

Introduction to Computer Graphics

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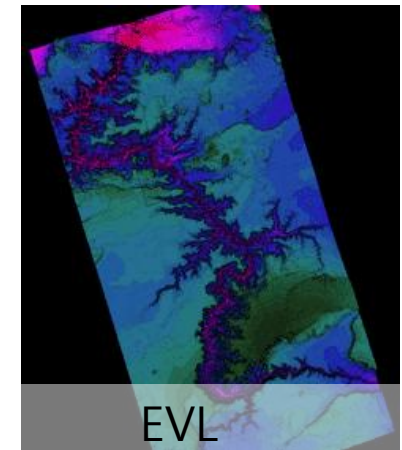
Fall 2025

9/7/2026

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Computer Graphics Applications

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



Computer Graphics Main Theme

- ❑ 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

□ 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

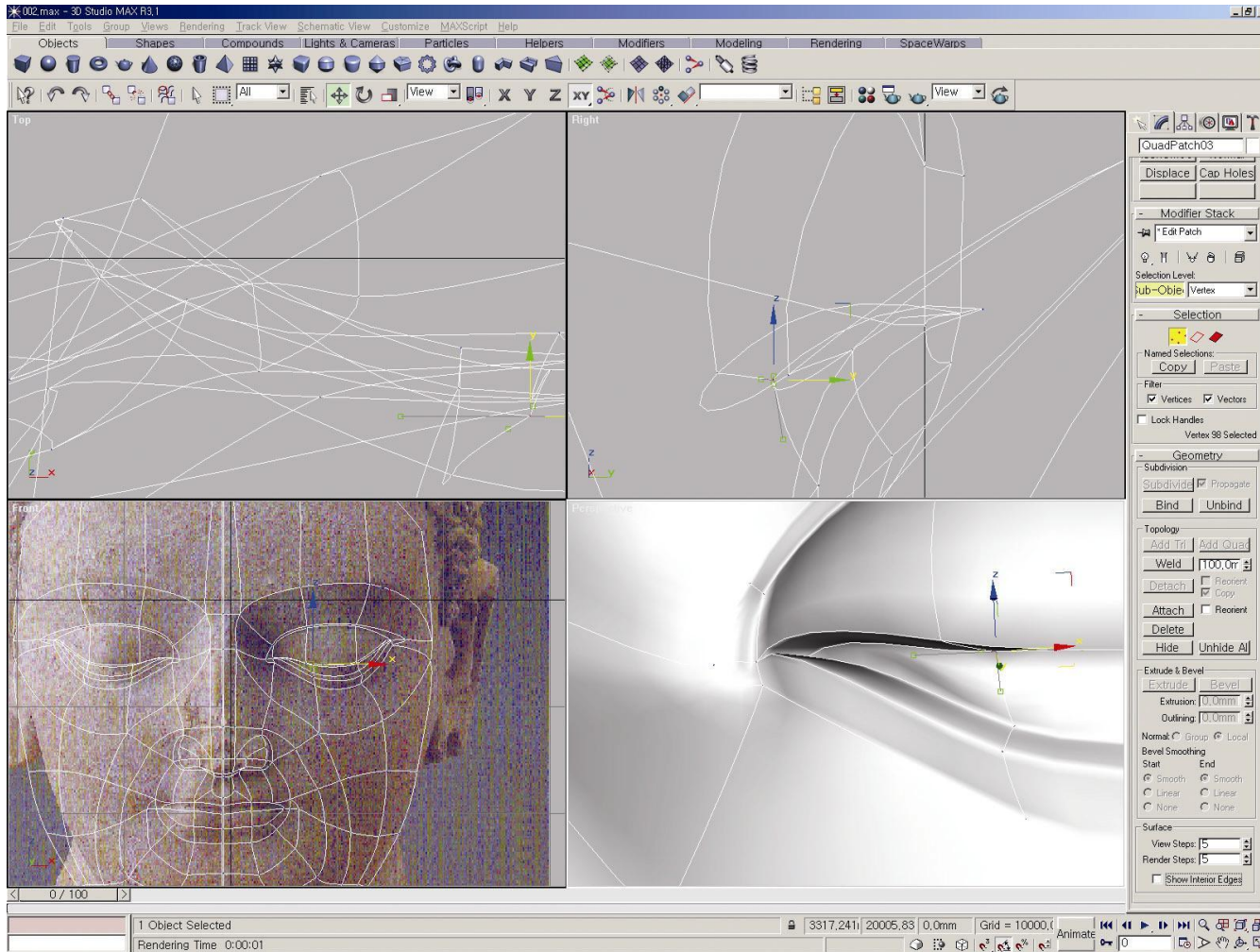
□ Physically Based Animation

- Create realistic interaction and animations through physically based animation

□ AI-based Behavior Animation

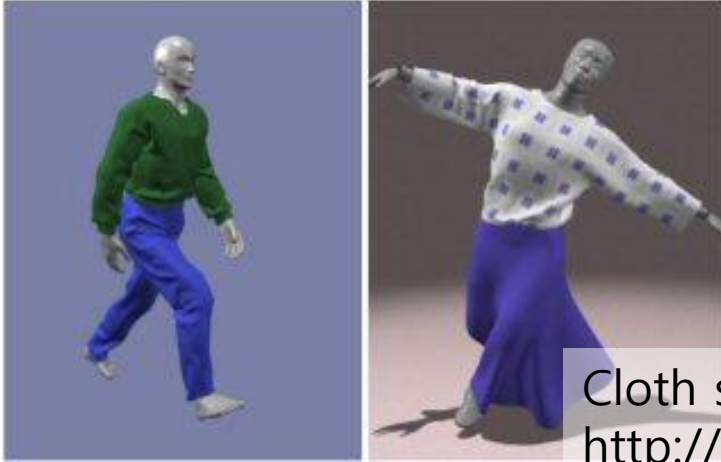
- Automatically create natural behaviors like real humans by giving the character intelligence and behavior

Geometric Modeling



3D Studio Max

Physically Based Modeling and Animation

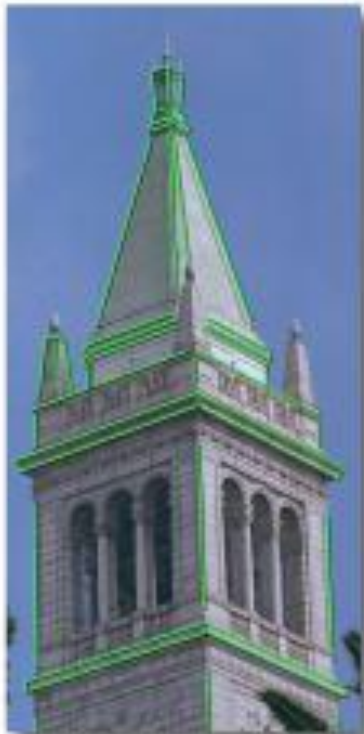


Cloth simulation, David Baraff and Andrew Witkin (1997)
<http://www.cs.cmu.edu/~baraff/sigcourse/index.html>

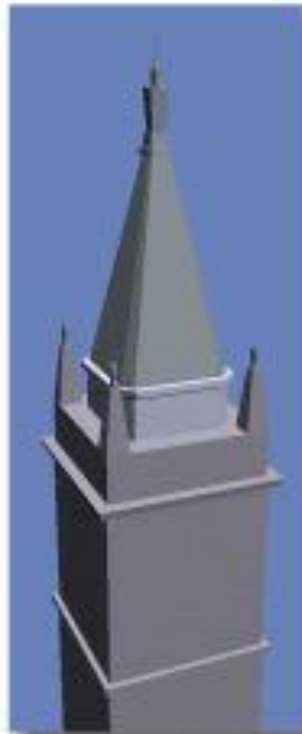


Fire, smoke, gas simulation
Duc Quang Nguyen, Ronald Fedkiw, Henrik Wann Jensen (SIGGRAPH2002)
<http://graphics.ucsd.edu/~henrik/papers/fire>

Image Based Modeling and Rendering



Original photograph with
marked edges



Recovered model



Model edges projected
onto photograph

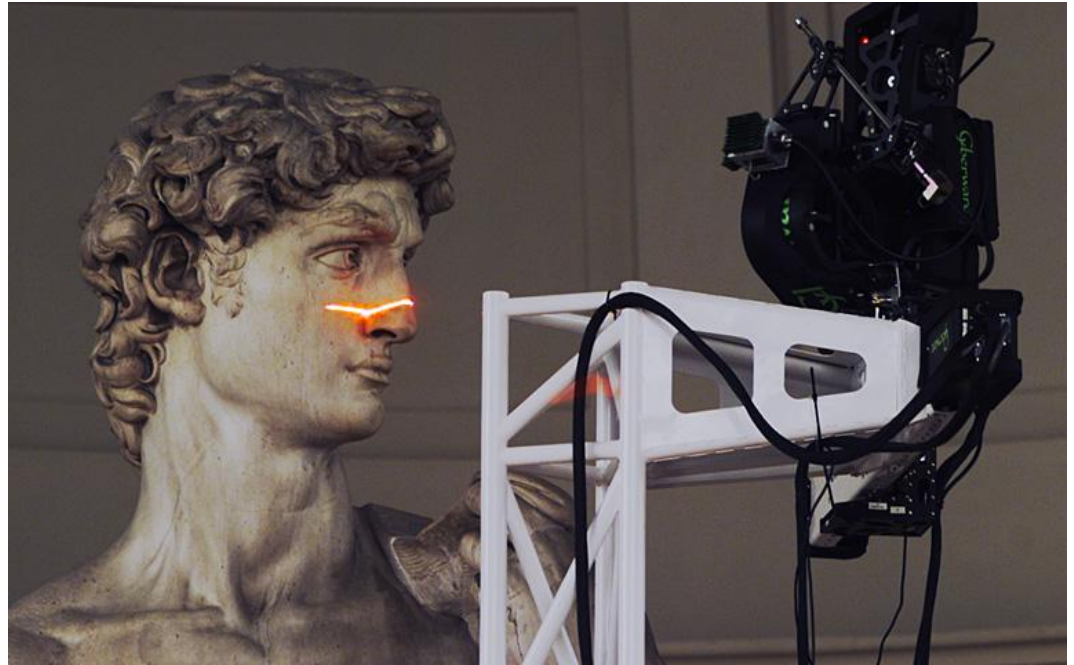


Synthetic rendering

Façade http://www.debevec.org/Research/IBMR_SIGGRAPH99

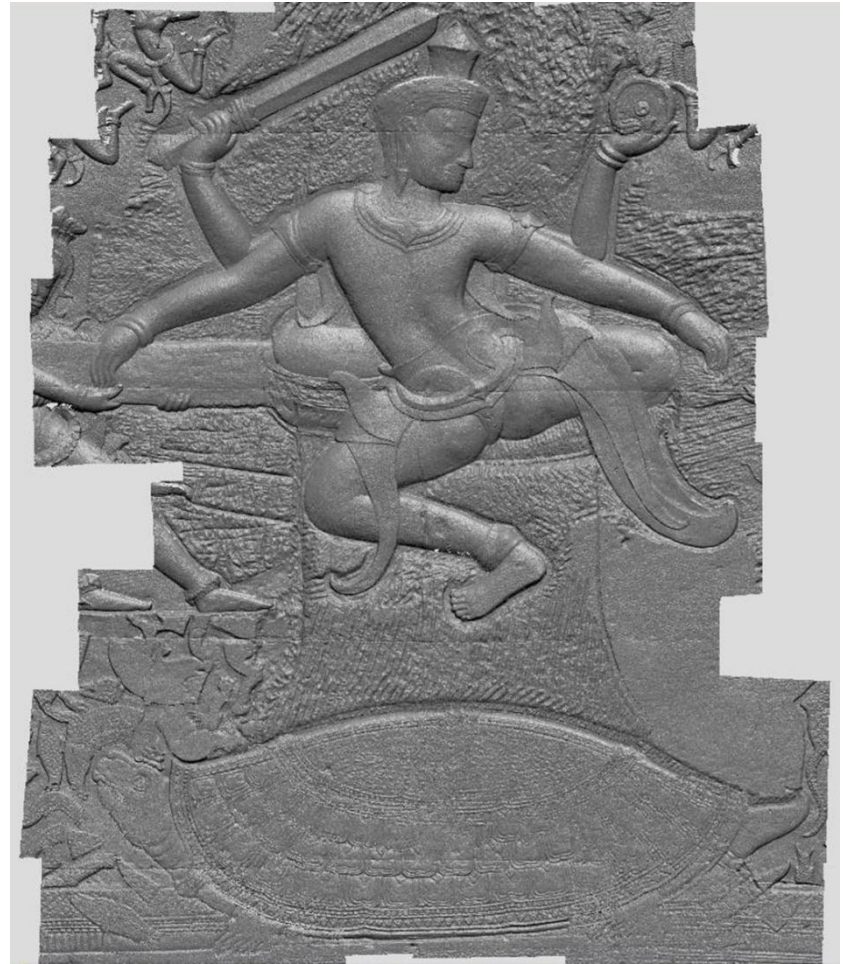
<https://pdfs.semanticscholar.org/e1c3/65e0a83ad131a5ca2c6c754a49d95d54aba6.pdf>

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



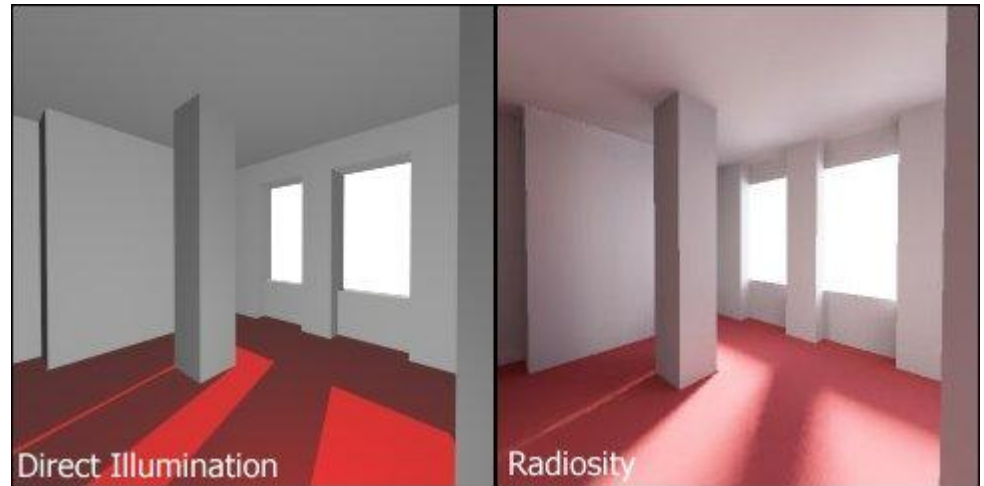
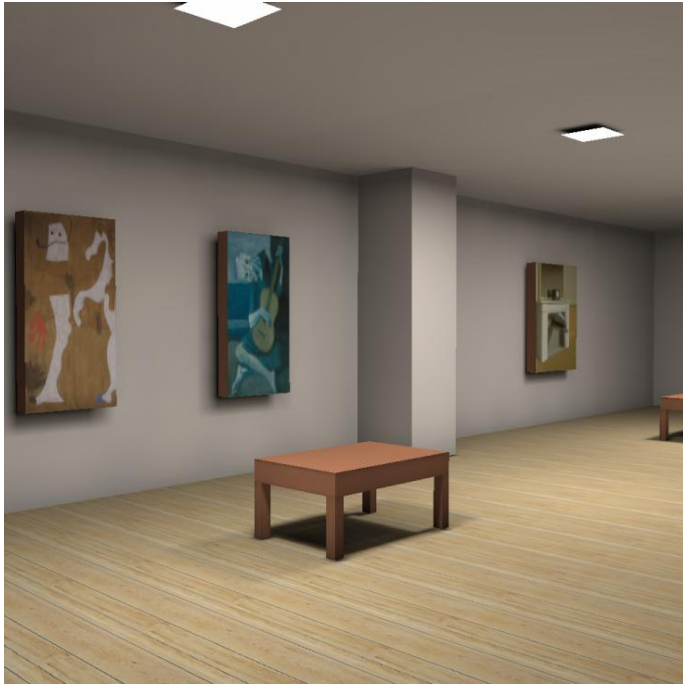
Monte Carlo Ray Tracer (CS488 Course Assignment 1999)

http://www.student.cs.uwaterloo.ca/~cs488/Contrib/a3patel/project/a3patel_index.html

Monte Carlo Ray Tracing (Lecture Note 2013)

<http://www.cs.cornell.edu/courses/cs4620/2013fa/lectures/22mcrt.pdf>

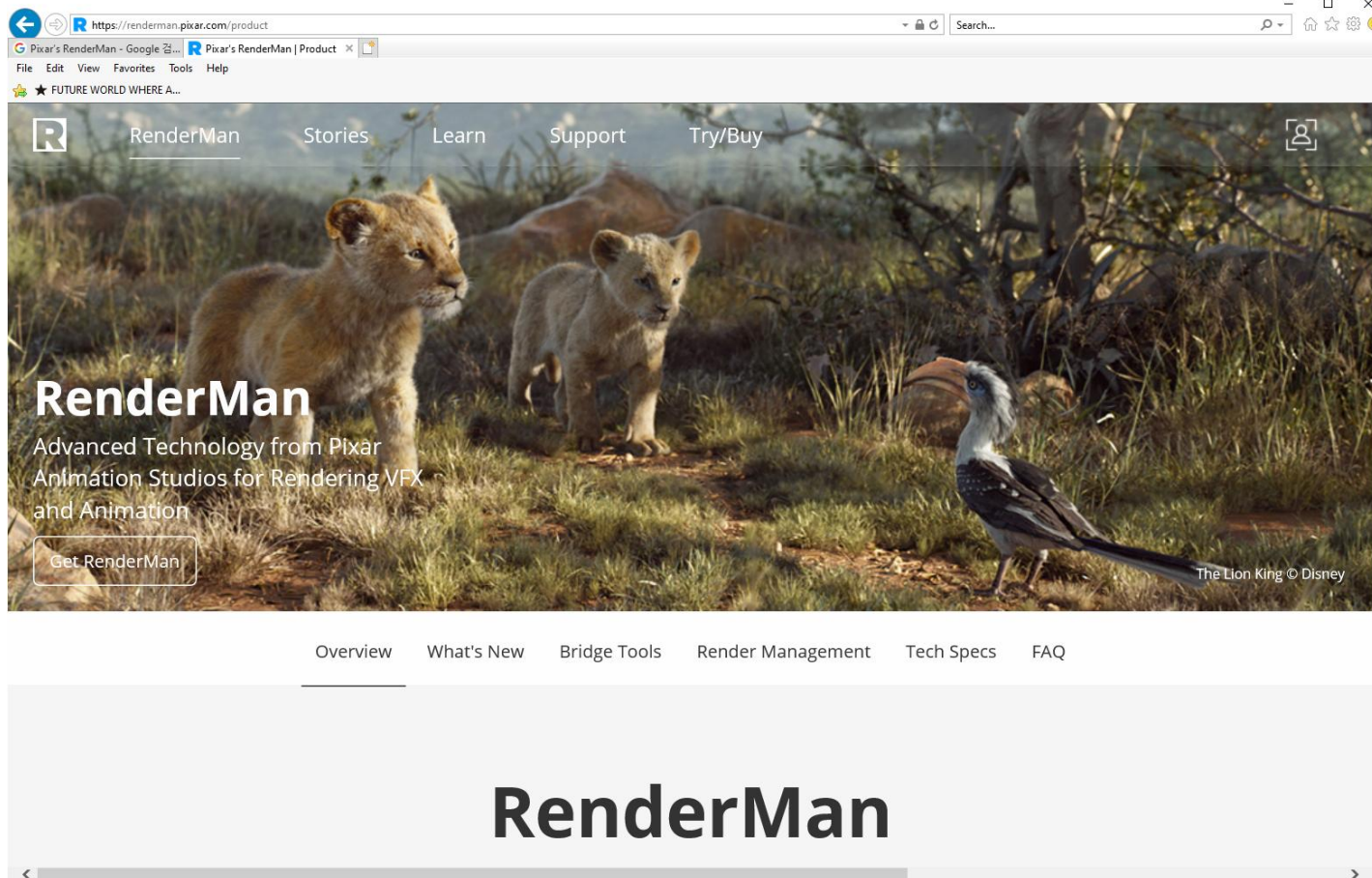
Photo-realistic Rendering



[https://en.wikipedia.org/wiki/Radiosity_\(computer_graphics\)](https://en.wikipedia.org/wiki/Radiosity_(computer_graphics))

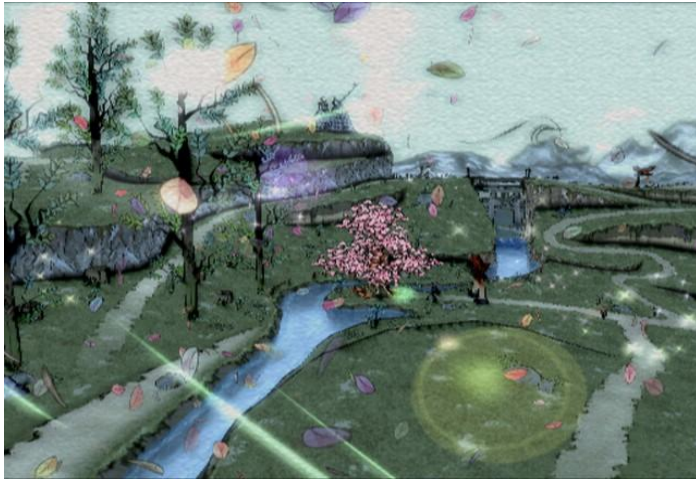
Radiosity on Graphics Hardware (SIGGRAPH 2005)
<http://www.cs.unc.edu/techreports/03-020.pdf>

Photo-Realistic Rendering



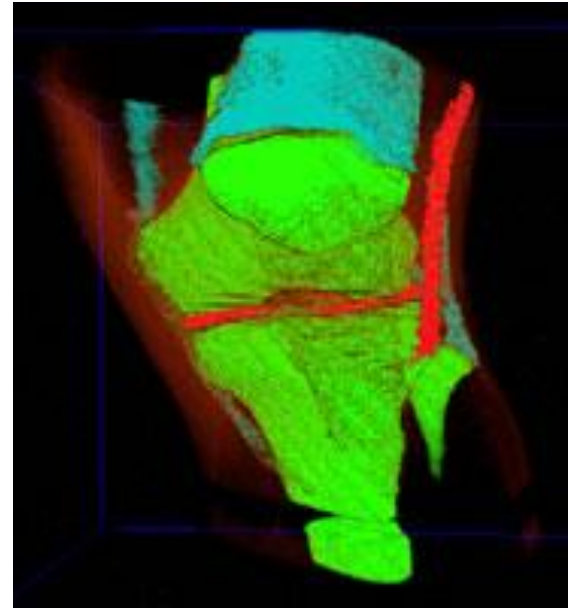
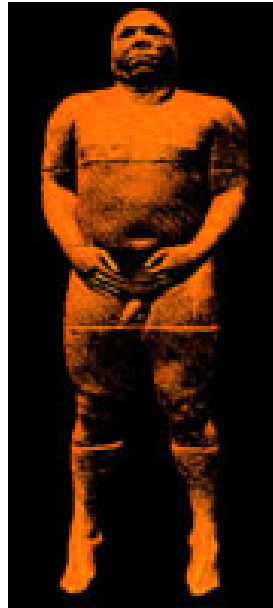
Pixar's RenderMan <https://renderman.pixar.com/>

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

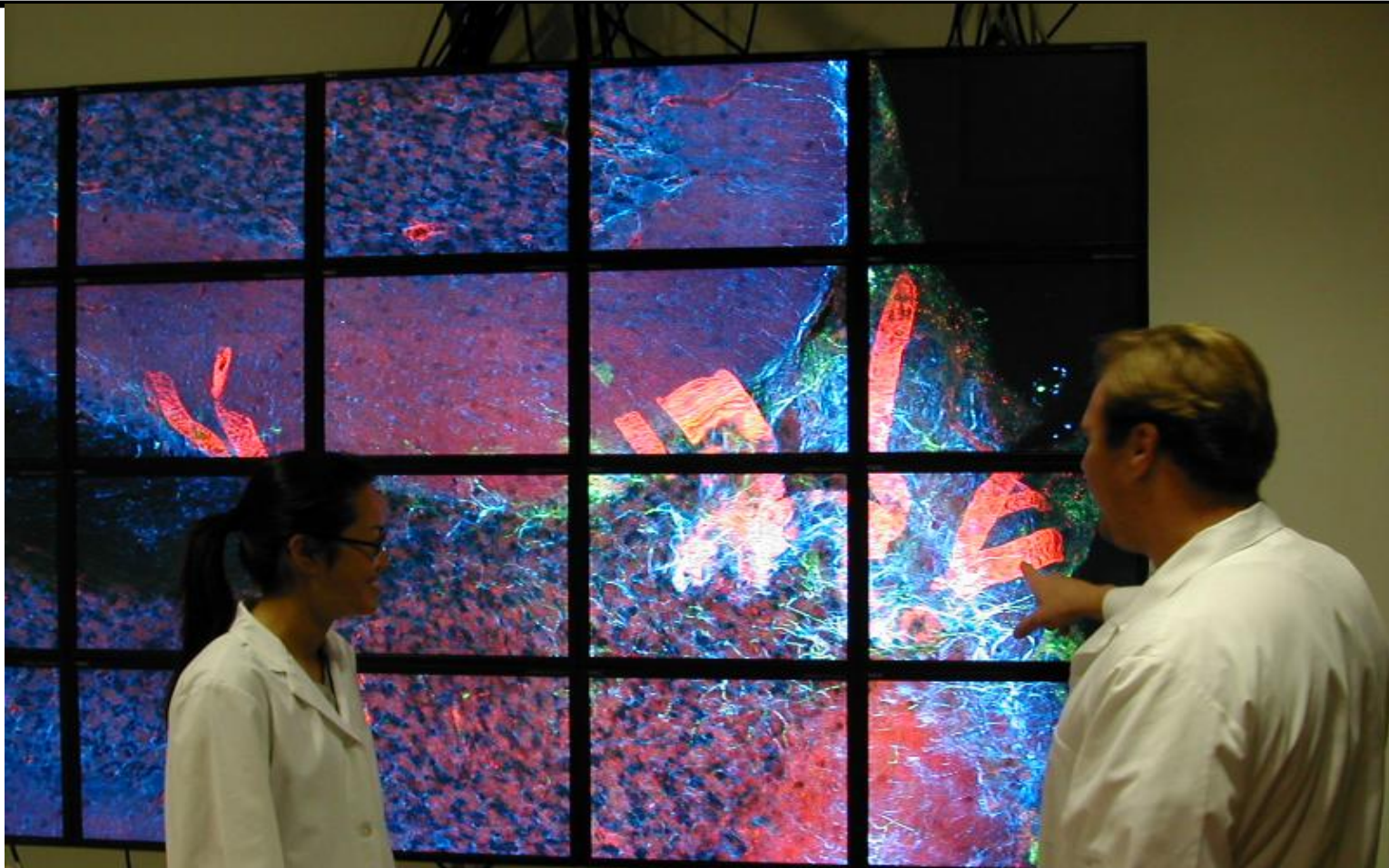
https://www.nlm.nih.gov/research/visible/getting_data.html

Scientific Visualization



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

Scientific Visualization



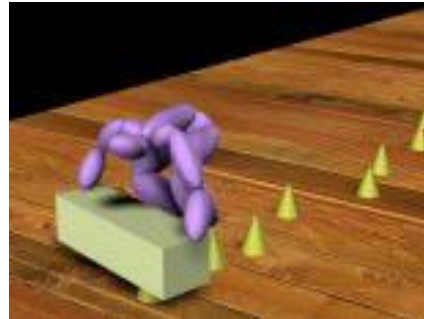
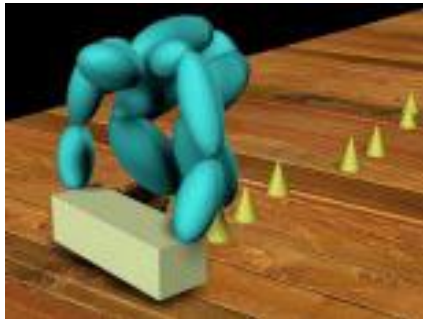
Rat Cerebellum Microscopy (NCMIR) on Tiled Display
National Center for Microscopy and Imaging Research, UC San Diego
<https://ncmir.ucsd.edu/press/in-the-news?news=9>

Motion Capture for Character Animation



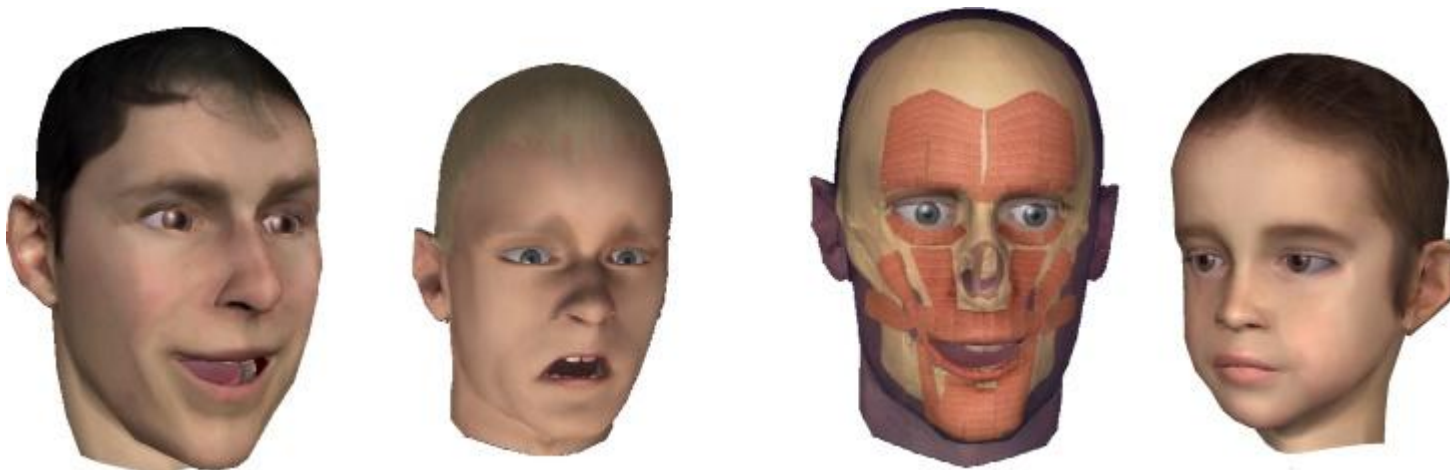
OptiTrack

<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

AI-based Behavior Animation



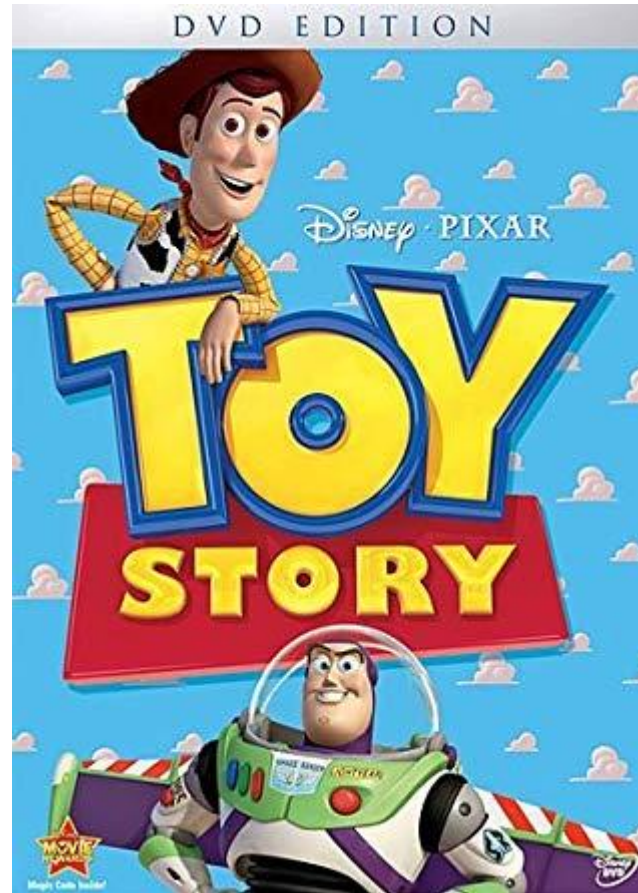
Panspermia, Karl Sims' Artificial Life (1990)
<https://www.karlsims.com/panspermia.html>

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

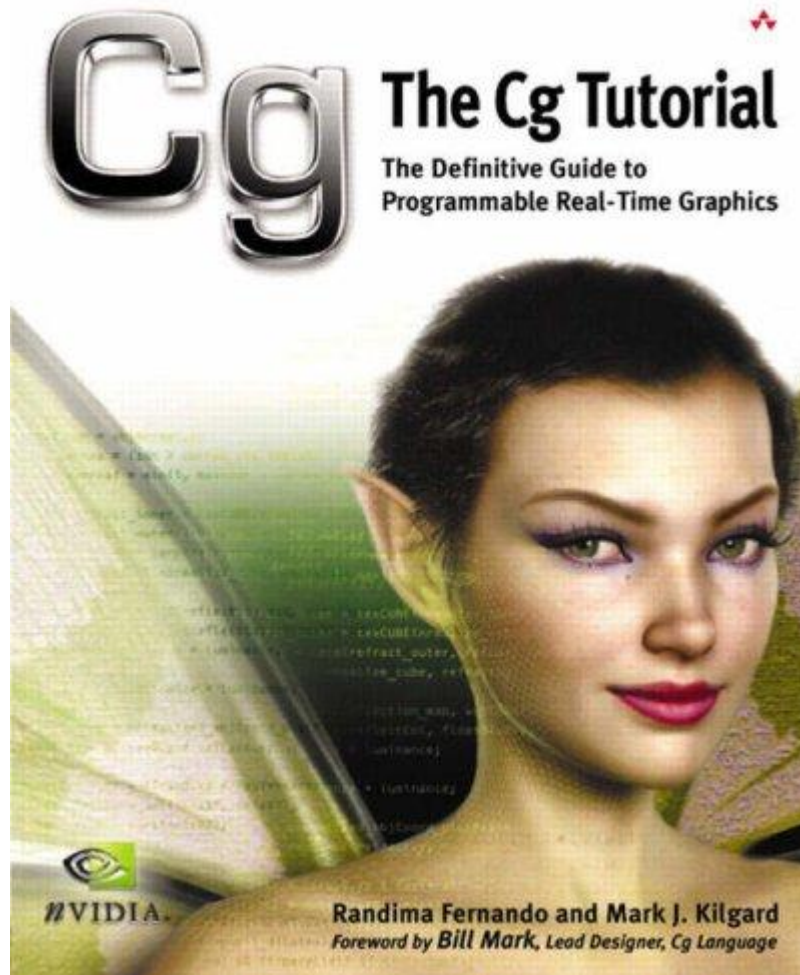


<https://www.biznews.com/briefs/2015/01/20/big-data-tops-humans-picking-significant-films-study/attachment/visitors-wear-3d-glasses-as-they-watch-a-preview-of-the-upcoming-movie-avatar-during-the-40th-annual-comic-con-convention-in-san-diego>



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

Real-Time Graphics



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

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



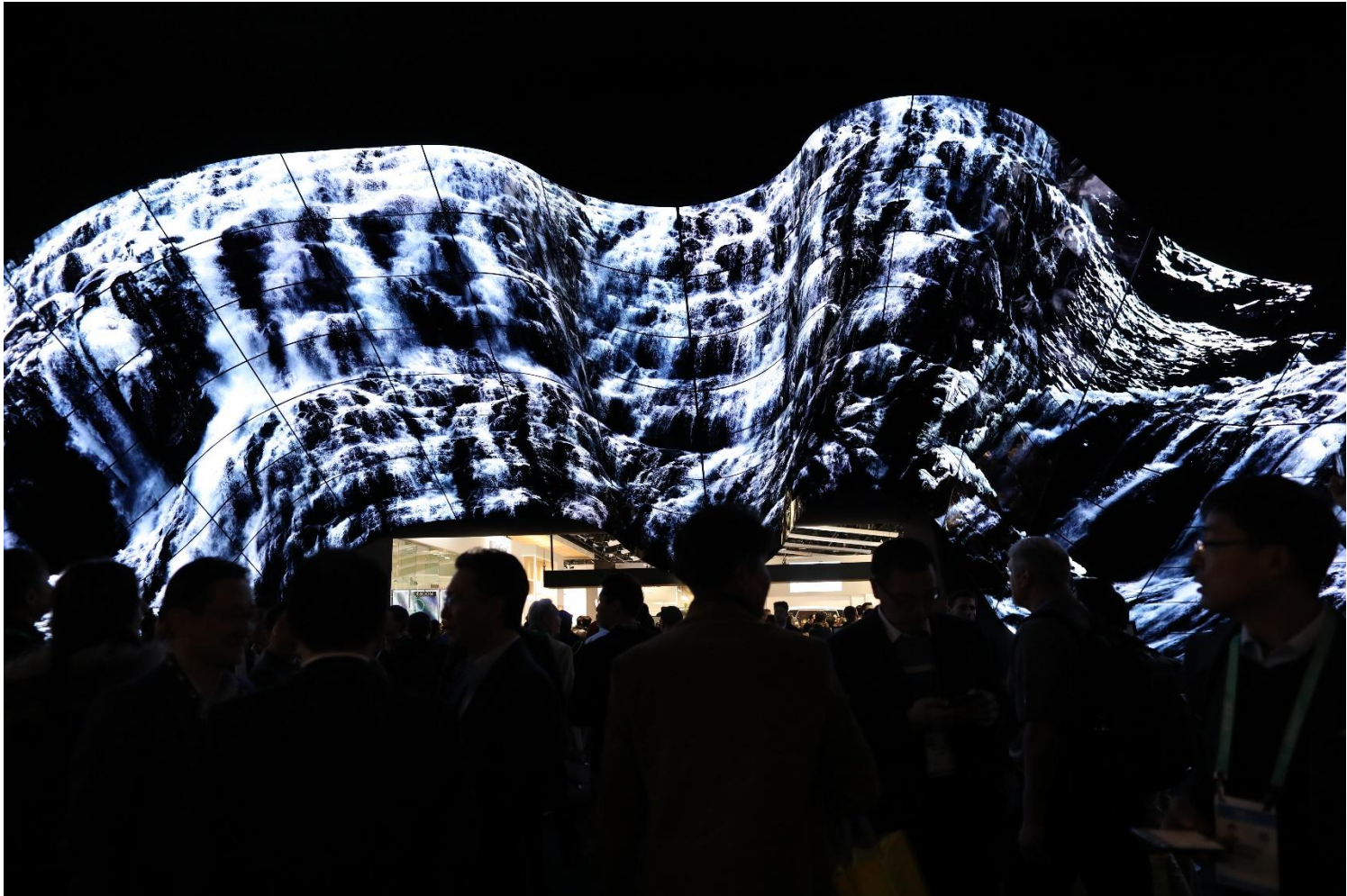
Simple contrast reduction



Local tone mapping

http://en.wikipedia.org/wiki/High-dynamic-range_imaging

Digital Signage



LG's Wave Display made by connecting 200 sheets of OLED Flexible Signage
@CES 2020 Jan 7 - 10

Virtual Reality

Meta Quest 3 (2023)

<https://about.fb.com/news/2023/06/meta-quest-3-coming-this-fall/>



The Best VR Headsets for 2023

<https://www.pcmag.com/picks/the-best-vr-headsets>

Augmented Reality



AR/MR Devices

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

Augmented Reality



Pokemon GO (2016)

<https://pokemongolive.com/>

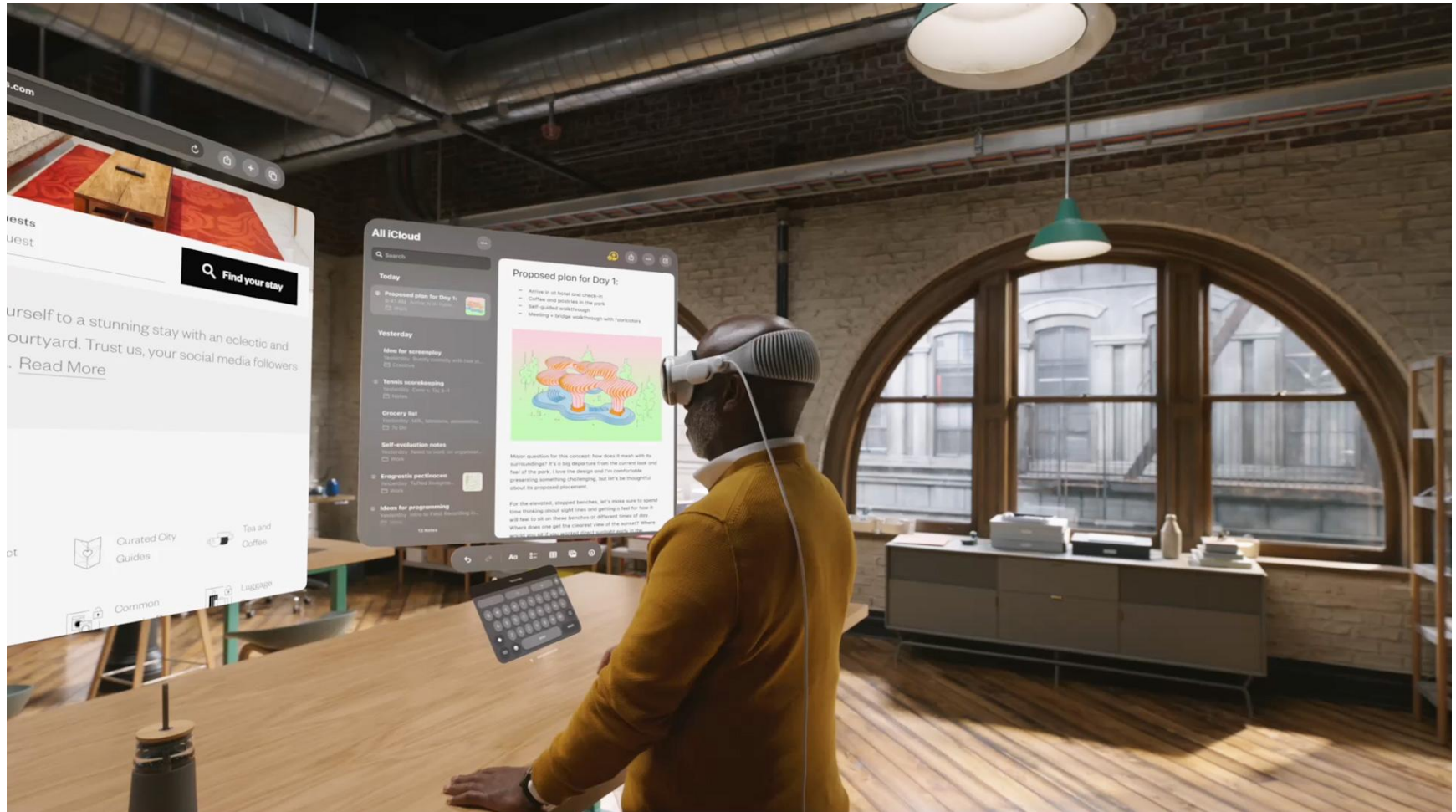
Mixed Reality



Microsoft HoloLens

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

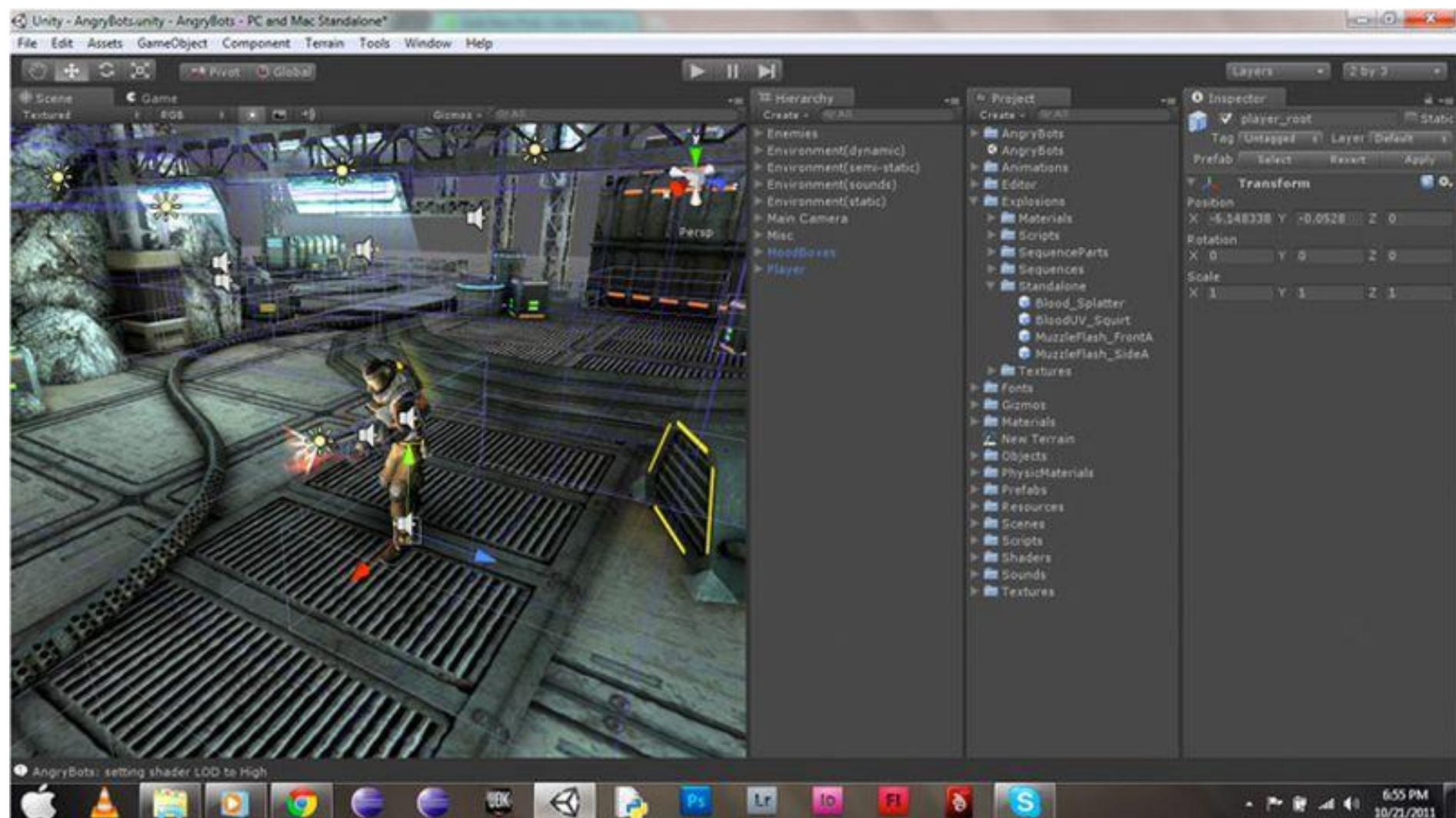
Mixed Reality



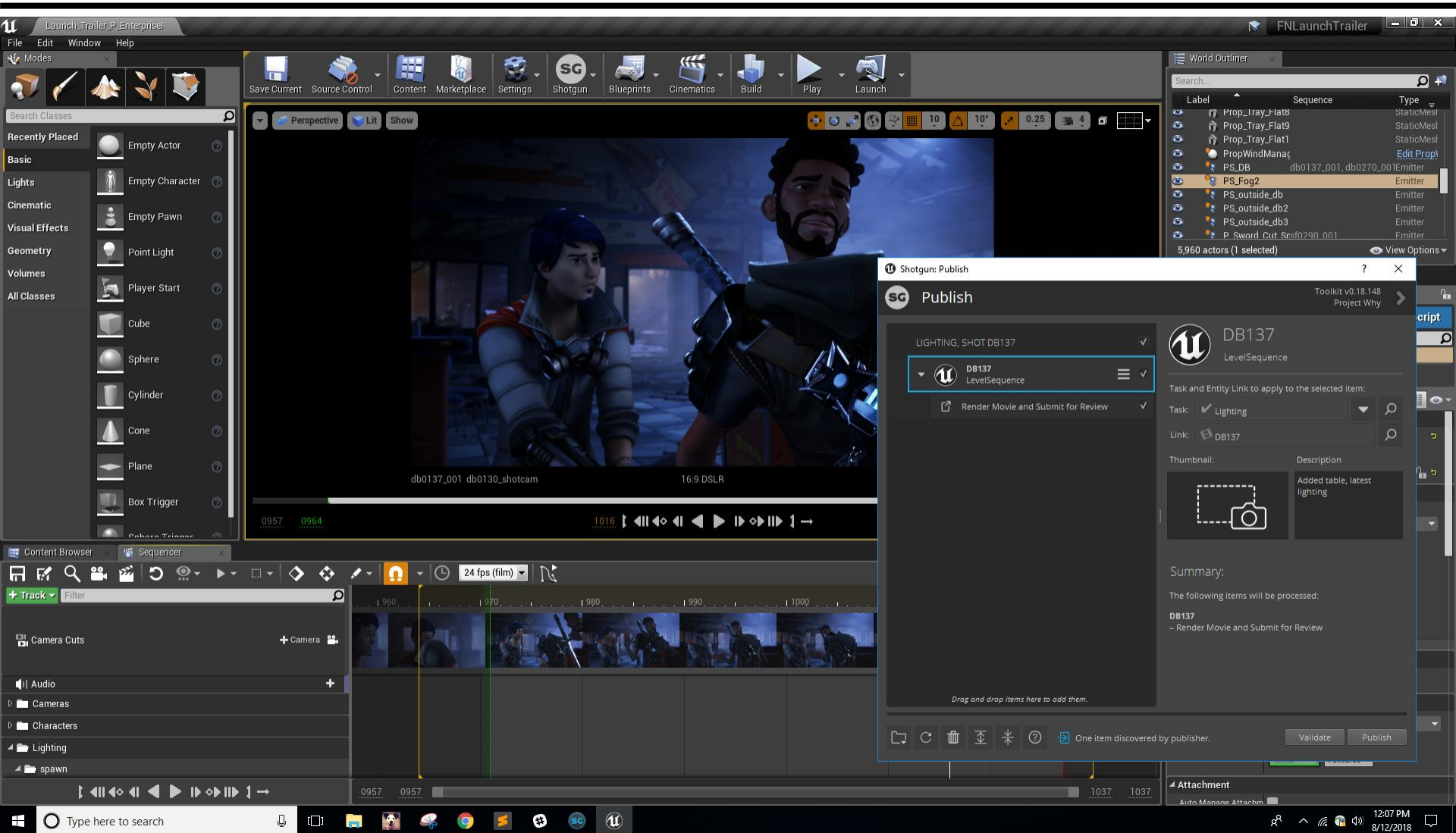
Apple Vision Pro

<https://www.apple.com/kr/newsroom/2023/06/introducing-apple-vision-pro/>

Unity3D



Unreal



OpenGL



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Mesa 20.0 Now Defaults To The New Intel Gallium3D Driver For Faster OpenGL

After missing their original target of transitioning to Intel Gallium3D by default for Mesa 19.3 as the preferred OpenGL Linux driver on Intel graphics hardware, this milestone has now been reached for Mesa 20.0.

Jan 24, 2020 | [Read article...](#) | [Permalink](#)

Khronos Group Releases Vulkan 1.2

The Khronos Group [announces the release of the Vulkan 1.2 specification](#) for GPU acceleration. This release integrates 23 proven extensions into the core Vulkan API, bringing significant developer-requested access to new hardware functionality, improved application performance, and enhanced API usability. Multiple GPU vendors have certified conformant implementations, and significant open source tooling is expected during January 2020. Vulkan continues to evolve by

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