3D-Graphik und Computerspiele

Techniken und historischer Überblick

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Who is this guy?

- Computer science at TU Wien ’94-’00
- Institute of Computer Graphics
- Currently at VRVis in Vienna

  Research on hardware-accelerated Viz
- Work on commercial games (’91-)
- Parsec (http://www.parsec.org)

  Free space-shooter for Linux, Mac, Win

Talk Outline

- Overview of the last nine 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
- Tentative look into the future

Act I:
Seminal 3D Games

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
- 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 raycasting 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 projectiles, …

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
- Precalculated lighting: lightmaps
- 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
- Bilinearly filtered textures; MIP mapping
- Lightmaps as additional alpha-texture
- Radiosity for static lighting (preprocess)
- Single-pass multi-texturing (SGIS ext.)

Quake vs. GLQuake (id Software, 1996)

Quake 3 Arena

id Software, 1999

- Basically still state of the art!
- 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, 200x (probably x > 1)

- First presented at Macworld Tokyo (Feb01)
- Exploiting highly programmable hardware
- GeForce 3 feature set is the target
- Outrageous polygon counts, characters
- Realistic shadows, many light sources
- Engine code moving to C++ (no pure C)
- In short: oh, wow!

Doom 3 (id Software, 200x)

Doom 3 (id Software, 200x)

Act II:
Consumer 3D Hardware

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

Glide

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
- Accessible for free to anyone interested
- Huge factor in 3dfx's market dominance

Voodoo II

3dfx Interactive, 1998

- First single-pass multi-texturing (2 TMUs)
- Great for lightmaps and trilinear 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!!
- “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. Whew!
- Decent fill-rate, but barely more than TNT2
- Fill-rate vs. geometry acceleration debate
- Incredible number of OpenGL extensions
- Register combiners (per-pixel shading)
- Cubic environment maps in hardware
- Great for graphics researchers :-)

ATI Radeon

ATI Technologies Inc., 2000

- First consumer hardware with 3D textures
- Three-texture multitexturing
- Tiled depth buffer for better performance
- Currently, only real competitor to GeForce
- GeForce 2 still better in most respects
- GeForce 3 on the horizon (practically here)

GeForce 3

NVIDIA Corporation, 2001

- Programmable like never before
- Vertex programs (custom RISC assembly)
- Per-pixel shading (tex-shaders, combiners)
- Hardware-tessellated high-order surfaces
- More textures (4), more combiners (8)
- Huge step towards photo-realism
- Programmers will need to catch up

Act III:
Additional Topics

API Wars

- Decided
- Direct3D (DirectX 8) is dominant on Win32
- OpenGL has established itself (Quake!)
- OpenGL is the only cross-platform solution
- Glide is now dead, 3dfx out of business
- Software rendering is very dead (for now)

Graphics chip vendors

- NVIDIA dominates technology and more
  - Strong influence on DirectX 8
  - Separate OpenGL group (extensions!)
  - Top researchers (SIGGRAPH, …)
- ATI only serious competitor left
  - Strong OEM market, mobile solutions
- Others: Matrox, 3Dlabs, ... (3dfx RIP)

The Future (1)

- Incredible polygon counts (geometry acc.)
- Large number of passes (high fill-rate)
- Programmability! (assembly, shaders)
- Advanced lighting (towards photo-realism)
- Large outdoor areas; lifelike characters
- Leverage of advanced graphics research

The Future (2)

- Hardware market consolidating rapidly
- Clean, stable feature sets
- Life for developers will become “easier”
- More precision enables entirely new class of algorithms (general computations!)
- Artists more and more able to work directly (authoring tools and engines converging)
- Distant: paradigm shift away from polys?