OPTIX UPDATE

- OptiX Introduction
- Current Goodness
- Upcoming Goodness
- Special Guest
RENDERING
RENDERING WITH RAY TRACING

- Sampling
  - What rays to trace?

- Ray tracing
  - What do the rays hit?

- Shading
  - What color are the rays?
RAY TRACING IN THE ABSTRACT

- Given a ray \((O, D)\) and a geometric dataset find
  - any hit
  - closest hit
  - all hits

- Current datasets ~1M to 100M primitives, usually triangles
- Use a spatial data structure optimized for these operations
- Datasets can also include GB of other data like textures
ACCELERATION STRUCTURES

- Bounding Volume Hierarchy (BVH)
GPUS - THE PROCESSOR FOR RAY TRACING

- Abundant parallelism, massive computational power
- GPUs excel at shading
- Opportunity for hybrid algorithms
RAY CASTING (APPEL, 1968)
**REAL TIME PATH TRACING**

- **What would it take?**
  - 4 rays / sample
  - 50 samples / pixel
  - 2M pixels / frame
  - 30 frames / second
  - 12B rays / second

- **GeForce GTX Titan:**
  - 350M rays / second
  - Need 34X speedup

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BEST OF GTC

- 1 shading sample
- 1 AA sample
- 9 shading samples
- 1 AA sample
- 18 shading samples
- 2 AA samples
- 36 shading samples
- 4 AA samples
- 72 shading samples
- 8 AA samples
- 144 shading samples
- 16 AA samples
DESIGN GARAGE: ITERATIVE PATH TRACER

- Closest hit programs do:
  - Direct lighting (next event estimation with shadow query ray)
  - Compute next ray (sample BSDF for reflected/refracted ray info)
  - Return direct light and next ray info to ray gen program

- Ray generation program iterates along path
DESIGNGARAGE: ITERATIVE PATH TRACER

RT_PROGRAM void rayGeneration() {
    float3 ray_dir = cameraGetRayDir();
    float3 result = tracePathRay( camera.pos, ray_dir, 1 );
    output_buffer[ launch_index ] = result;
}

RT_PROGRAM void closestHit() {
    // Calculate BSDF sample for next path ray
    float3 ray_direction, ray_weight;
    sampleBSDF( wo, N, ray_direction, ray_weight );
    // Recurse
    float3 indirect_light = tracePathRay( P, ray_direction, ray_weight );
    // Perform direct lighting
    ...
    prd.result = indirect_light + direct_light;
}
RT_PROGRAM void rayGeneration() {
    PerRayData prd;
    prd.ray_dir = cameraGetRayDir();
    prd.ray_origin = camera.position;
    float3 weight = make_float3(1.0f);
    float3 result = make_float3(0.0f);

    for (i = 0; i < MAX_DEPTH; ++i) {
        traceRay(prd.ray_origin,
                 prd.ray_dir, prd);
        result += prd.direct*weight;
        weight *= prd.ray_weight;
    }

    output_buffer[launch_index] = result;
}

RT_PROGRAM void closestHit() {
    // Calculate BSDF sample for next path ray
    float3 ray_direction, ray_weight;
    sampleBSDF(wo, N, ray_direction, ray_weight);

    // Return sampled ray info and let ray_gen iterate
    prd.ray_dir = ray_direction;
    prd.ray_origin = P;
    prd.ray_weight = ray_weight;
    prd.direct = direct_light;

    // Perform direct lighting
    ...
}
WHAT’S THE LATEST
REGISTERED DEVELOPER PROGRAM

- Access latest OptiX version
- Access private beta releases
- Tighter communication with OptiX developers

800 registered developers in 4 months
OPTIX 3.6

- CUDA 6 support
- Maxwell (SM 5.0) support
  - Great performance
- Callable Program IDs
  - Use with Bindless Buffer IDs and Texture IDs
  - Finishes our composable shading solution
  - See Pixar, Danny Nahmias, NVIDIA Theater, Tue.3:20
- Optimized CPU ray tracing in OptiX Prime *(Commercial)*
ACCELERATION BUILDER OPTIONS

- Sbvh
- Bvh
- MedianBvh
- Lbvh
- Trbvh

Options:
- Slow Build
- Fast Build
- Slow Render
- Fast Render
TRBVH MEMORY FOOTPRINT IMPROVED

- Scratch space used to limit build size
- Also, 2 GB max build size
- For a 40 million triangle model
  - Before 4.5 GB
  - Now 2.8 GB
- Builds Trbvh in chunks.
  - Chunk size parameter
  - Virtually the same ray tracing performance
- Both OptiX and OptiX Prime
OPTIX PRIME

- Specialized for ray tracing (no shading)
- Replaces rtuTraversal (rtuTraversal is still available)
- Improved performance
  - Uses latest algorithms from NVIDIA Research
    - ray tracing kernels [Aila and Laine 2009; Aila et al. 2012]
    - Treelet Reordering BVH (TRBVH) [Karras 2013]
  - Can use CUDA buffers as input/output
  - Support for asynchronous computation
- Ships with OptiX 3.6
OPTIX PRIME RAY TRACING PERFORMANCE

Primary Mrays/s

Arabic
Armadillo
Babylonian
Bar
Blade
Bubs
Buddha
City
Conference
Crown
Crytek-Sp
Dragon
Fairy
Hairball
Italian
Motor
Mustang
PowerPla-16
Sibenik
Soda
Vegetation
Veyron-NG
OPTIX PRIME RAY TRACING PERFORMANCE

DIFFUSE Mrays/s

Arabic  Armadillo  Babylonian  Bar  Blade  Bubs  Buddha  City  Conference  Crown  Crytek-Sp  Dragon  Fairy  Hairball  Italian  Motor  Mustang  PowerPla-16  Sibenik  Soda  Vegetation  Veyron-NG
OPTIX PRIME RAY TRACING PERFORMANCE

- This is the best single-chip ray tracing performance ever reported.
- By more than 2X.
WHAT’S COMING
MAJOR ARCHITECTURAL RENOVATION

- LLVM-based OptiX compiler

- Priorities
  - Better GPU ray tracing performance
  - More fluid interactive rendering
  - Better multi-GPU scaling
  - More efficient complex node graphs
  - Additional input languages
  - CPU backend
UNIFIED VIRTUAL MEMORY

- Merges CPU and GPU memory spaces
- Full read/write access from both processors
- Eliminates GPU memory footprint barrier
- Coming in Pascal architecture (2016)
NVIDIA VCA

Under the Hood

- **GPUs**: 8 x K6000-VCA GPUs
- **GPU Memory**: 12 GB per GPU
- **CUDA Cores**: 23,040
- **CPU Cores**: 20
- **System Memory**: 256 GB
- **Storage**: 4 x 512GB SSD
- **Network**
  - 2 x 1GigE
  - 2 x 10GigE (SFP+)
  - 1 x InfiniBand
- **Installed Software**
  - Cent OS Linux + Iray IQ
  - + VCA Cluster Manager
- **U.S. MSRP**: $50,000
OptiX on VCA

Interactive Image Stream

Incremental Updates

OptiX App

Ethernet or Internet

Coming Next Year

Custom OptiX Applications
All Processing on VCA

OptiX Leveraging
Same Infrastructure as Iray (using DiCE)

Minimal Work
within the OptiX App

NVIDIA

VCA
MOVING PICTURE COMPANY

- Damien Fagnau
  - Global Head, VFX Operations
OPTIX AT SIGGRAPH

- OptiX on Titan Z and VCA, NVIDIA booth, Tue. - Thu.
- Iray on NVIDIA VCA, NVIDIA booth, Tue. - Thu.
- Recent Advances in Light-Transport, room 109, Tue. 2:00
- Pixar, Danny Nahmias, NVIDIA Theater, Tue. 3:20
- Bunkspeed with Iray Interactive, NVIDIA Theater, Wed. 12:00
- MPC, Damien Fagnou, NVIDIA Theater, Wed. 12:40