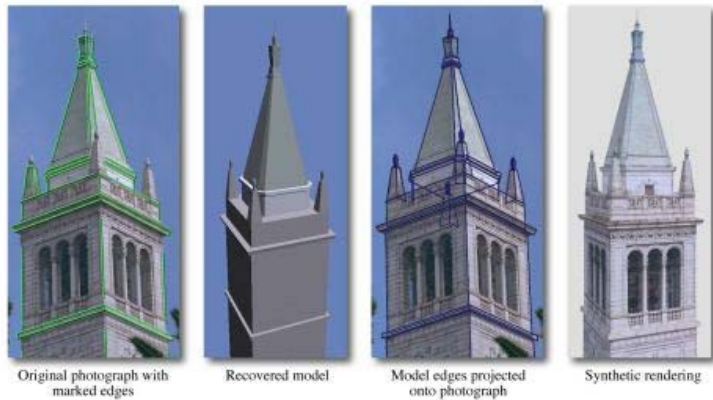


Cloth simulation, David Baraff and Andrew Witkin (1997)  
<http://www.cs.cmu.edu/~baraff/sigcourse/index.html>



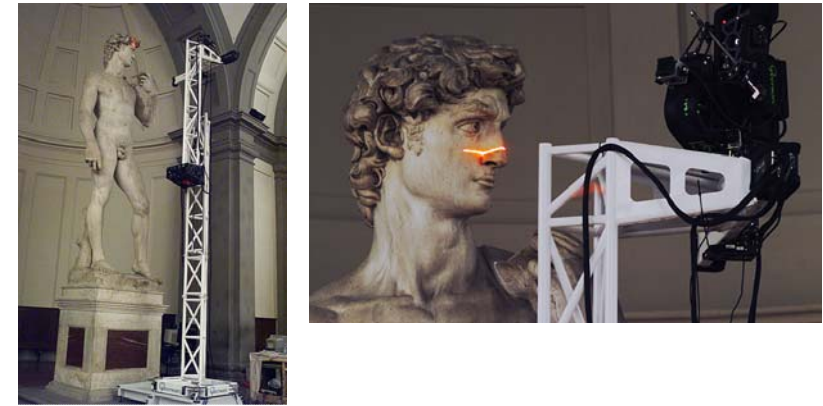
Fire, smoke, gas simulation  
Duc Quang Nguyen, Ronald Fedkiw, Henrik Wann Jensen (SIGGRAPH2002)  
<http://graphics.ucsd.edu/~henrik/papers/fire>

## Image Based Modeling and Rendering



Façade [http://www.debevec.org/Research/IBMR\\_SIGGRAPH99](http://www.debevec.org/Research/IBMR_SIGGRAPH99)  
<https://pdfs.semanticscholar.org/e1c3/65e0a83ad131a5ca2c6c754a49d95d54aba6.pdf>

## 3D Scanning



Digital Michelangelo Project, Marc Levoy, Paul Debevec (1999)  
<https://graphics.stanford.edu/data/mich/>

## 3D Scanning



2006.4 – 3D scanning of wall reliefs of Angkor Wat temple in Cambodia

## Photo-realistic Rendering

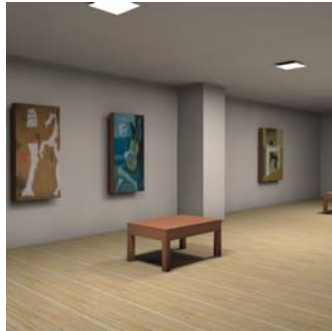


Monte Carlo Ray Tracer (CS488 Course Assignment 1999)  
[http://www.student.cs.uwaterloo.ca/~cs488/Contrib/a3patel/project/a3patel\\_index.html](http://www.student.cs.uwaterloo.ca/~cs488/Contrib/a3patel/project/a3patel_index.html)

Monte Carlo Ray Tracing (Lecture Note 2013)  
<http://www.cs.cornell.edu/courses/cs4620/2013fa/lectures/22mcrt.pdf>



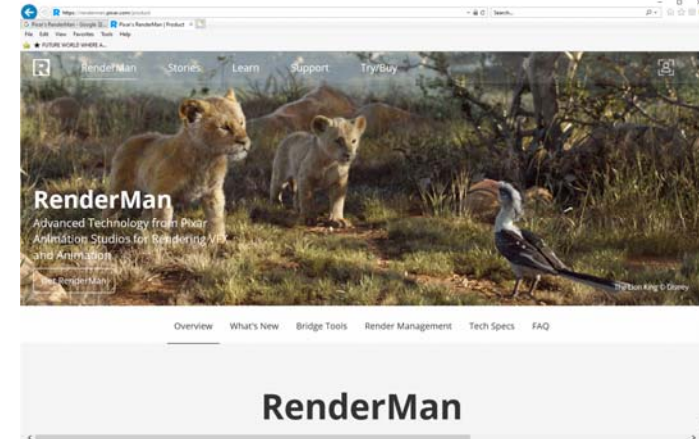
## Photo-realistic Rendering



[https://en.wikipedia.org/wiki/Radiosity\\_\(computer\\_graphics\)](https://en.wikipedia.org/wiki/Radiosity_(computer_graphics))

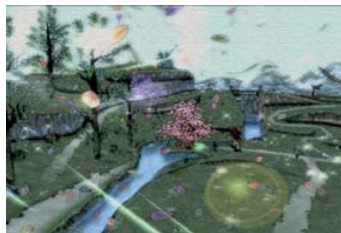
Radiosity on Graphics Hardware (SIGGRAPH 2005)  
<http://www.cs.unc.edu/techreports/03-020.pdf>

## Photo-Realistic Rendering



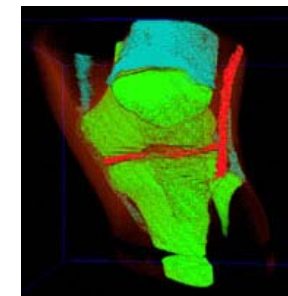
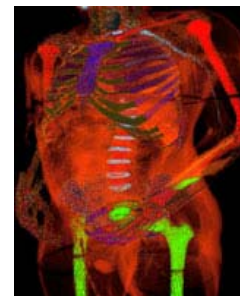
Pixar's RenderMan <https://renderman.pixar.com/>

## Non Photorealistic Rendering (NPR)



Oriental Ink Wash Painting Rendering Technique  
Capcom's PS2 Game called Okami (released in 2006)

## Volume Rendering



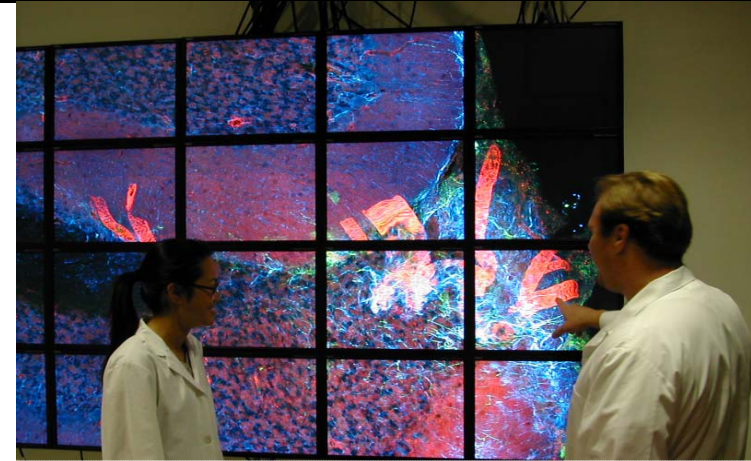
6.77GB Visible Male Data sets  
The Visible Human Project  
[https://www.nlm.nih.gov/research/visible/getting\\_data.html](https://www.nlm.nih.gov/research/visible/getting_data.html)

## Scientific Visualization



Typhoon Maemi in 2003 Visualization/VOSS System  
Korea Institute of Ocean Science & Technology

## Scientific Visualization



Rat Cerebellum Microscopy (NCMIR) on Tiled Display  
National Center for Microscopy and Imaging Research, UC San Diego  
<https://ncmir.ucsd.edu/press/in-the-news?news=9>

## Motion Capture for Character Animation



OptiTrack  
<https://optitrack.com/support/accessories/motion-capture-suit-care.html>



Motion Retargetting

## Facial Expression Animation



Facial animation and modeling, MPI Informatik (2001)  
<http://www.mpi-inf.mpg.de/resources/FAM/>

## Facial Expression Animation



More About Motion Capture (2013)  
<http://animationandvideogames.blogspot.com/2013/11/motion-capture-methods.html#!/2013/11/motion-capture-methods.html>  
Facial Motion Capture  
[https://en.wikipedia.org/wiki/Facial\\_motion\\_capture](https://en.wikipedia.org/wiki/Facial_motion_capture)

## AI-based Behavior Animation



Panspermia, Karl Sims' Artificial Life (1990)  
<https://www.karlsims.com/panspermia.html>

## 3D CG Animation



Pixar Luxo Jr. (2 min, SIGGRAPH 1986)

## Full 3D CG Film



Toy Story (81 min, 1995) First full 3D CG movie



## Full 3D CG Film



Final Fantasy: The Spirits Within (56:36 min, 2001)  
First photorealistic computer-animated feature film

## 3D (Stereoscopic) Movie

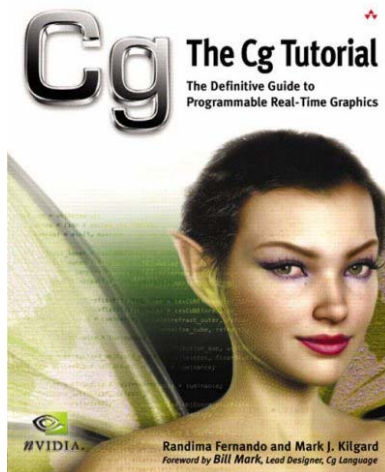


James Cameron's Avatar (161 min, 2009), 3D stereoscopic movie

<https://www.biznews.com/briefs/2015/01/20/big-data-tops-humans-picking-significant-films-study/attachment/visitors-wear-3d-glasses-as-they-watch-a-preview-of-the-upcoming-movie-avatar-during-the-40th-annual-comic-con-convention-in-san-diego>



## Real-Time Graphics



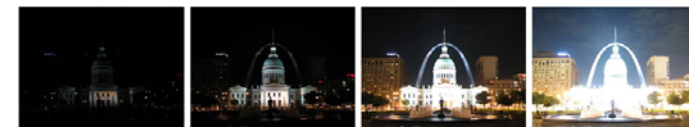
GPU programming by nVidia Cg,  
OpenGL/GLSL, DirectX/HLSL

[http://en.wikipedia.org/wiki/Real-time\\_computer\\_graphics](http://en.wikipedia.org/wiki/Real-time_computer_graphics)

<http://www.e-booksdirectory.com/details.php?ebook=2474>

## HDR (High Dynamic Range) Imaging

Original images



-4 stops

-2 stops

+2 stops

+4 stops

Results after processing



Simple contrast reduction

Local tone mapping

[http://en.wikipedia.org/wiki/High-dynamic-range\\_imaging](http://en.wikipedia.org/wiki/High-dynamic-range_imaging)

## Virtual Reality



The best VR headsets  
<http://www.wareable.com/headgear/the-best-ar-and-vr-headsets>

## Augmented Reality



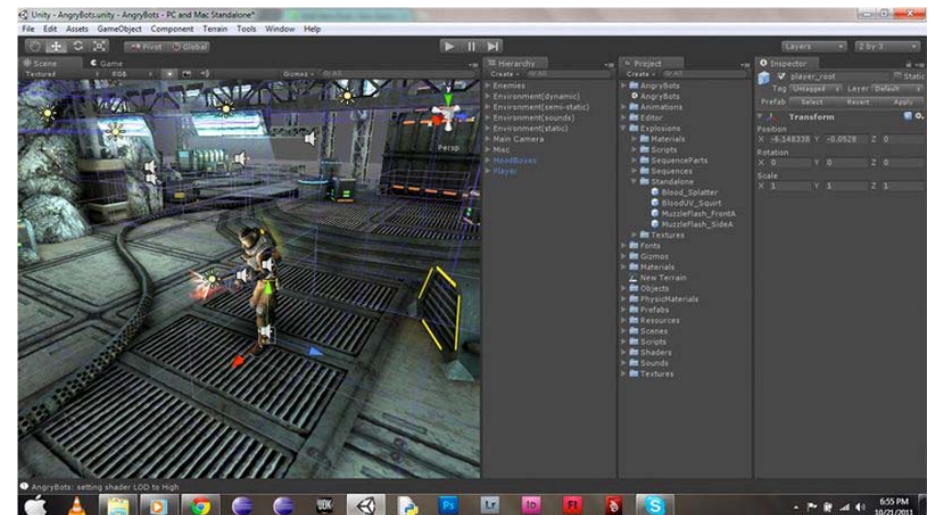
AR/MR Devices  
<https://www.augmented-minds.com/en/augmented-reality/ar-hardware-devices/>

## Mixed Reality



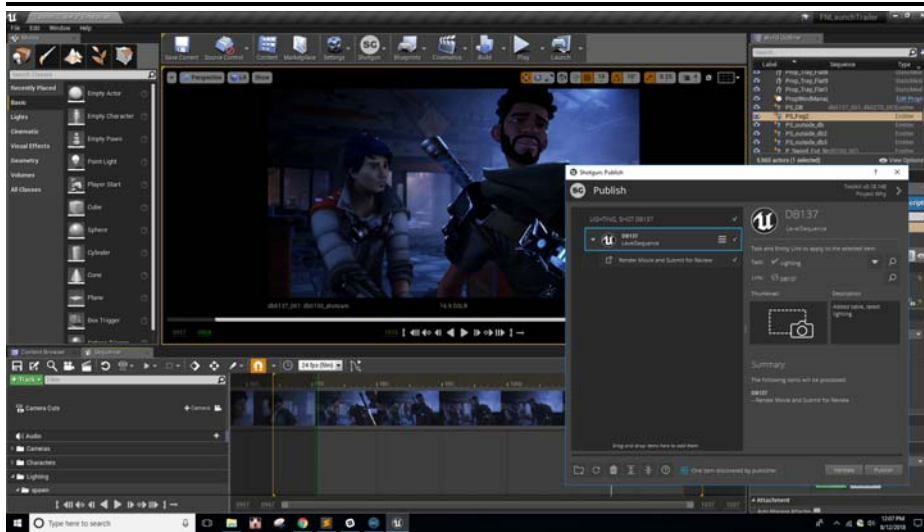
Microsoft HoloLens  
<https://www.microsoft.com/microsoft-hololens/en-us>

## Unity3D

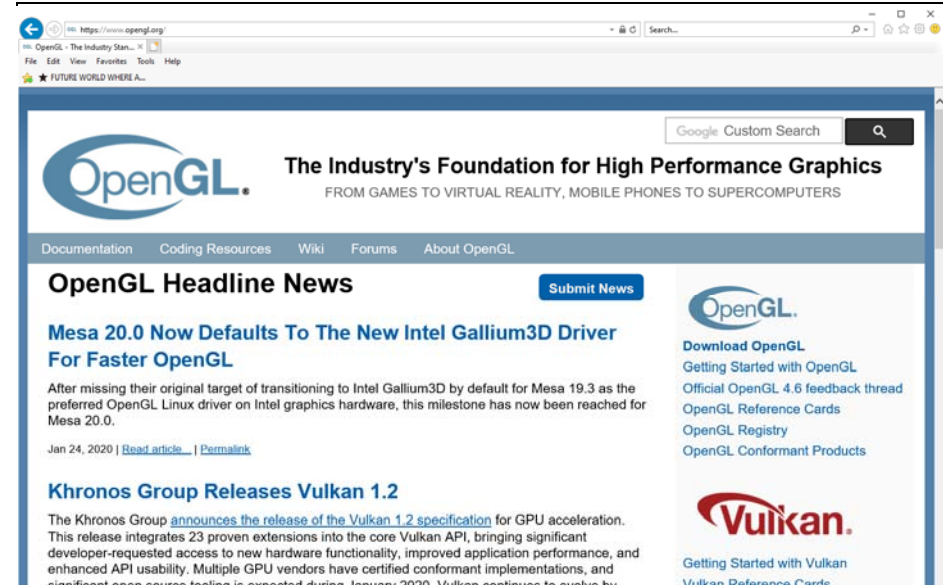




## Unreal



## OpenGL



## HW

- History of Computer Graphics
- History of Computer Animation
- History of Teapot
- History of Video Games
- History of Virtual Reality
- History of Augmented Reality
- GPU Programming
- Silicon Graphics Industry
- Pixar RenderMan
- Volume Rendering
- Non-Photorealistic Rendering (NPR)
- ....