# 3D Computer Games History and Technology

Markus Hadwiger
VRVis Research Center
http://www.vrvis.at

## Lecture Outline

- Overview of the last 10-15 years
- A look at seminal 3D computer games
- Most important techniques employed
- Graphics research and games R&D
- Transition software to hardware rendering
- Most important consumer 3D hardware

# Part 1:
# Seminal 3D Games



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# Ultima Underworld

Looking Glass Technologies, 1992

- First real-time 3D role-playing game
- No technological viewpoint restrictions
- Correct looking up and down
- Fully texture-mapped world
- But: affine mapping (perspective incorrect!)
- Very small rendering window
- Rather slow; far from fast action game




Ultima Underworld (Looking Glass, 1992)

# Wolfenstein 3D

id Software, 1992

- Eventually created a new genre: FPS
- Three (2+1) degrees of freedom
- Only walls texture-mapped
- Simple ray-casting algorithm for columns
- Only 90-degree angles between walls
- Billboard characters (sprites)
- Shareware distribution model!




Wolfenstein 3D (id Software, 1992)

# Doom

id Software, 1993

- First fully texture-mapped action game
- One large 2D BSP tree for visibility
- No rooms above rooms
- Front to back rendering
- “Constant z” texture mapping
- Network game play using IPX on LANs
- Highly user-extensible (levels, graphics)




DOOM (id Software, 1993)

# Descent

Parallax Software, 1994

- First 360-degree, 6 DOF action game
- Portals for visibility determination
- Portals are intrinsic part of representation
- World building blocks: convex “six-faces”
- Clever restrictions: 64x64 textures, ...
- Polygonal, 3D characters (robots)
- Still using billboards for power-ups, …




Descent (Parallax Software, 1994)

# Quake

id Software, 1996

- First FPS with real 3D; complex geometry
- 3D BSP, potentially visible sets, z write
- 3D characters with several hundred polys
- Projective texture mapping; subdivision
- Pre-calculated lighting: light maps
- CSG modeling paradigm for level building
- Internet network game play (QuakeWorld)




Quake (id Software, 1996)

# GLQuake

id Software, 1996

- Killer application for 3D hardware (3dfx!)
- Introduced OpenGL to game developers
- Bi-linearly filtered textures; MIP mapping
- Light maps as additional alpha texture
- Radiosity for static lighting (pre-process)
- Single-pass multi-texturing (Voodoo 2)




Quake vs. GLQuake (id Software, 1996)

# Quake 3 Arena

id Software, 1999

- Major move toward true-color artwork
- 3D hardware accelerator mandatory
- 3D BSP tree and potentially visible sets
- Curved surfaces (quadratic bézier patches)
- Multi-pass rendering for very high quality
- Real-time shaders (“shading language”)
- Focus on multiplayer Internet gaming



Quake 3 Arena (id Software, 1999)

# Doom 3

id Software, 2004

- Macworld Tokyo (Feb. 2001) + E3 2002
- For highly programmable hardware (GF3+)
- Outrageous polygon counts + normal maps
- Source art contains extremely high detail
- Real-time lighting/shadows; no light maps!
- Physics engine
- Engine moved to C++ (no pure C)



Doom 3 (id Software, 2004)

Doom 3 (id Software, 2004)

# Part 2:
# Consumer 3D Hardware



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## Voodoo Graphics

3dfx Interactive, 1996

- Breakthrough for consumer 3D hardware
- Add-on card; no rendering in window
- 2MB frame buffer + 2MB texture memory
- 16-bit color buffer; 16-bit depth buffer
- Screen resolution up to 640x480
- Texture res up to 256x256; power-of-two!
- No performance hit for feature use



## The Glide API

3dfx Interactive, 1996

- Low-level, hardware-oriented API
- No clipping, no texture mem management
- Proprietary; only for 3dfx hardware
- Very high performance
- Very easy to use; freely available
- Huge factor in 3dfx's market dominance
- Really seminal, but now as dead as 3dfx

## Voodoo 2

3dfx Interactive, 1998

- First single-pass multi-texturing (2 TMUs)
- Great for light maps and tri-linear filtering
- 4MB frame + 2*(2|4)MB texture memory
- Screen resolution up to 800x600
- SLI for doubling the fill-rate (2x texmem!)
- Enhanced dithering to 16 bits



## Riva TNT

NVIDIA Corporation, 1998

- High quality rendering with OpenGL!
- 32-bit color buffer, 24-bit depth buffer
- 8-bit stencil buffer! (not available before!)
- “Twin-texel”: single-pass multi-texturing
- Texture size up to 2048x2048
- Robust OpenGL 1.1 implementation
- Why OpenGL in games? Quake and TNT!

## GeForce 256

NVIDIA Corporation, 1999

- Full geometry acceleration in hardware
- Incredible number of OpenGL extensions
- Register combiners (per-pixel shading)
- Cubic environment maps in hardware
- First really viable platform for research



## Radeon

ATI Technologies Inc., 2000

- First consumer hardware with 3D textures
- Three-texture multitexturing
- Tiled depth buffer for better performance
- Was only real competitor to GeForce 256/2
- GeForce 2 still better in most respects

## GeForce 3

NVIDIA Corporation, 2001

- First move toward shaders and GPUs
- Vertex shaders (RISC assembly code)
- Per-pixel shading (tex shaders, combiners)
- Dependent texture look-ups
- Hardware-tessellated high-order surfaces
- More textures (4), more combiners (8)



## Radeon 8500

ATI Technologies Inc., 2001

- DirectX 8.1 feature set (with ps.1.4)
- Six simultaneous textures
- Unified OpenGL fragment shading model
- Colors and texcoords interchangeable (but: precision problems)
- Easy dependent texturing
- 12-bit internal color precision

## GeForce 4

NVIDIA Corporation, 2002

- Mainly performance-optimized GeForce 3
- New tex-shading modes; still hard-wired :-(
- Point sprites (one vtx per textured particle)
- Two vertex shaders (no new API feature)
- High-performance full-screen antialiasing
- Occlusion culling support (also for GF3)
- Render-to-texture support (also for GF3)



## Radeon 9700

ATI Technologies Inc., 2002

- First “real” GPU (with shader programs)
- DirectX 9 feature set (with ps.2.0)
- First full floating-point color pipeline
- Highly programmable shading model (`ARB_fragment_program, ARB_vertex_program`)
- 64 ALU instructions in the pixel shader
- 16 texture images; 32 accesses

## GeForce FX

NVIDIA Corporation, 2003

- DirectX 9 feature set and more
- Longer pixel shaders than Radeon 9700
- More OpenGL extensions
- Cg (“C for Graphics”) high-level shading language
- Performance similar to Radeon 9700 (except slower fragment shading)



## GeForce 6 / GeForce 7

NVIDIA Corporation, 2004 / 2005

- Pixel shaders 3.0 feature set
- Data-dependent branching in shaders
- Texture-access in vertex shader
- Support for very long shaders
- High-performance 32-bit support throughout all shaders
- 512 MB / 1 GB configurations

# Radeon X1800 / X1900

ATI Technologies Inc., 2005

- Pixel shaders 3.0 feature set
- OpenGL shaders: GLSL
- “Ultra-threaded” architecture
- Fast execution of pixel shader conditionals
- 16 pixel pipelines; X1900: 3 ALUs/pipeline
- 512 MB / 1 GB configurations

## State of the Art (1)

- Programmability (vertex/fragment shaders) via high-level shading languages
- Many rendering passes (high fill-rate)
- Incredible polygon counts (geometry acc.)
- Advanced lighting (towards photo-realism)
- Large outdoor areas; lifelike characters
- Leverage of advanced (graphics) research



## State of the Art (2)

- Competition of two vendors: NVIDIA, ATI
- Clean, stable feature sets
- More precision enables entirely new class of algorithms (general purpose computations!)
- Artists more and more able to work directly
- Fast off-line movie-quality rendering (e.g.: `http://film.nvidia.com`)

Half-Life 2 (Valve, 2004)

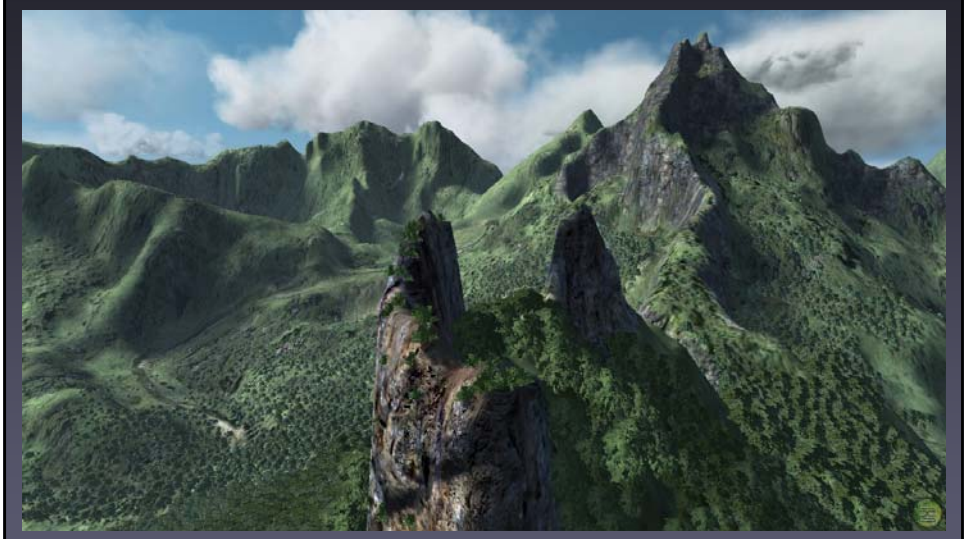



Half-Life 2: The Lost Coast (Valve, 2005)

Unreal Engine 3 Preview (Epic Games, 2005/6...)

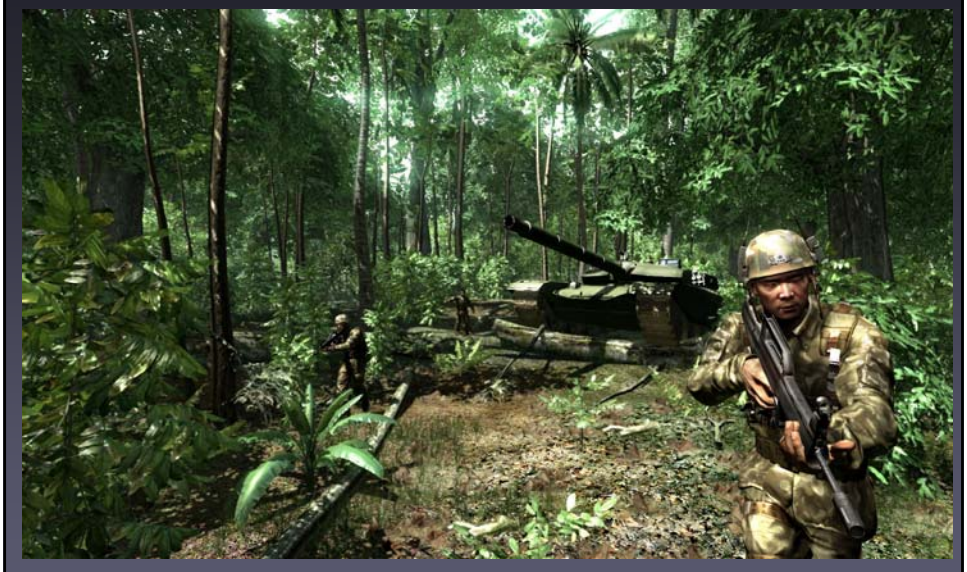


Unreal Engine 3 Preview (Epic Games, 2005/6...)



Crysis (Crytek, 2006?)





Crysis (Crytek, 2006?)

Stalker (GSC Game World, 2006?)



Stalker (GSC Game World, 2006?)