Introduction to Computer Graphics

527970
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9/4/2025

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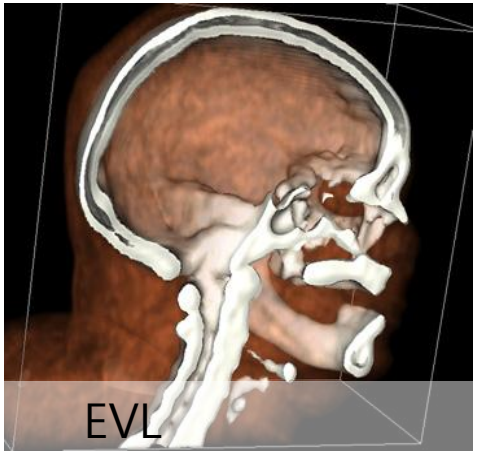
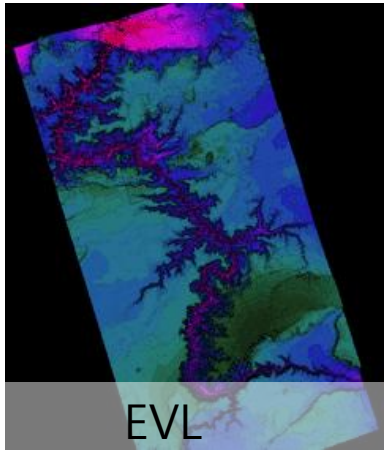
Computer Graphics Applications

- 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

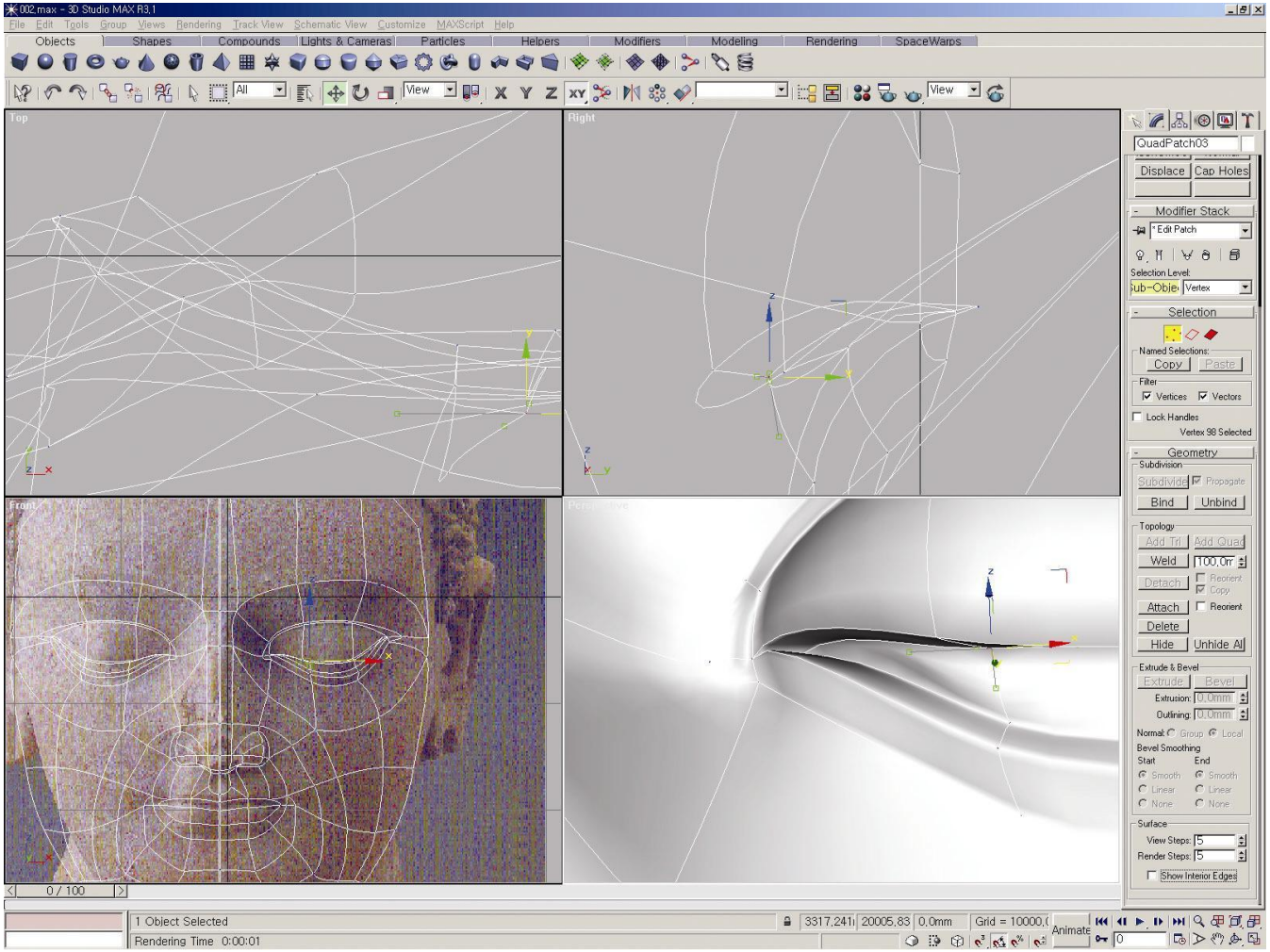
Rendering

- 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



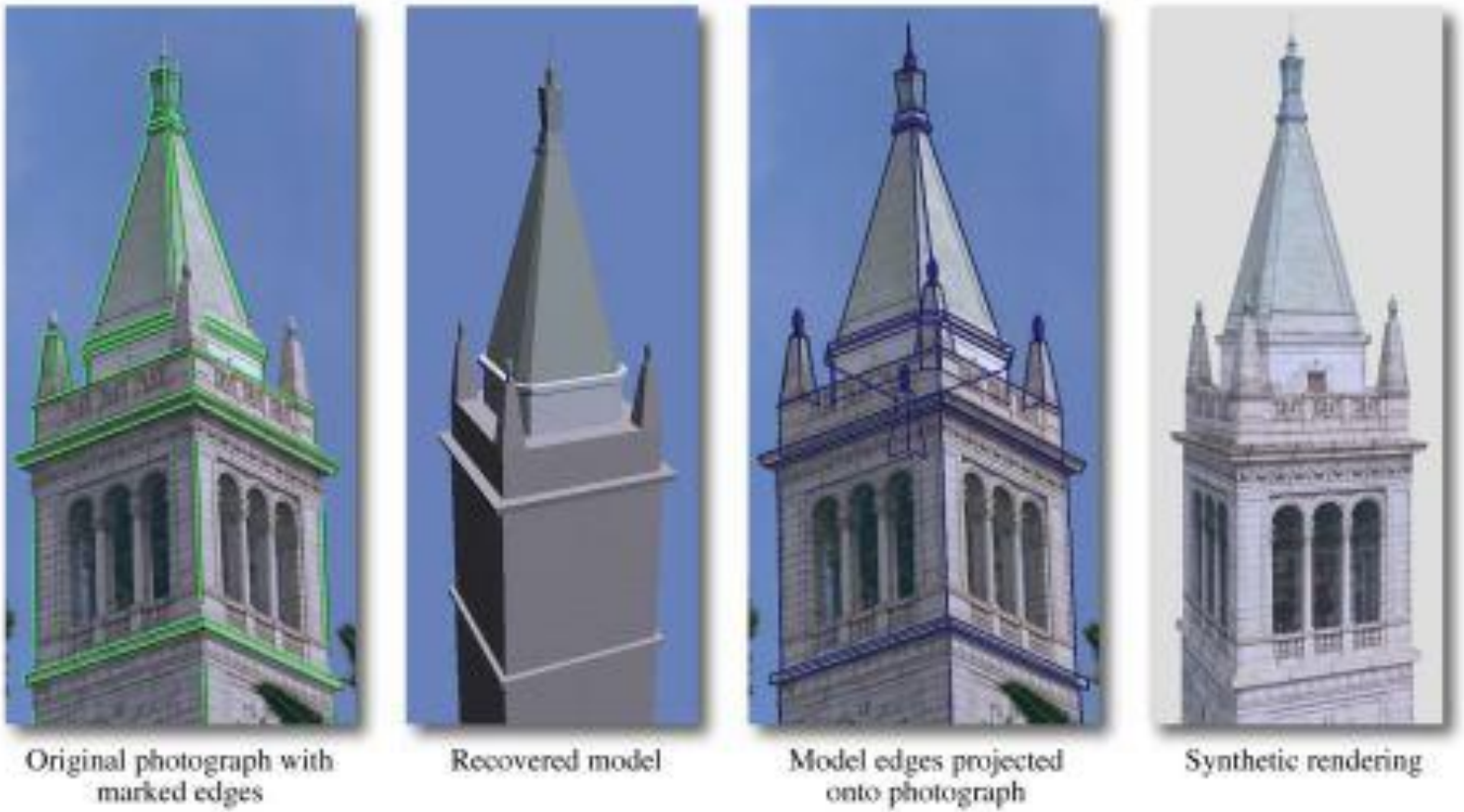
3D Studio Max

Physically Based Modeling and Animation

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

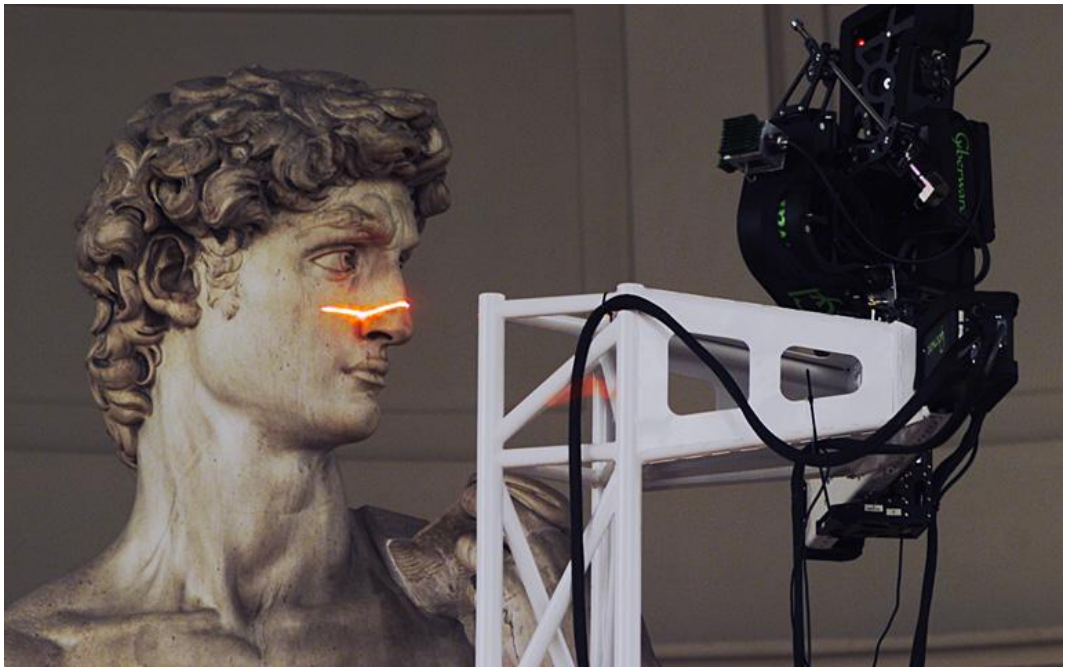
Fire, smoke, gas simulation
Duc Quang Nguyen,Ronald Fedkiw, Henrik Wann Jensen (SIGGRAPH2002)
http://graphics.ucsd.edu/~henrik/papers/fire

Image Based Modeling and Rendering



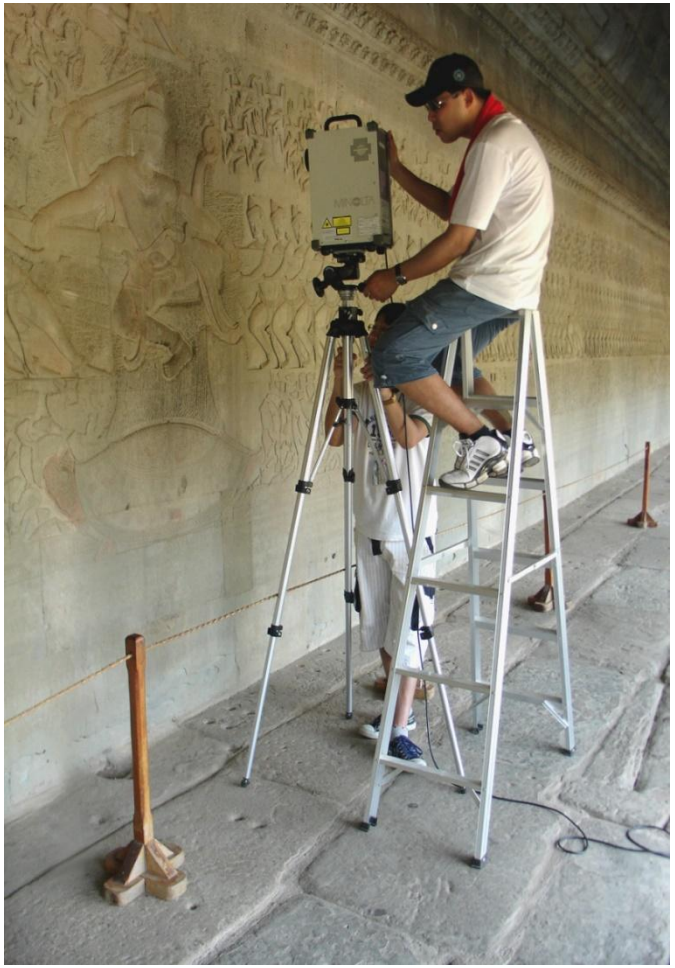
Façade http://www.debevec.org/Research/
IBMR SIGGRAPH99
https://pdfs.semanticscholar.org/e1c3/65e0a83ad131a5ca2c6c754a49d95d54aba6.pdf

3D Scanning



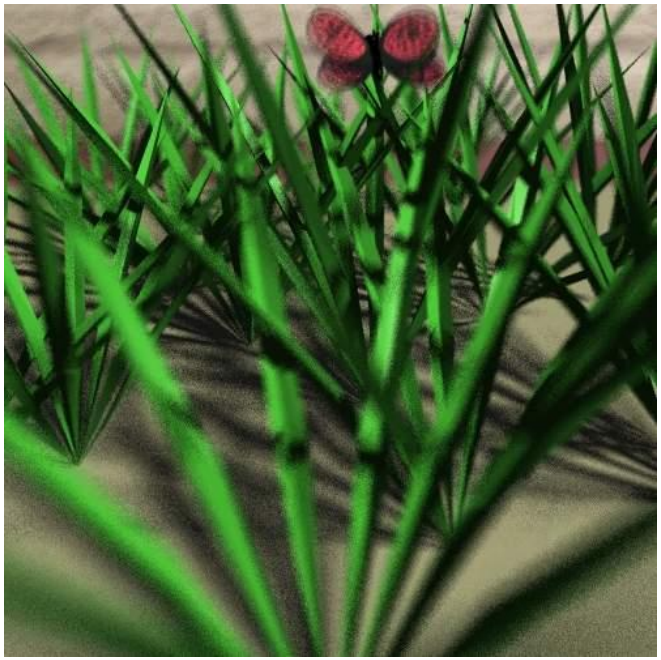
Digital Michelangelo Project, Marc Levoy, Paul Debevec (1999)
https://graphics.stanford.edu/data/mich/

3D Scanning



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

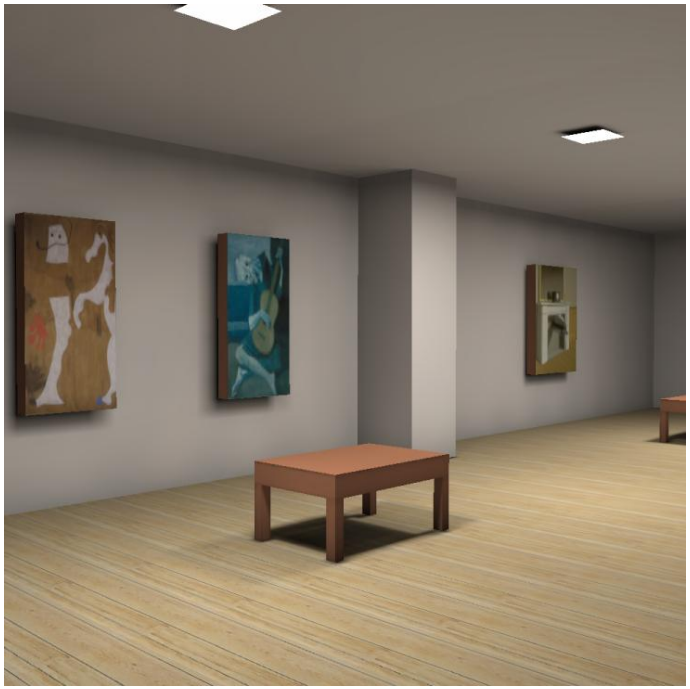
Photo-realistic Rendering



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

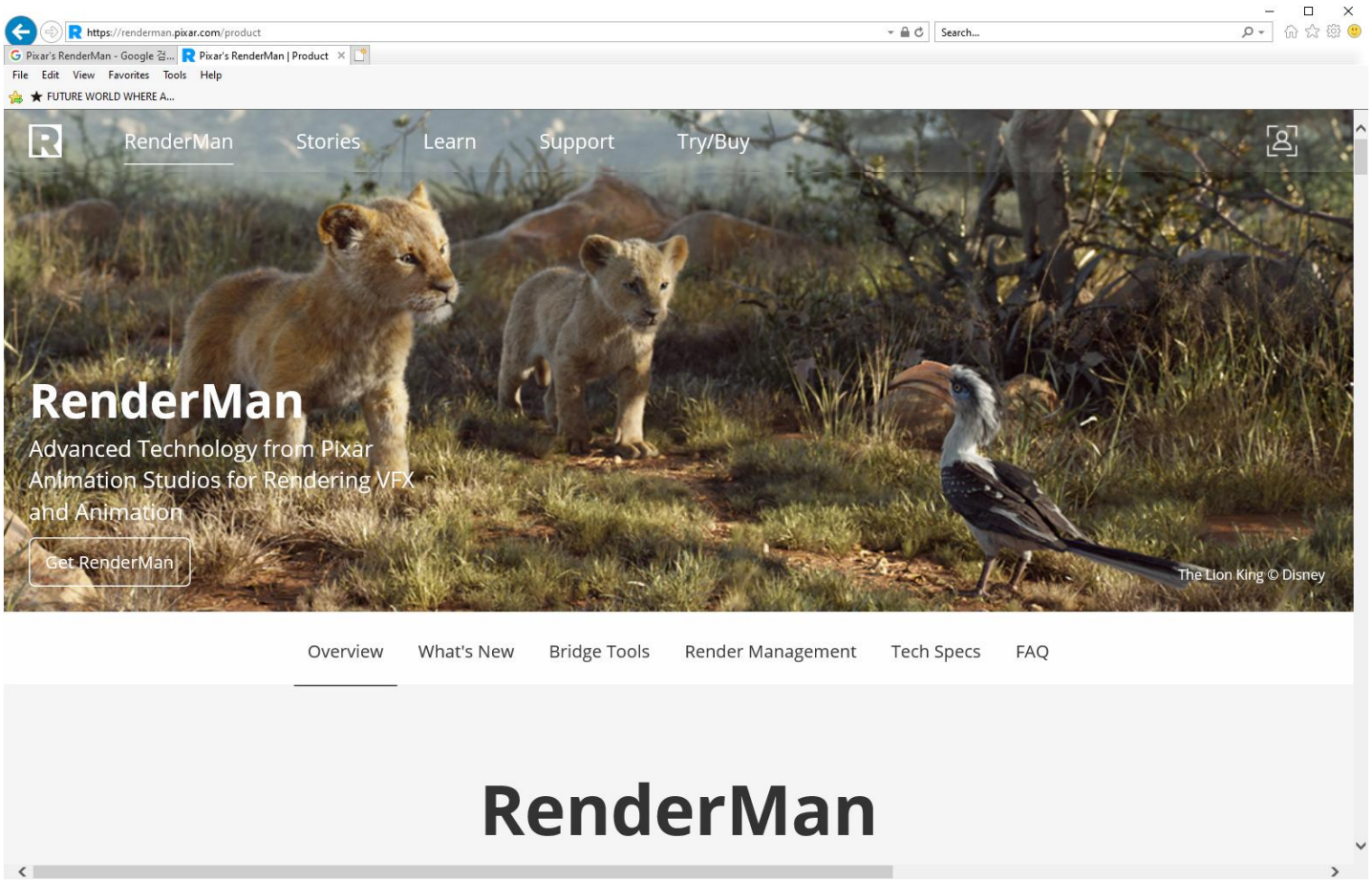
Photo-realistic Rendering



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

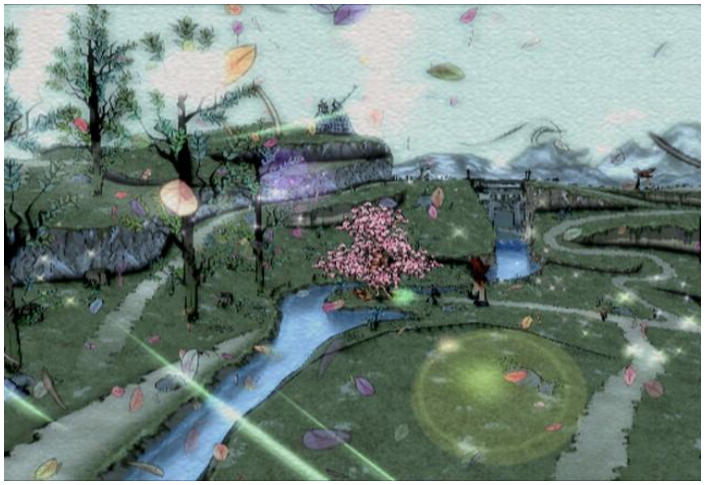
Radiosity on Graphics Hardware (SIGGRAPH 2005)
http://www.cs.unc.edu/techreports/03-020.pdf

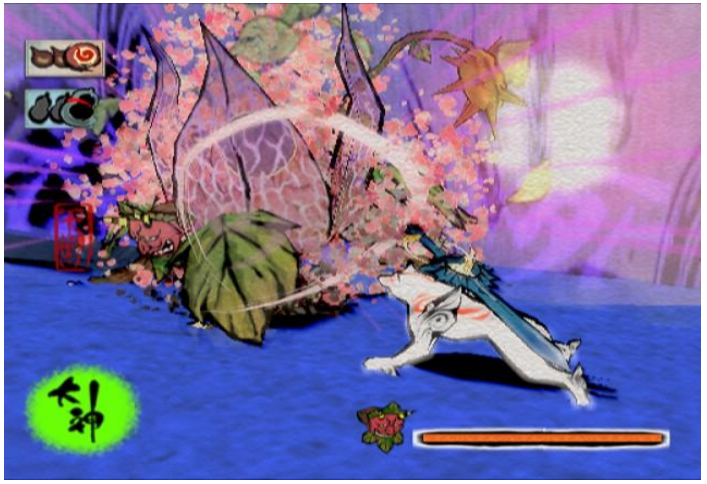
Photo-Realistic Rendering



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

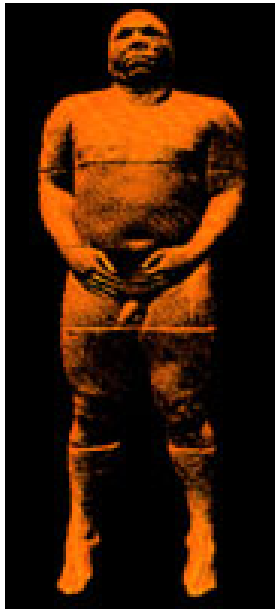
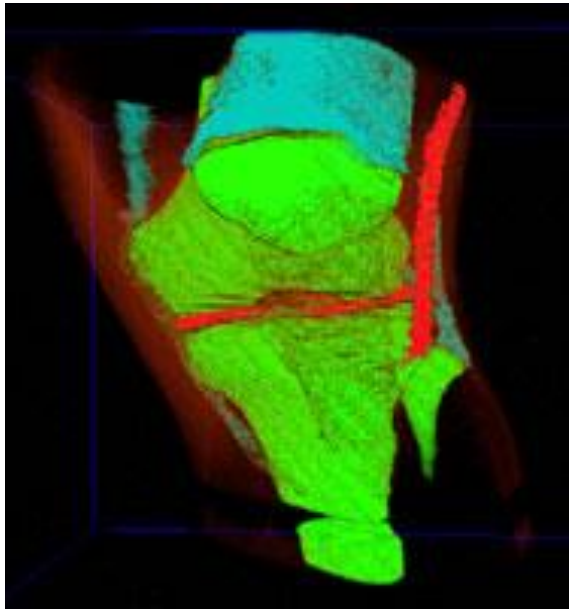
Non Photorealistic Rendering (NPR)





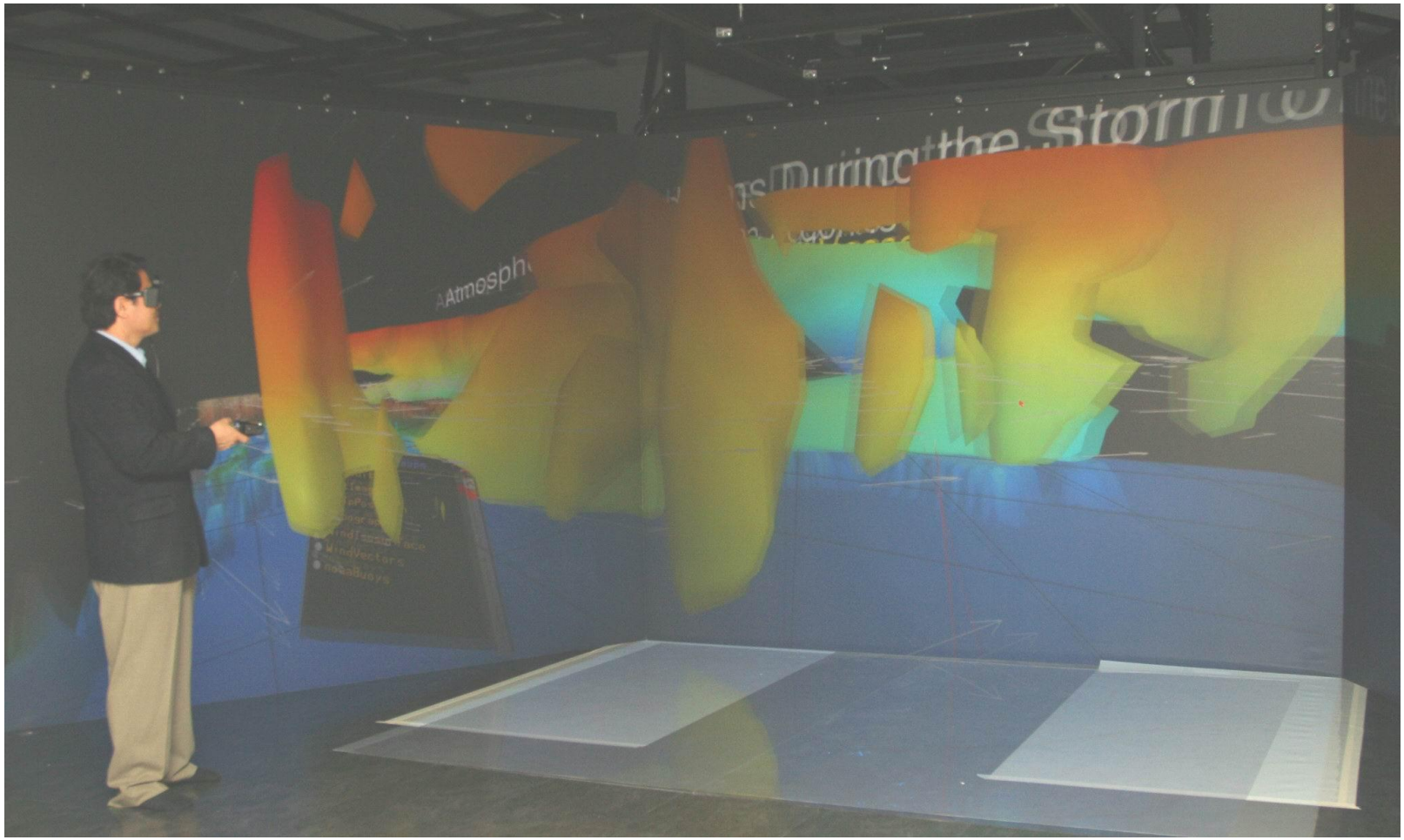
Oriental Ink Wash Painting Rendering Technique
Capcom's PS2 Game called Okami (released in 2006)

Volume Rendering

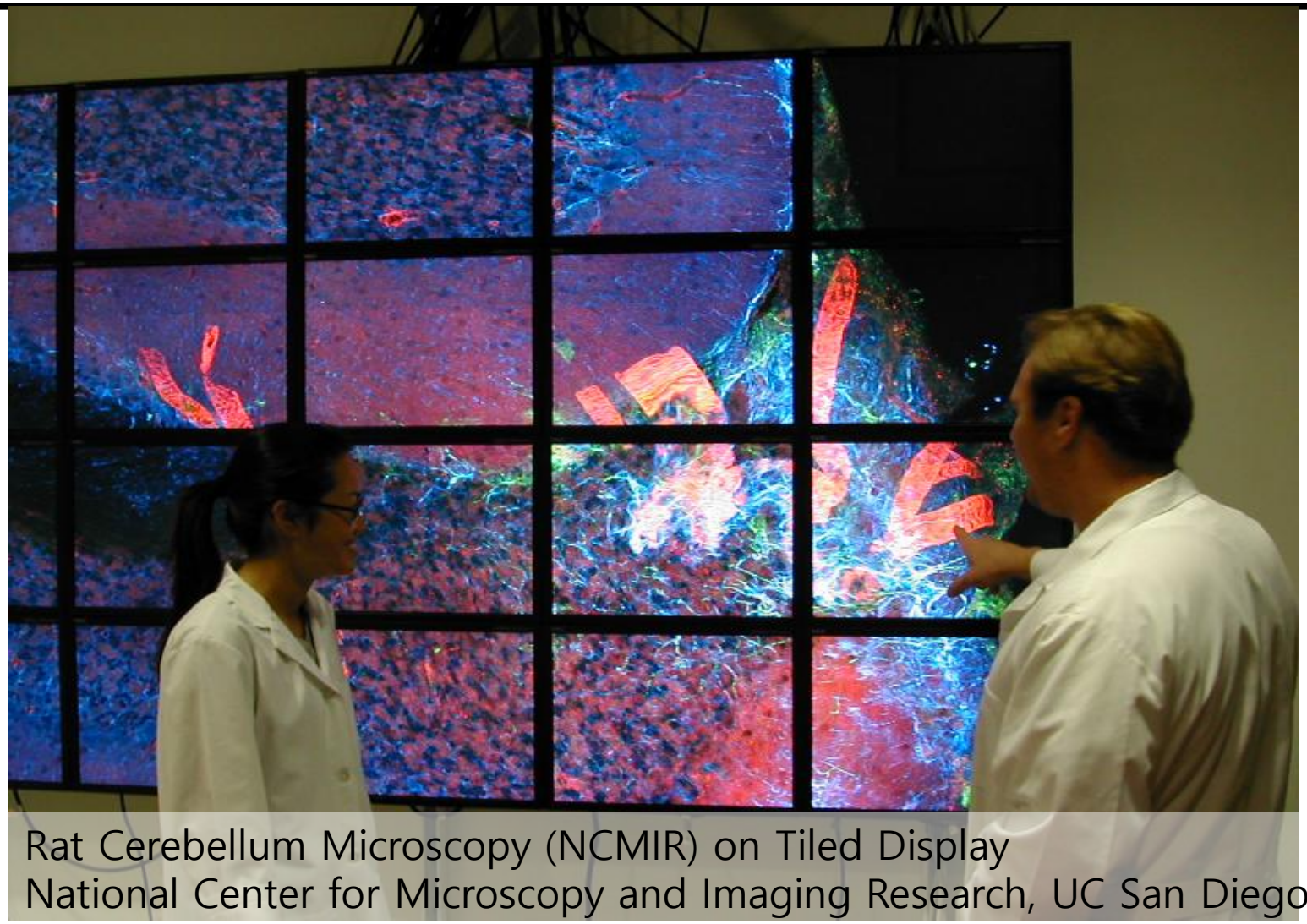
6.77GB Visible Male Data sets
The Visible Human Project
https://www.nlm.nih.gov/research/visible/getting_data.html

Scientific Visualization



Typoon 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

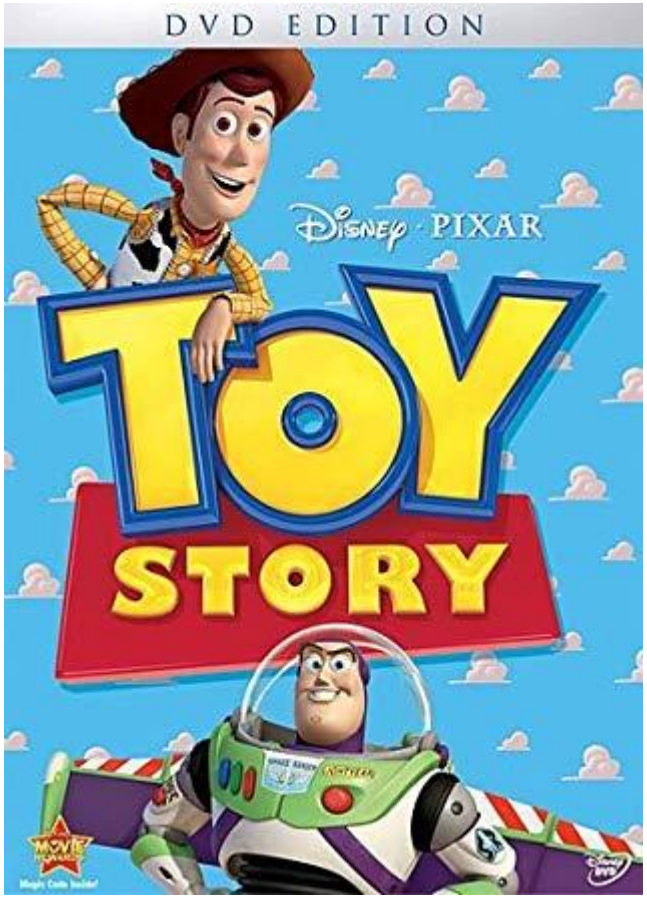


Panspermia, Karl Sims' Artificial Life (1990)
https://www.karlsims.com/panspermia.html

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

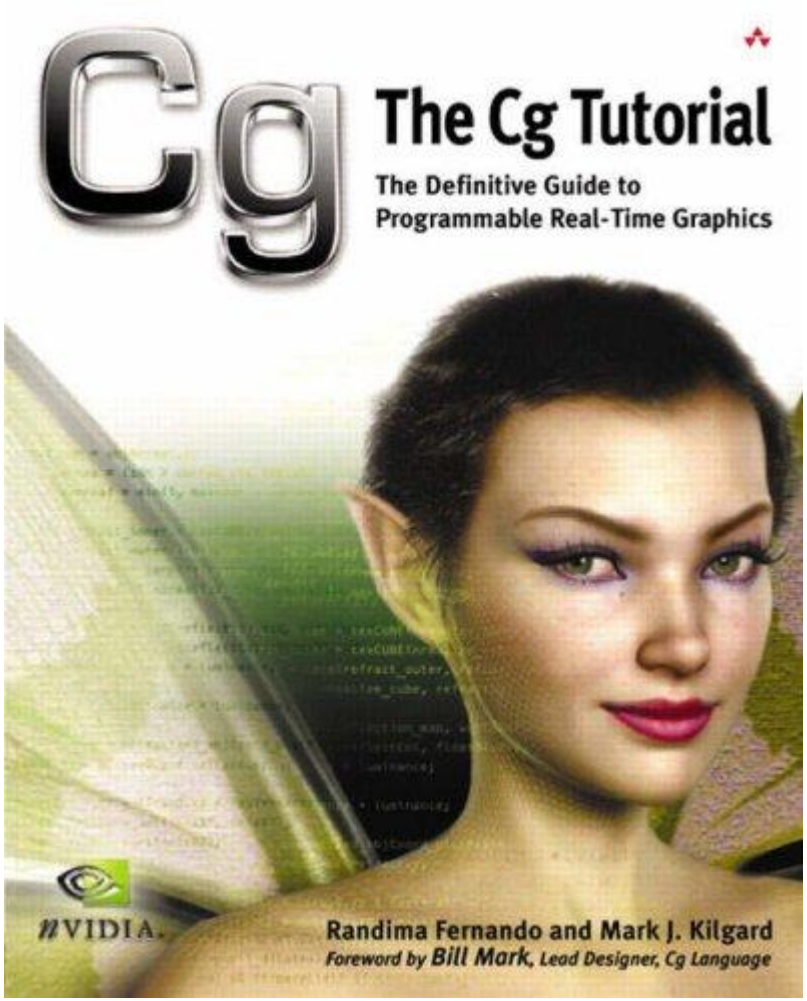
Final Fantasy: The Spirits Within (56:36 min, 2001)
First photorealistic computer-animated feature film

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

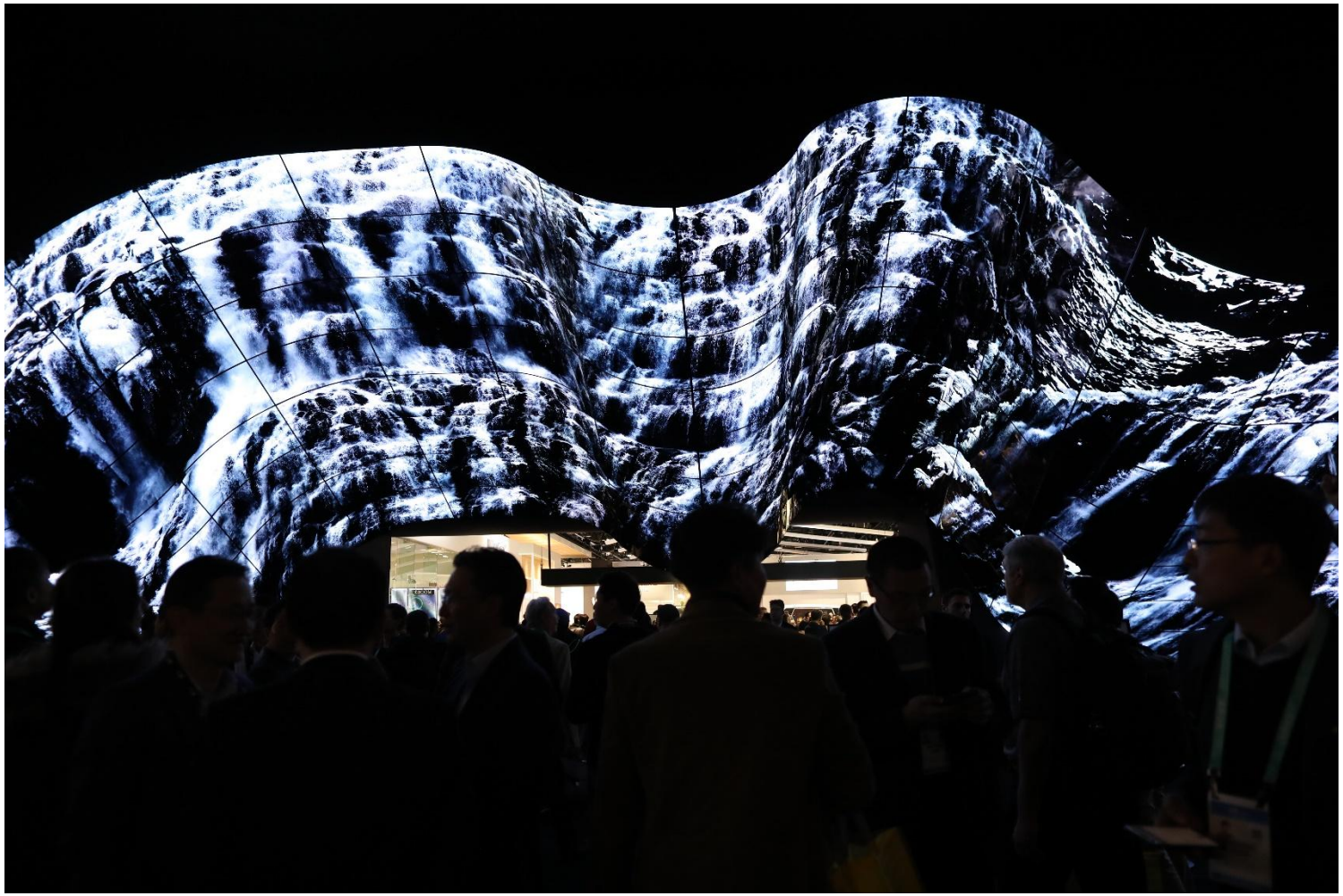
–4 stops | –2 stops | +2 stops | +4 stops

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/

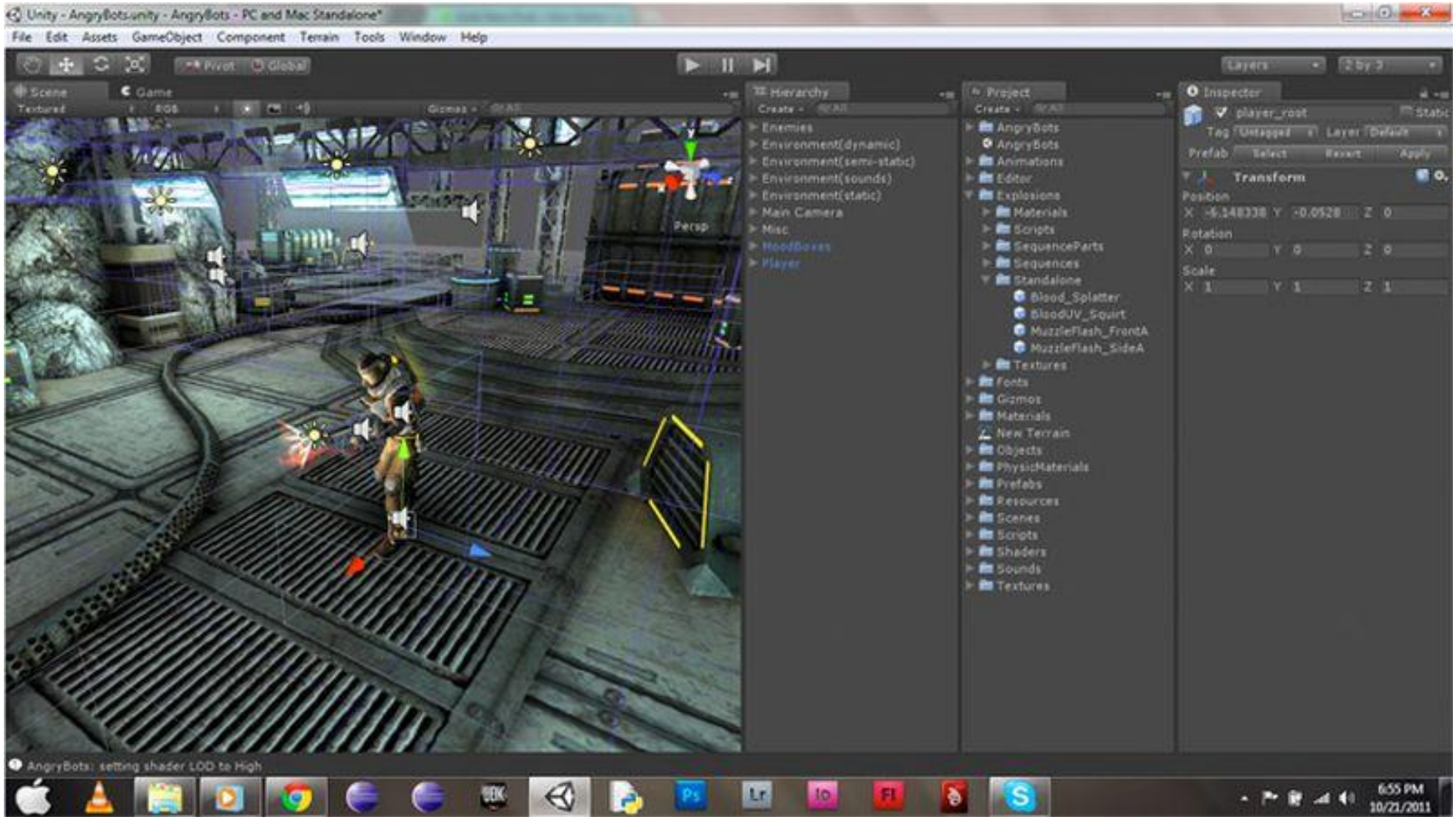
Mixed Reality

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

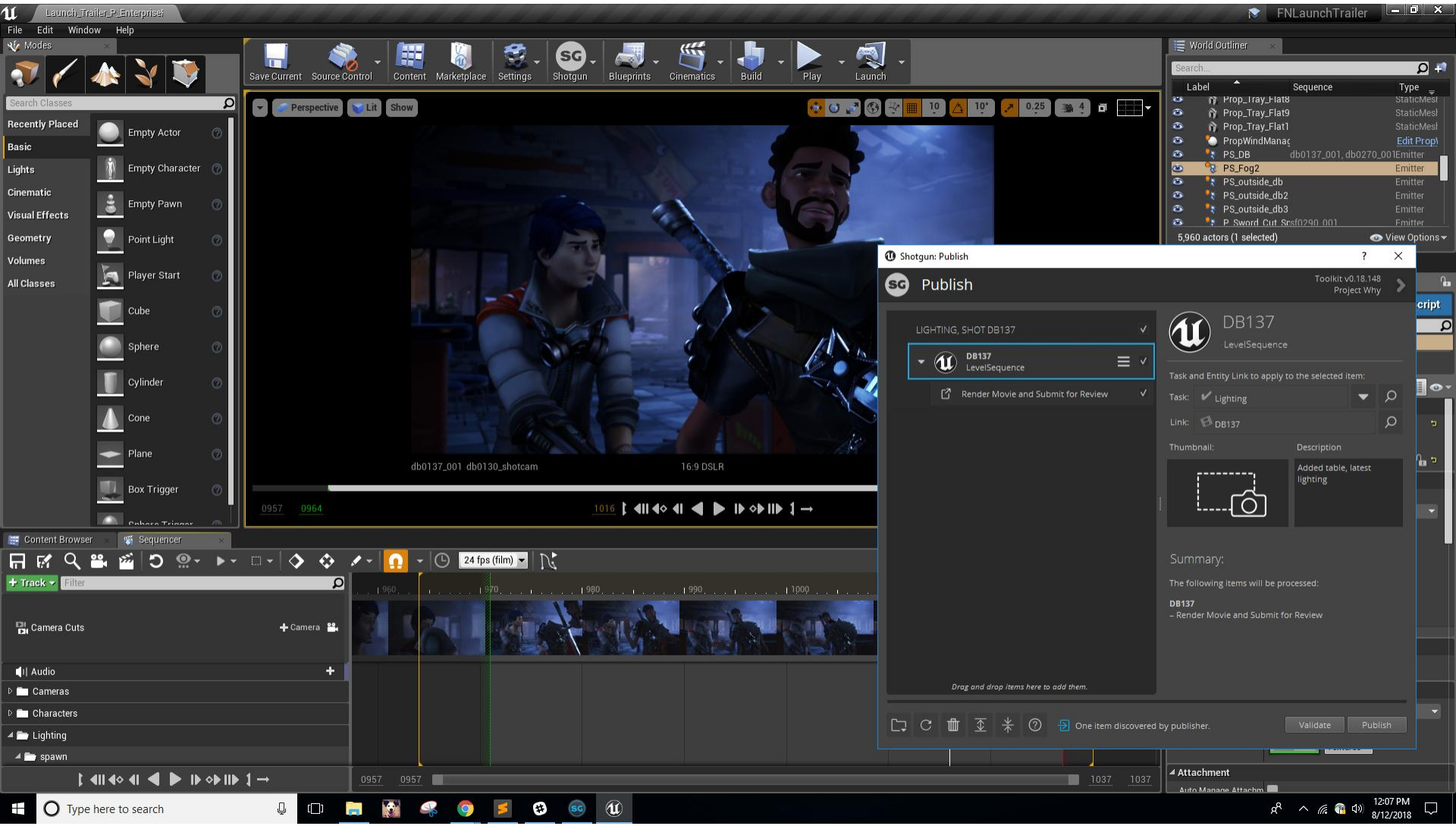
Mixed Reality

Apple Vision Pro
https://www.apple.com/kr/newsroom/2023/06/introducing-apple-vision-pro/

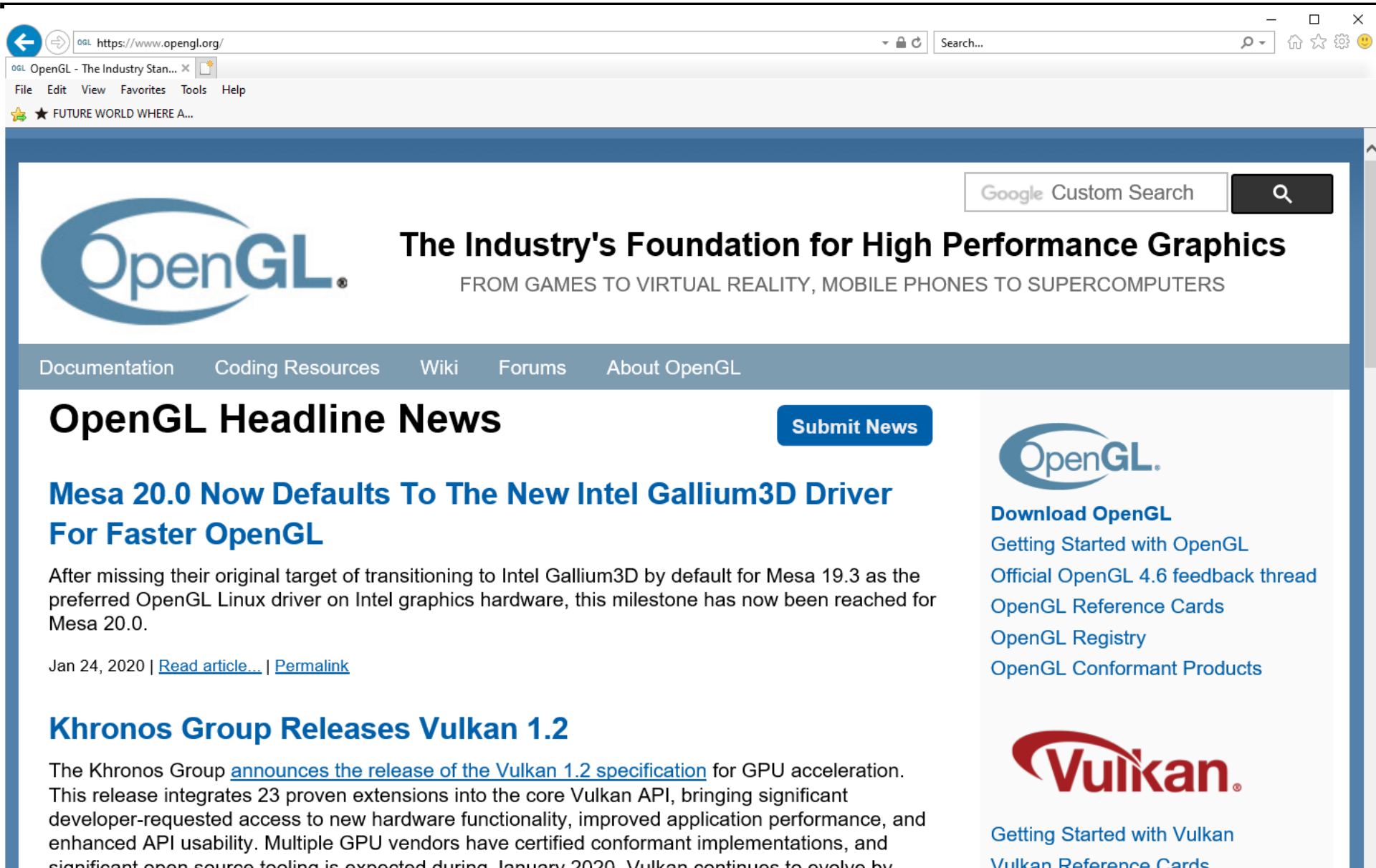
Unity3D


Unity - AngryBots.unity - AngryBots - PC and Mac Standalone*
File Edit Assets GameObject Component Terrain Tools Window Help
Scene
Game
Hierarchy
Project
Inspector
Enemies
Environment(dynamic)
Environment(semi-static)
Environment(sounds)
Environment(static)
Main Camera
Misc
MoodBoxes
Player
AngryBots
AngryBots
Animations
Editor
Explosions
Materials
Scripts
SequenceParts
Sequences
Standalone
Blood_Splatter
BloodUV_Squirt
MuzzleFlash_FrontA
MuzzleFlash_SideA
Textures
Fonts
Gizmos
Materials
New Terrain
Objects
PhysicMaterials
Prefabs
Resources
Scenes
Scripts
Shaders
Sounds
Textures
player_root
Transform
Position
Rotation
Scale
AngryBots: setting shader LOD to High
6:55 PM
10/21/2011

Unreal


Launch_Trailer_P_Enterprise
FNLaunchTrailer
File Edit Window Help
Modes
Save Current
Source Control
Content
Marketplace
Settings
Shotgun
Blueprints
Cinematics
Build
Play
Launch
World Outliner
Search Classes
Recently Placed
Basic
Lights
Cinematic
Visual Effects
Geometry
Volumes
All Classes
Empty Actor
Empty Character
Empty Pawn
Point Light
Player Start
Cube
Sphere
Cylinder
Cone
Plane
Box Trigger
Perspective
Lit
Show
db0137_001 db0130_shotcam
16:9 DSLR
Shotgun: Publish
Publish
Toolkit v0.18.148
Project Why
LIGHTING, SHOT DB137
DB137
LevelSequence
Render Movie and Submit for Review
Task and Entity Link to apply to the selected item:
Task: Lighting
Link: DB137
Thumbnail:
Description
Added table, latest lighting
Summary:
The following items will be processed:
DB137
– Render Movie and Submit for Review
Drag and drop items here to add them.
One item discovered by publisher.
Validate
Publish
Content Browser
Sequencer
24 fps (film)
Track
Filter
Camera Cuts
Camera
Audio
Cameras
Characters
Lighting
spawn
Attachment
Type here to search
12:07 PM
8/12/2018

OpenGL


https://www.opengl.org/
Search...
OpenGL - The Industry Stan...
File Edit View Favorites Tools Help
FUTURE WORLD WHERE A...
Google Custom Search
The Industry's Foundation for High Performance Graphics
FROM GAMES TO VIRTUAL REALITY, MOBILE PHONES TO SUPERCOMPUTERS
Documentation
Coding Resources
Wiki
Forums
About OpenGL
OpenGL Headline News
Submit News
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
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OpenGL Reference Cards
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Vulkan
Getting Started with Vulkan