Rendering Faster and Better with VRWorks

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Talk Overview

VRWorks Features
  Context Priority, Audio, VR SLI
  Multi-Res Shading, Lens Matched Shading, Single Pass Stereo

UnrealEngine 4 Integration

VR Tools
How is VR rendering different?
How is VR rendering different?

High framerate, low latency

High FPS, low latency

Stereo Rendering

Lens Distortion

gameworks.nvidia.com
NVIDIA VRWorks
COMPREHENSIVE SDK FOR VR DEVELOPERS

GRAPHICS
- Lens Matched Shading
- Single Pass Stereo
- MultiRes Shading
- VR SLI

HEADSET
- Context Priority
- Direct Mode
- Front Buffer Rendering

AUDIO
- VRWorks Audio

PROFESSIONAL
- Warp & Blend
- Synchronization
- GPU Affinity
- GPUDirect FOR VIDEO

Touch & Physics
- PhysX
Context Priority and Async Timewarp
Context priority for asynchronous time warp
Reduces latency from head rotation

Frame (Left) → Frame (Right) → Warped Frame
Head Tracking (t) → Head Tracking (t+1)
Pascal Graphics Preemption
Improves responsiveness
Timewarp with Maxwell

Conservative Preemption Request

GPU

BUFFER

TIMEWARP

Flip

Scanout

Flash backlight

Latency
Timewarp with Pascal

- Pascal
- Preemption Request
- GPU
- TIMEWARP
- Flip
- Scanout
- Flash backlight
- Latency
VRWorks Audio
Simulating Audio in VR

SYNTHESIS
Creation of Source Sounds

DIRECTION
Location of Incoming Sound

PROPAGATION
How Sound Moves in Space
NVIDIA VRWORKS AUDIO
Models Direction and Propagation Using Ray Tracing

- 16k rays
- 12 bounces each
VRWorks Audio Pipeline

**INPUTS**
- Sound Source
- Location & Orientation
- Environmental Geometry
- Environmental Material

**PROCESSING**
- VRWorks Audio & OptiX

**OUTPUT**
- Left/Right Ear
- Convolution Filter:
  - Occlusion of sound
  - Absorption & Reflection
  - HRTFs
  - Distance-based attenuation
  - Reverb
VR SLI
VR SLI

Two eyes...two GPUs!
“Normal” SLI

GPUs render alternate frames

- CPU: N, N+1
- GPU 0: N
- GPU 1: N+1
- Display: N, N+1

Latency
VR SLI

Each GPU renders one eye—lower latency

- **CPU**: N, N+1
- **GPU 0**: N_L, N+1_L
- **GPU 1**: N_R, N+1_R
- **Display**: N, N+1

Latency

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VR SLI

GPU affinity masking: full control

Left eye rendering

Shadow maps, GPU physics, etc.

Right eye rendering

UINT SetGPUMask(
    [in]UINT GPUMask
);

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VR SLI

Broadcasting reduces CPU overhead

Render scene once
VR SLI

Per-GPU constant buffers, viewports, scissors

Engine

Multi-GPU API

NvAPI_Status VSSetConstantBuffers(
    [in] ID3D11DeviceContext *pContext,
    [in] UINT GPUMask,
    [in] UINT StartSlot,
    [in] UINT NumBuffers,
);

void glGPUNamedBufferSubDataNVX ( GLbitfield gpuMask,
    GLuint buffer,
    GLintptr offset,
    GLsizei size,
    const GLvoid *data );

gameworks.nvidia.com
VR SLI

Cross-GPU data transfer via PCI Express

```c
void gllGPUCopyImageSubDataNVX ( 
    GLuint sourceGpu, 
    GLbitfield destinationGpuMask, 
    GLuint srcName, 
    GLuint srcTarget, 
    GLint srcLevel, 
    GLint srcX, 
    GLint srcY, 
    GLint srcZ, 
    GLuint dstName, 
    GLuint dstTarget, 
    GLint dstLevel, 
    GLint dstX, 
    GLint dstY, 
    GLint dstZ, 
    GLsizei width, 
    GLsizei height, 
    GLsizei depth );
```

```c
NvAPI_Status CopySubresourceRegion( 
    [in] ID3D11DeviceContext *pContext, 
    [in] ID3D11Resource *pDstResource, 
    [in] UINT DstSubresource, 
    [in] UINT DstGPUIndex, 
    [in] UINT DstX, 
    [in] UINT DstY, 
    [in] UINT DstZ, 
    [in] ID3D11Resource *pSrcResource, 
    [in] UINT SrcGPUIndex, 
    [in] UINT SrcSubresource, 
    [in] UINT SrcTarget, 
    [in, optional] D3D11_BOX *pSrcBox, 
    [in, optional] UINT ExtendedFlags = 0 );
```
VR SLI - GL NVx extension

GL_NVX_linked_gpu_multicast
Command & data broadcast
BufferSubData to specific GPU
CopyImageSubData
Query # GPUs

Image courtesy of Autodesk
VR SLI - GL NV extension

Upcoming NV version

Command & data broadcast

BufferSubData to specific GPU

CopyImageSubData & CopyBufferSubData

Query # GPUs

GPU Masks

Per-GPU sample locations

Per-GPU queries
Multi-Resolution Shading
VR headset optics

Distortion and counter-distortion
VR headset optics

Distortion and counter-distortion

Image Displayed  Optics  User’s view

Gameworks.nvidia.com
Distorted rendering

Render normally, then resample
Distorted rendering
Over-rendering the outskirts

Rendered image

Distorted image
Multi-resolution shading

Subdivide the image, and shrink the outskirts
Multi-resolution shading

Fast viewport broadcast on NVIDIA Maxwell and beyond GPUs

Geometry Pipeline

Viewport 1
Viewport 2
...
Viewport N
Lens Matched Shading

RENDERS TO A LENS CORRECTED SURFACE
Lens Matched Shading

RENDERS TO A LENS CORRECTED SURFACE
TRADITIONAL STEREO RENDERING

REQUIRES 2 GEOMETRY PASSES

Left Eye (Pass 1)

Right Eye (Pass 2)
SINGLE PASS STEREO
RENDERS LEFT & RIGHT EYE IN ONE GEOMETRY PASS
Multi-Res in UnrealEngine 4
Multi-resolution shading

Unreal Engine integration

We’ve integrated multi-res in UE 4.10, 4.11, and 4.12

Currently limited support for post effects with multi-res

Available on GitHub

https://github.com/NvPhysX/UnrealEngine/tree/MultiRes-4.10

Pascal features coming soon
UE4 integration 4.10

https://github.com/NvPhysX/UnrealEngine/tree/MultiRes-4.10

Postprocessing passes supported:

- Bloom & lens flare
- Tonemapping
- Temporal AA
- Reflection environment (not screen-space reflection)
- Height fog
- Decals
- Distortion/refraction
UE4 integration 4.11 / 4.12


Adds postprocessing passes supported:

- SSAO
- Screenspace Reflections

Supports Instanced Stereo Rendering

Major refactoring
Multi-resolution shading

Performance

UE4 Infiltrator demo: +30% to +40% FPS

@ approximate VR render res

Everest VR seeing up to +40%

Best when pixel-bound

We’ve seen ~50% perf boosts
Demo Time

Demo UE4
Nsight VSE and VR

Jeff Kiel - Manager, Graphics Tools
AGENDA

Intro to Nsight & Developer Tools
VR debugging
GPU Range Profiling
Roadmap
NSIGHT VISUAL STUDIO EDITION 5.2
VR, Vulkan, and Advanced Graphics Profiling

Oculus VR SDK support (D3D & OpenGL)
Vulkan API support
New Range Profiler, including DirectX12
New Geometry View
CUDA 8.0 support
UE4’s VR Engine

Render pass per eye
Roadmap

When you get back from SIGGRAPH: 5.2 RC1
- VR Goodness
  - OCULUS SDK, OpenGL and Direct3D
  - OpenGL Multicast Rendering
- Range Profiler (OpenGL & D3D)
- Vulkan
  - Frame Debugging
  - Beta: Serialized Captures
- DX12 Serialized Captures

September, 2016: 5.2 Final
Roadmap

Q4 2016: 5.3
- More VR Goodness
- More Profiler Screens & Metrics
- Shader Perf Returns!
- MS Hybrid Support & UWP

The Future
- Vulkan Profiling
- Shader Source Correlated Performance Information
- Pipeline Statistics
- Compare API State/Profile Runs
- Your Feature Here...

Tell Me What You Need!?!?