SIGGRAPH2010

The People Behind the Pixels

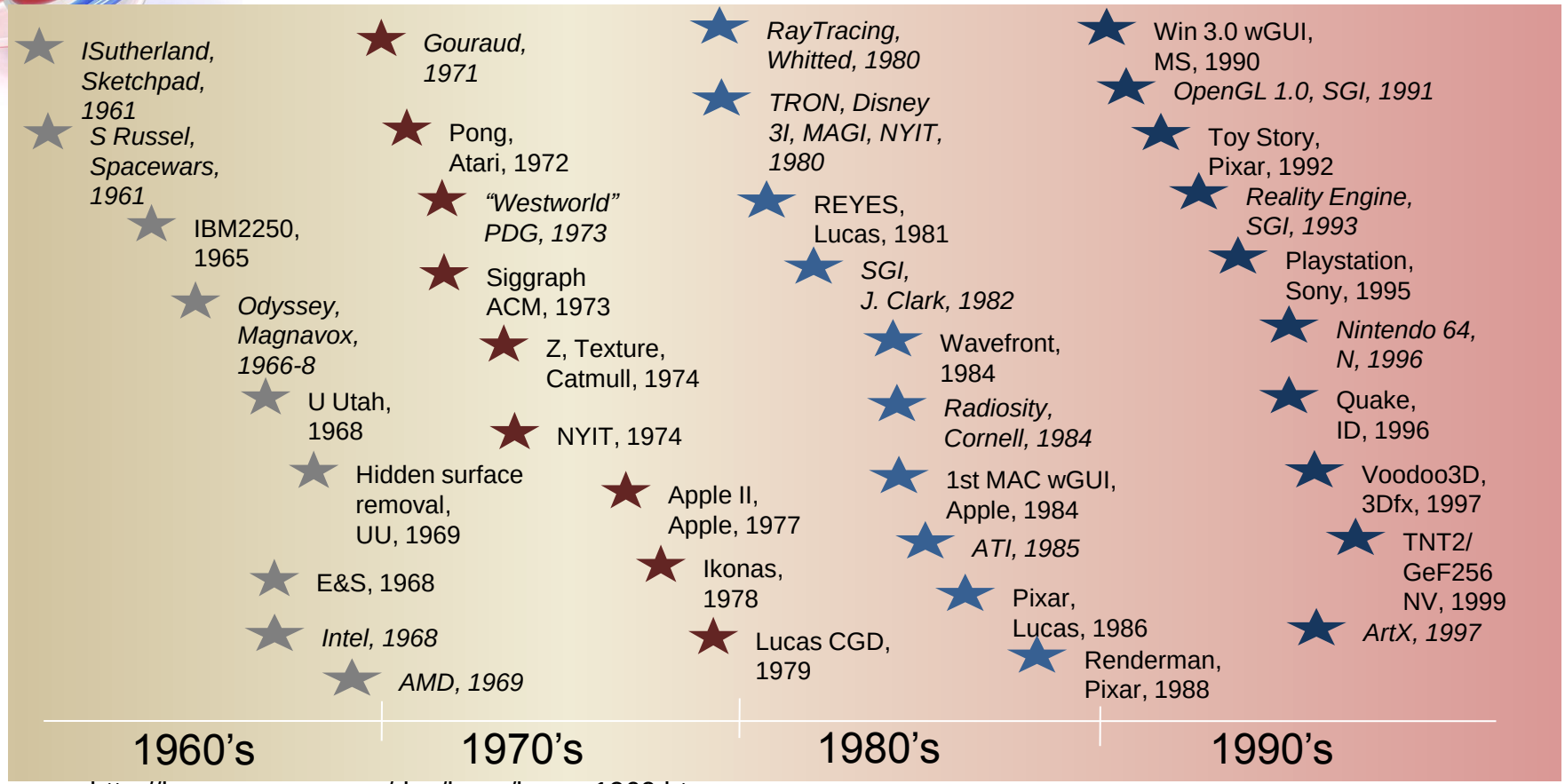
Looking Back, Looking Forward, Why and How is Interactive Rendering Changing

Mike Houston

AMD

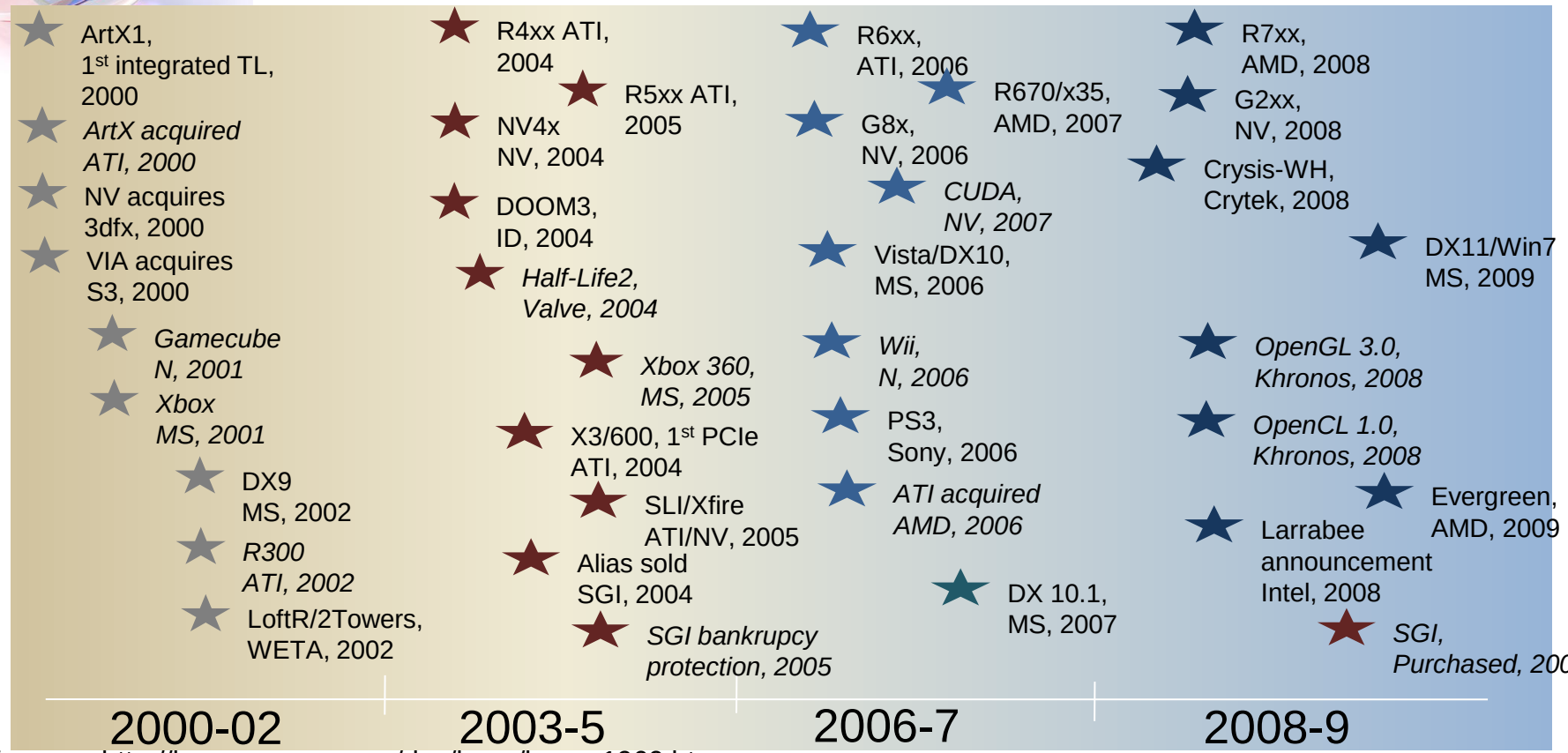
Welcome to
Beyond Programmable Shading!

A quick history 1960's to 2000s



Reference: http://hem.passagen.se/des/hocg/hocg_1960.htm

A quick history since 2000



Reference: http://hem.passagen.se/des/hocg/hocg_1960.htm

Interactive
rendering techniques
are created using an inseparable mix of
data- and task-parallel algorithms
and graphics pipelines

How do users
write new interactive 3D
rendering algorithms?

Fixed Function Pipelines (DX7)

- Writing new rendering algorithms means
  - Tricks with multitexture, stencil buffer, depth buffer, blending …

- Examples
  - Stencil shadow volumes
  - Hidden line removal
  - …

Programmable Shaders (DX8-10)

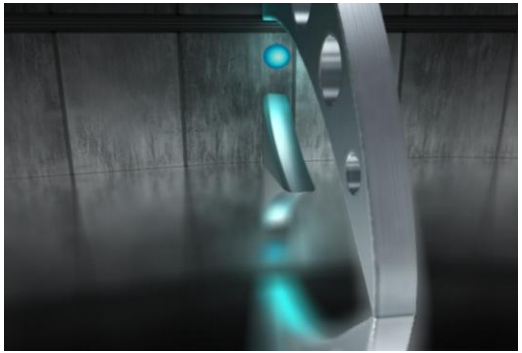
- Writing new rendering algorithms means
  - Tricks with stencil buffer, depth buffer, blending …
  - Plus: Writing shaders

- Examples
  - User-defined materials
  - User-defined lights
  - User-defined data structures (built in texture memory)

Software Graphics: Part I (DX11)

- Writing new rendering algorithms means
  - Tricks with stencil buffer, depth buffer, blending …
  - Plus: Writing shaders
  - Plus: Writing data- and task-parallel algorithms
    - Analyze results of rendering pipeline
    - Synthesize data structures

- Examples
  - Dynamic summed area table
  - Dynamic quadtree adaptive shadow map
  - Dynamic histogram-analysis shadow map
  - Dynamic ambient occlusion
  - …



"Fast Summed-Area Table Generation and its Applications,"
Hensley et al., Eurographics 2005

"Dynamic Ambient Occlusion and Indirect Lighting," *Bunnell, GPU Gems II, 2005*

"Real-Time Approximate Sorting for Self Shadowing
and Transparency in Hair Rendering,"
Sintorn et al., I3D 2008

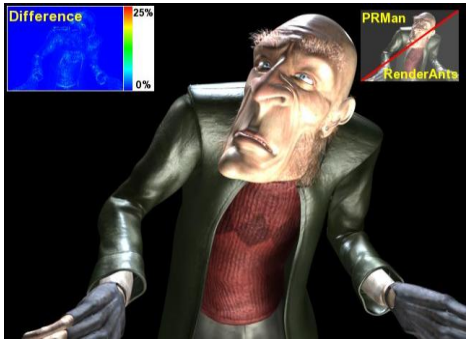
"Resolution Matched Shadow Maps,"
Lefohn et al., ACM Transactions on Graphics 2007

Software Graphics: Part II (DX11+)

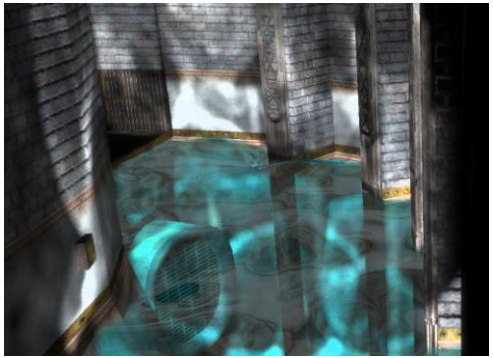
- Writing new rendering algorithms means
  - Tricks with stencil buffer, depth buffer, blending …
  - Plus: Writing shaders
  - Plus: Writing data- and task-parallel algorithms
    - Analyze results of rendering pipeline
    - Synthesize data structures
  - Plus: Creating new and extended rendering pipelines

- Examples
  - Micropolygon rendering
  - Ray tracing pipelines
  - …

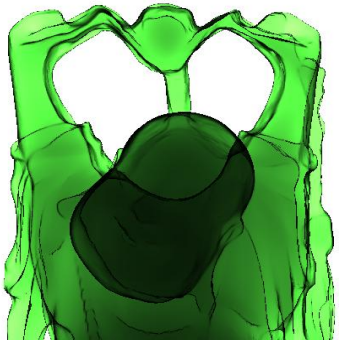
OptiX, *NVIDIA 2008*



"RenderAnts: Interactive Reyes Rendering on GPUs,"
Zhou et al., ACM SIGGRAPH Asia 2009



"Hardware-Accelerated Global Illumination by Image Space Photon Mapping,"
McGuire and Luebke, High Performance Graphics 2009



"FreePipe: a Programmable Parallel Rendering Architecture
for Efficient Multi-Fragment Effects,"
Liu et al., ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games 2010

“Render to Data Structures”

- DX11 PixelShader 5
  - Atomics to global memory
  - Gather/scatter to memory (“unordered access views”

- Order independent transparency
  - Capture all rendered fragments
    - Render directly to grid-of-lists data structure instead of framebuffer
    - No framebuffer bound while rendering ☺
    - Increment global counter to get unique address for fragment
    - Scatter {depth, color,prevFrag} to UAV shared by all pixels
    - Result is grid of linked lists
  - Sort and blend lists for final image (pixel shader or compute shader)

Order Independent Transparency

There is no single graphics pipeline

- There is no single workload to optimize

- Moving forward, interactive rendering is an inseparable mix of
  - Task- and data-parallel algorithms
  - Standard, extended and custom graphics pipelines

But Some Food For Thought…

The Wheel of Reincarnation

Gradually the processor became more complex.... Finally the display processor came to resemble a full-fledged computer with some special graphics features. And then a strange thing happened. We felt compelled to add to the processor a second, subsidiary processor, which, itself, began to grow in complexity. It was then that we discovered a disturbing truth. Designing a display processor can become a never-ending cyclical process. In fact, we found the process so frustrating that we have come to call it the "wheel of reincarnation."

- Myer and Sutherland "On The Design of Display Processors", Communications of the ACM, **1968**

Will There Be Another Turn of The Wheel of Reincarnation?

- Is “the rise of SW graphics” a temporary (5-10) year window as we go around the wheel of reincarnation or has the wheel stopped turning?
- If it has stopped turning, why?
- If it hasn’t stopped turning, what will be the next fixed-function hardware?

Conclusions

- Software + hardware graphics is here today (beginning “for real” in DX11)
  - Graphics programming is no longer simply a single pre-defined pipeline
  - Research is ablaze with software rendering research on GPUs and CPUs
- Future real-time rendering programming will consist of
  - A pre-defined (Direct3D/OpenGL) rendering pipeline
  - User-defined software pipelines
  - User-defined data- and task-parallel code tightly coupled to graphics pipelines
- Is the wheel of reincarnation still turning?

Beyond Programmable Shading I

9:00–9:20 - Mike Houston, AMD

Looking Back, Looking Forward, Why and How is Interactive Rendering Changing

9:20–9:45 - Johan Andersson, DICE

Five Major Challenges in Interactive Rendering

9:45–10:15 - Kayvon Fatahalian, Stanford

Running Code at a Teraflop: How a GPU Shader Core Works

10:15–10:45 - Aaron Lefohn, Intel

Parallel Programming for Real-Time Graphics

10:45–11:15 - Chas Boyd, Microsoft

DirectCompute Use in Real-Time Rendering Products

11:15–11:45 - David Luebke, NVIDIA Research

Surveying Real-Time Beyond Programmable Shading Rendering Algorithms

11:45–12:15 - Johan Andersson, DICE

Bending the Graphics Pipeline

Beyond Programmable Shading II

2:00–2:05 - Aaron Lefohn, Intel

Welcome and Re-Introduction

2:05–2:35 - Jonathan Ragan-Kelley, MIT

Keeping Many Cores Busy: Scheduling the Graphics Pipeline

2:35–3:10 - Kayvon Fatahalian, Stanford

Evolving the Direct3D Pipeline for Real-Time Micropolygon Rendering

3:10–3:30 - Jonathan Ragan-Kelley, MIT

Decoupled Sampling for Real-Time Graphics Pipelines

3:30–3:50 - Andrew Lauritzen, Intel

Deferred Rendering for Current and Future Rendering Pipelines

3:50–4:15 - Luca Fascione, WETA

Jacopo Pantaleoni, NVIDIA Research

PantaRay: A Case Study in GPU Ray-Tracing for Movies

4:15–4:30 - Mike Houston, AMD

Wrapup: What's Next for Interactive Rendering Research?

Beyond Programmable Shading II

4:30–5:15

Panel: *What Role Will Fixed-Function Hardware Play in Future Graphics Architectures?*

Moderator: Kurt Akeley
Microsoft Research

Panelists:
Steve Molnar, NVIDIA
David Blythe, Intel
Mike Houston, AMD
Johan Andersson, DICE
Kayvon Fatahalian, Stanford

Course webpage and slides:

http://bps10.idav.ucdavis.edu