中国游戏开发者大会

CHINA GAME DEVELOPERS CONFERENCE

The development & optimization of the DX12 version of *King Of Wushu*

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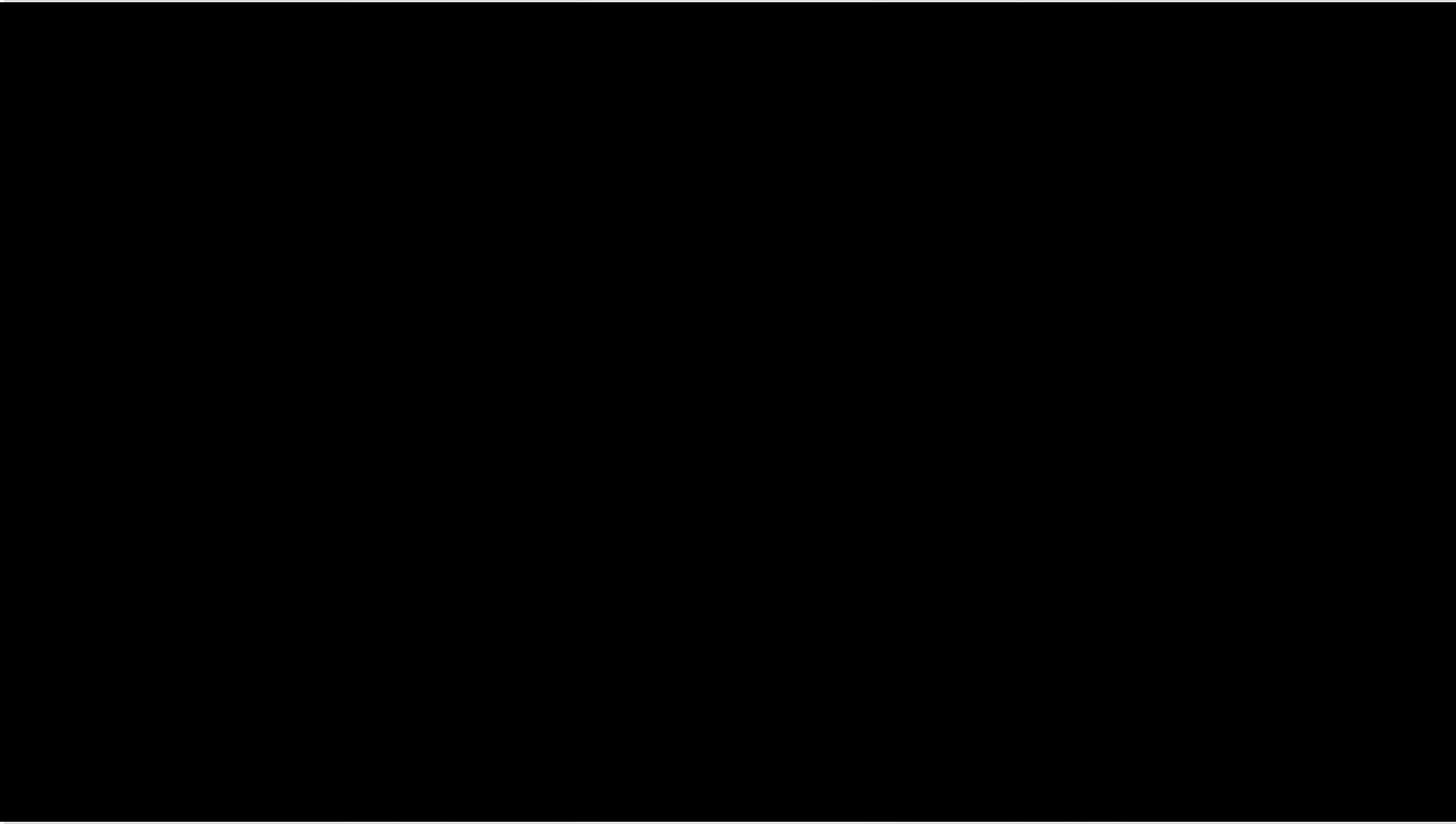
King Of Wushu

- First 3D martial arts MOBA
- With top real-time graphics effects
- First DirectX12 multi-platform online game in China
- Latest NVIDIA GameWorks Integration
- Xbox One & PlayStation 4 version have been released in China, PC verson is coming soon in this year



DX12 Porting

From DirectX11 to DirectX12

- 2 senior graphics engineers, 6 weeks
- Override DX11 interfaces with DX12 APIs
- Manage rendering states with hash map, storing and searching dynamically in real-time
- Assign an unique ID to each resource and state to generate Hash value, if the resource is released, the ID can be reassigned
- Every resource has its bit width in the Hash value, and has ID upper limit
- SDKLayer(Debug Runtime) helps you to find potential rendering issues as early as possible

PipelineStateObject Management

- State settings based on DX11 are cached and delayed until the draw call is executed
  1. RasterizerState
  2. BlendState
  3. DepthStencilState
  4. InputLayout
  5. Shader

- Speedup the generation of PSOs by getting the cached PSO via GetCachedBlob

Sampler Management

- Sampler management

1. One sampler heap can store 2048 Samplers at most

2. Group the 16 samplers of each shader and generate hash value for each group, so there are at most 128 sampler groups in one frame

3. Set the same sampler to the fixed slot, e.g. NormalMap，ShadowMap

4. Have to switch heaps if you want more sampler groups

View Management

- Shader Resource View management

1. One view heap can store 1M view descriptors at most
2. With the same management to the samplers, max 16 SRVs are used in one draw call

- Constant Buffer View management

1. Instead of descriptor table, we use root descriptor. Because constant buffers are dynamic, their GPU address changes frequently
2. Static CB can be managed with descriptor table, but the slots should be fixed
3. 256 bytes align is required for the constant buffers used in each shader stage
4. Call map before set to avoid iteratively accessing

Command List

- API calling in Command List is not thread–safe
- The submit in the Command Queue is thread-safe
- Generate multiple command lists to avoid rendering stall
- Sync the command lists with fences, using the frame ID as the expected value
- Driver and run-time don’t provide extra threads for building and committing render commands asynchronously
- Store the D3D11 commands in the command buffer, send it to a work thread and execute it at the end of each frame. you need to reinterpret D3D11 commands to D3D12 commands in the work thread

Summary

- Developers have more options with the open memory management mode
- Flexible resource binding reduces the requirement of bandwidth
- Powerful and low overhead command submit pipeline is helpful to customized parallelized rendering

Integration of NVIDIA GameWorks & GPU New Features

TXAA Integration

- Reuse the graphics pipeline of CE3 MSAA mode
- Need velocity map in resolve pass due to temporal AA
  - Use the velocity map generated by motion blur
  - Need to decode the packed data to float16
- Record the TXAA result of previous frame
- Set programmable sample locations via NVAPI

HBAO+ Integration

- Need to transform the view space normals into world normals
- Convert the depths to view space
- Be aware of the texture format in MSAA mode

Fast GS Integration

- Render the shadow maps in one pass
- Combine the visible objects lists of each LOD
- Use the coarsest view frustum that contains all the view frustums of each LOD
- Store shadow maps in a texture array
  - Rendered as a render target array
  - Render LOD of shadow maps by setting different viewports
  - Render the render target array with fast GS

Summary

- Besides the GameWorks & features above, we also have integrated HairWorks & Clothing
- Saved lots of development cost by using GameWorks
- GameWorks makes game more competitive in the market
- NVIDIA provides reliable technical supports
- Take full advantage of the newest GPU features
  - Vendors fully understand their products

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NVIDIA GameWorks and GPU new features in *King Of Wushu*

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Agenda

- GameWorks - VisualFX
  - PostWorks : FXAA3.0
  - ShadowWorks : HBAO+
  - HairWorks
- GameWorks – PhysX
  - Clothing
- Maxwell features
  - Multi-Projection Acceleration
    - Fast Geometry Shader (Fast GS)
    - Fast Viewport Multi-casting

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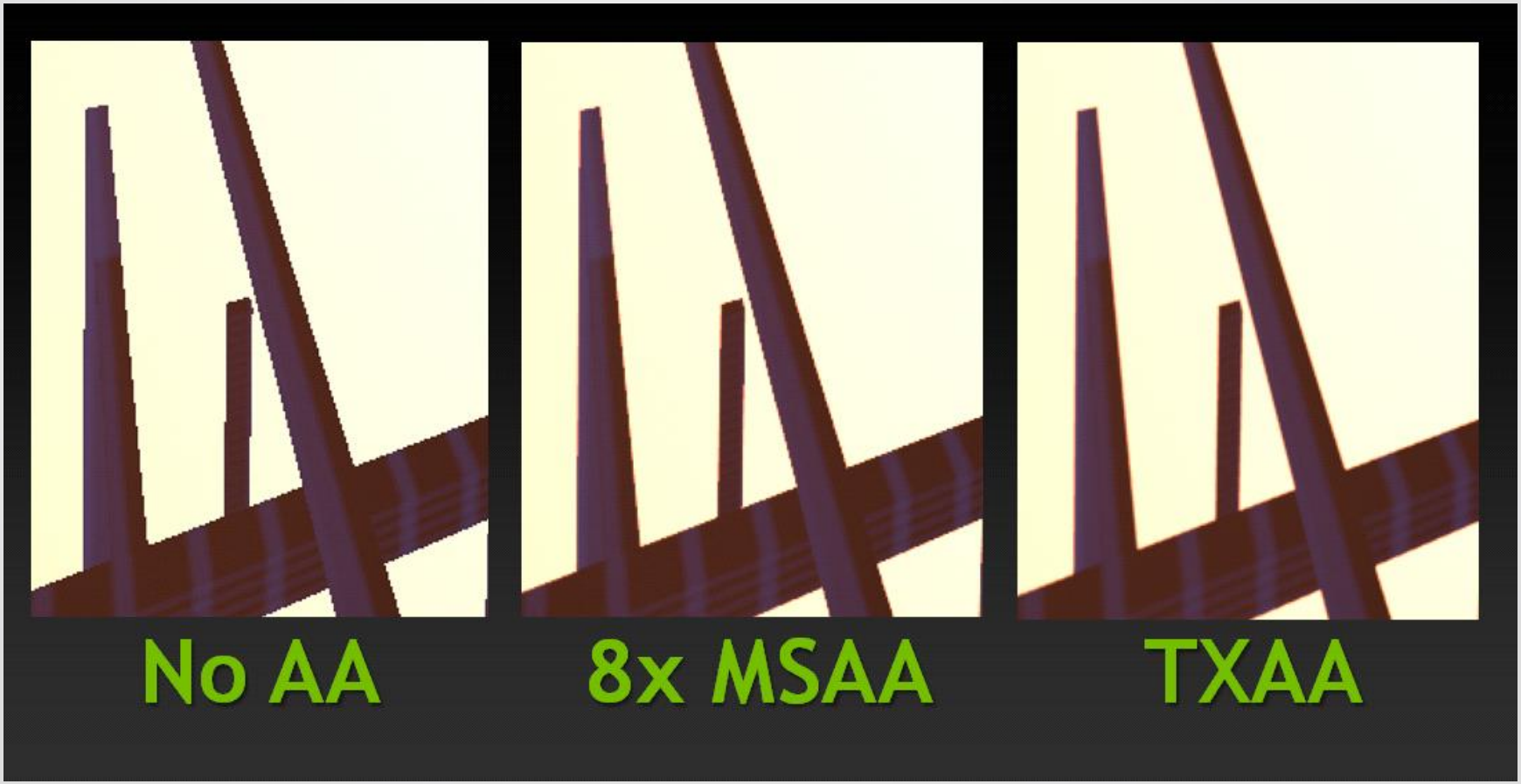
TXAA 3.0



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What is TXAA

- Temporal AA mixed with MSAA
- Replaces MSAA Resolve
- Provides higher quality resolve filter
  - Better than the default MSAA box filter

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What's new TXAA 3.0

- More user controls
  - Control of the reconstruction filter that's used
  - Per-pixel control of AA application
- Higher AA quality & faster perf
  - Maxwell feature : Programmable sample locations

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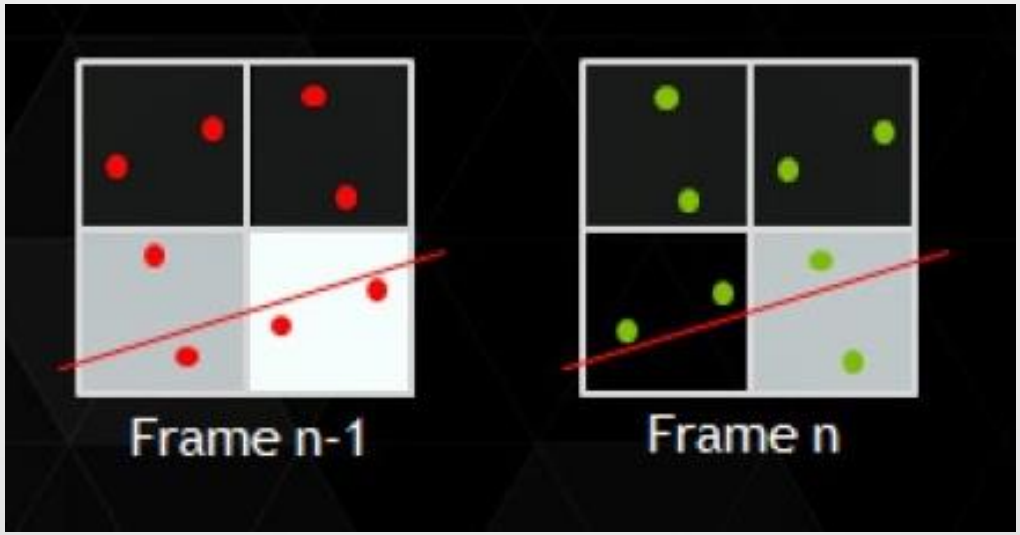
Programmable sample locations

- Sample locations fully programmable



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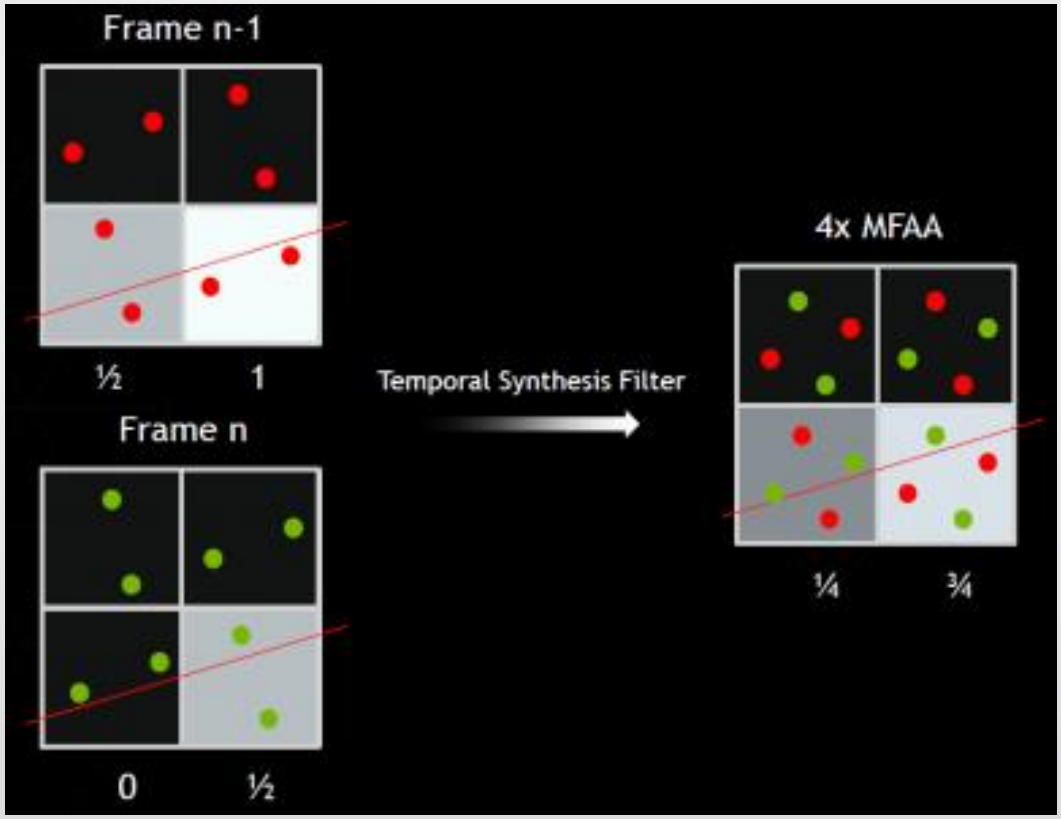
Programmable sample locations

- High-level MSAA quality at low-level MSAA cost



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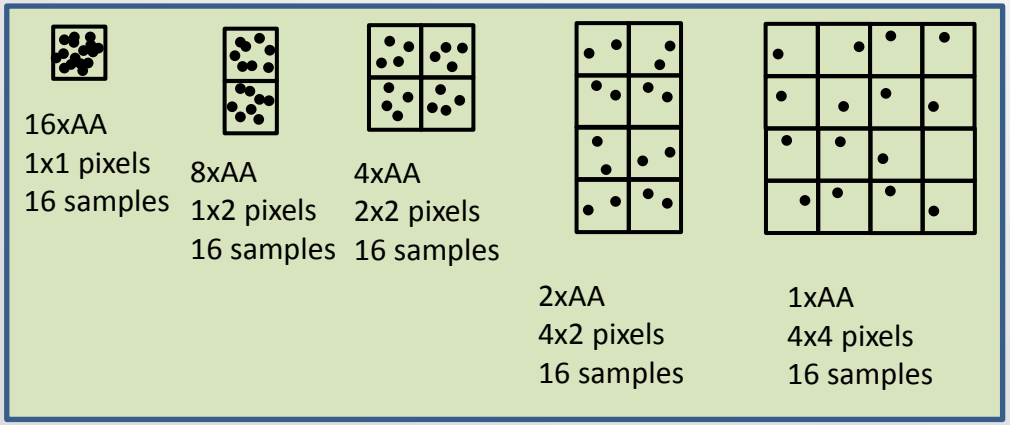
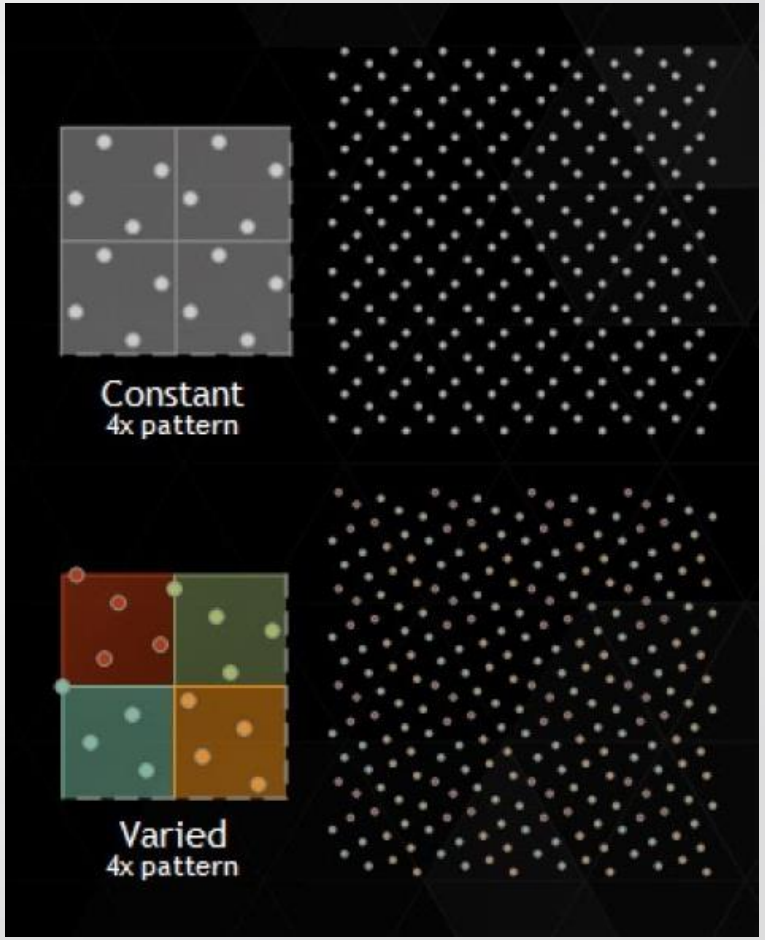
Programmable sample locations

- Interleaved sample positions
  - 16x sample locations can be tiled to a set of pixels
  - Higher AA quality





AA Off

4xMSAA

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TXAA 3.0
(4xTXAA+PSL)

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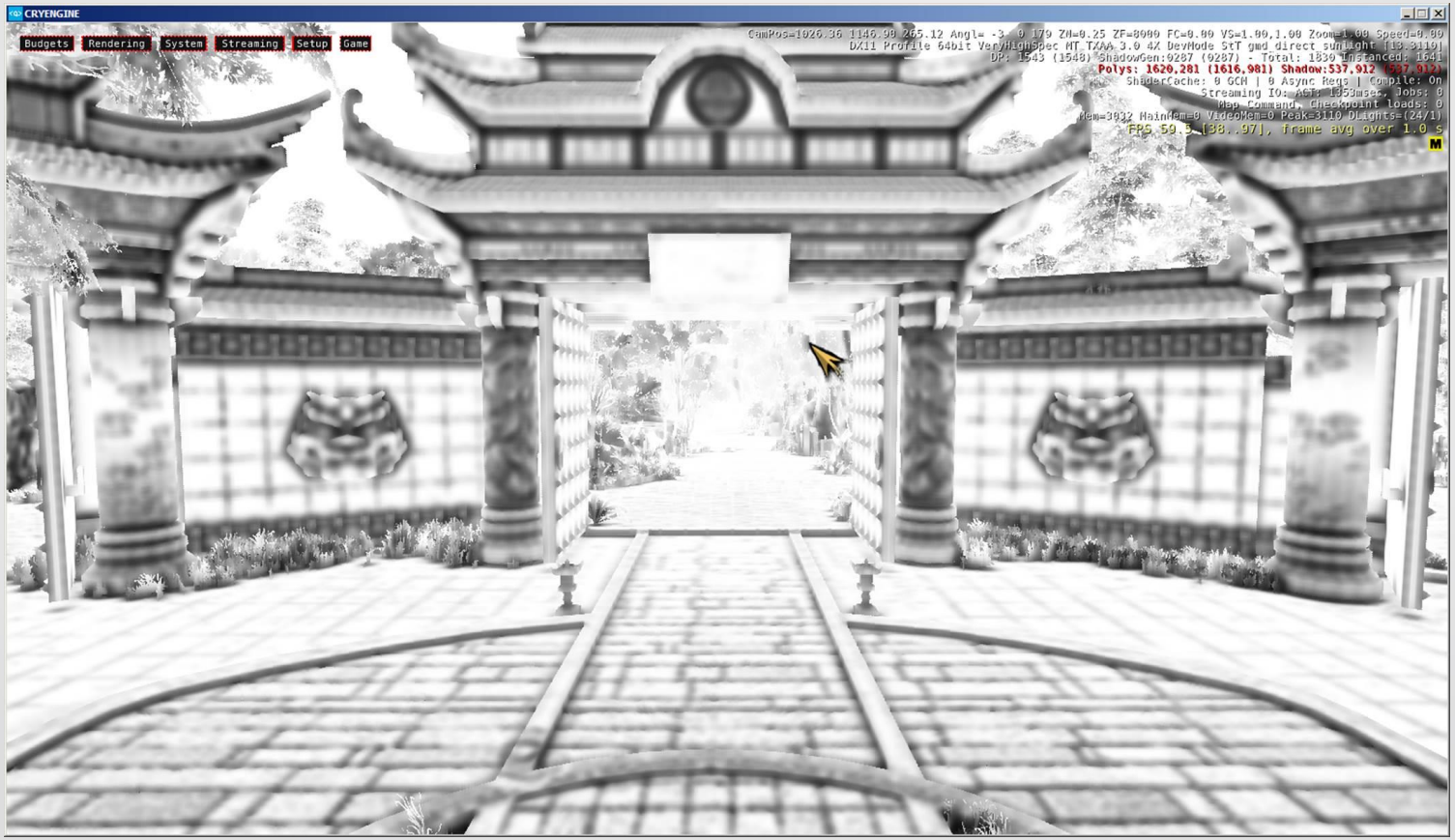
HBAO+



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HBAO+ Design Goals

- Look better than the HBAO algorithm
  - HBAO suffers from over-occlusion behind thin objects
- Better efficiency than the HBAO algorithm
  - Minimize the math ops / TEX sample
  - Interleaved rendering, have the highest possible texture cache hit rate
- Full-res SSAO, not half-res
  - Rendering SSAO in half-res tends to cause bad flickering on thin geometry (e.g. alpha-tested surfaces)
- Easy to integrate

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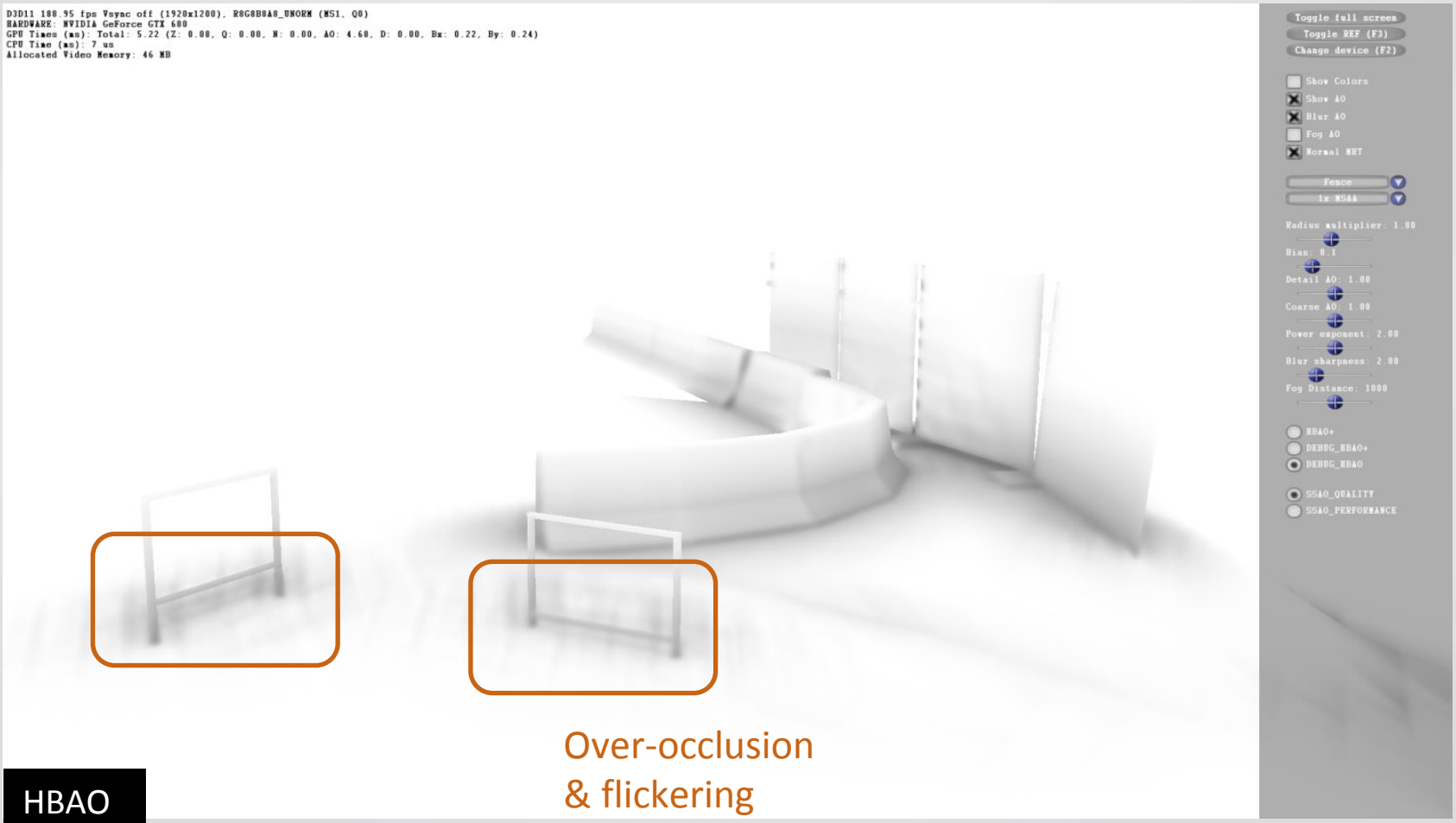
HBAO



Over-occlusion
& flickering

HBAO

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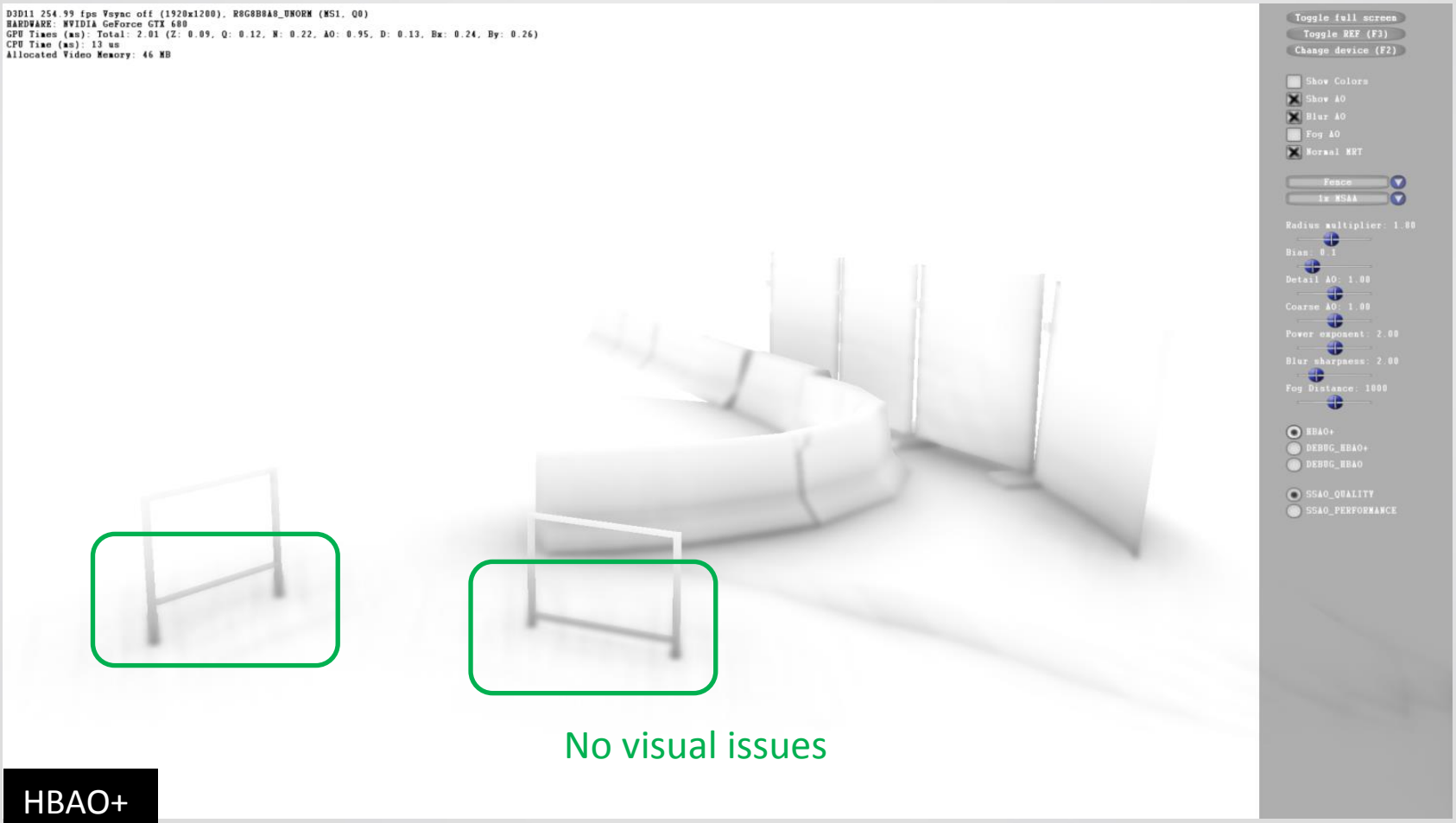
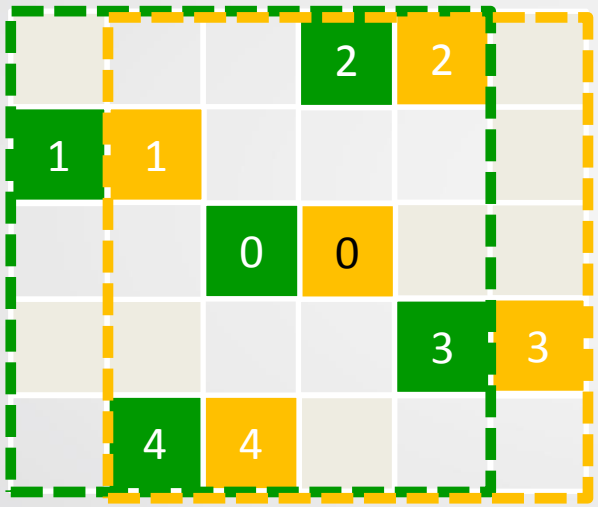
HBAO+


D3D11 254.99 fps Vsync off (1920x1200), R8G8B8A8_UNORM (MS1, Q0)
HARDWARE: NVIDIA GeForce GTX 680
GPU Times (ms): Total: 2.01 (Z: 0.09, Q: 0.12, N: 0.22, AO: 0.95, D: 0.13, Bx: 0.24, By: 0.26)
CPU Time (ms): 13 us
Allocated Video Memory: 46 MB
Toggle full screen
Toggle REF (F3)
Change device (F2)
Show Colors
Show AO
Blur AO
Fog AO
Normal MRT
Fence
1x MSAA
Radius multiplier: 1.80
Bias: 0.1
Detail AO: 1.00
Coarse AO: 1.00
Power exponent: 2.00
Blur sharpness: 2.00
Fog Distance: 1000
HBAO+
DEBUG_HBAO+
DEBUG_HBAO
SSAO_QUALITY
SSAO_PERFORMANCE
No visual issues
HBAO+

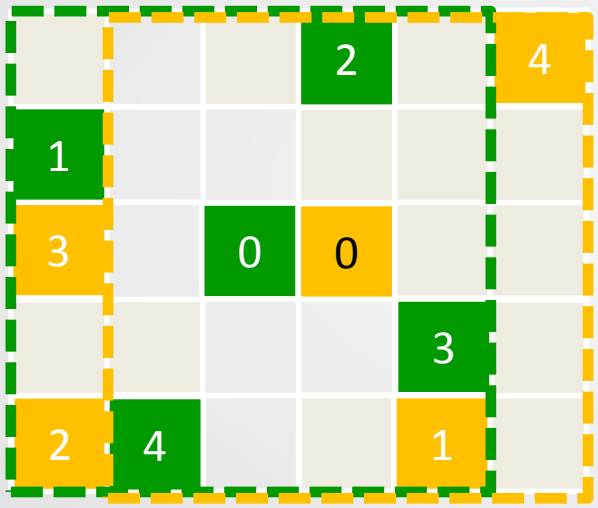
Fixed Sampling Pattern



For each sample,
adjacent pixels fetching
adjacent texels

➔ Good spatial locality ☺

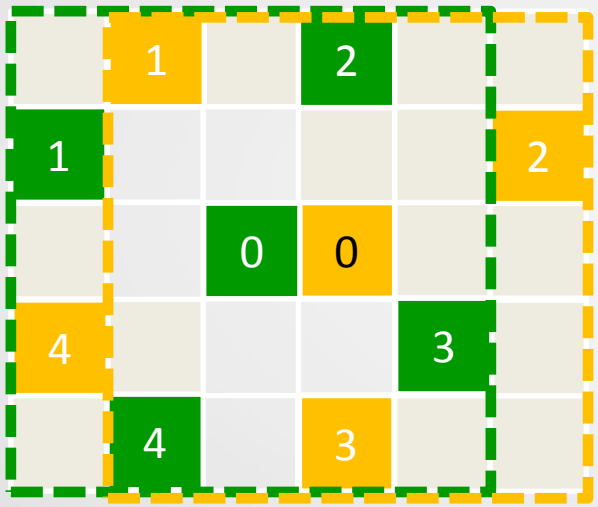
Random Sampling Pattern



For each sample,
adjacent pixels fetching
far-apart texels

➔ Poor spatial locality ☹

Jittered Sampling Pattern



For each sample,
adjacent pixels fetching
sectored texels

➔ Better spatial locality

… but as kernel size increases, sector size increases too ☹

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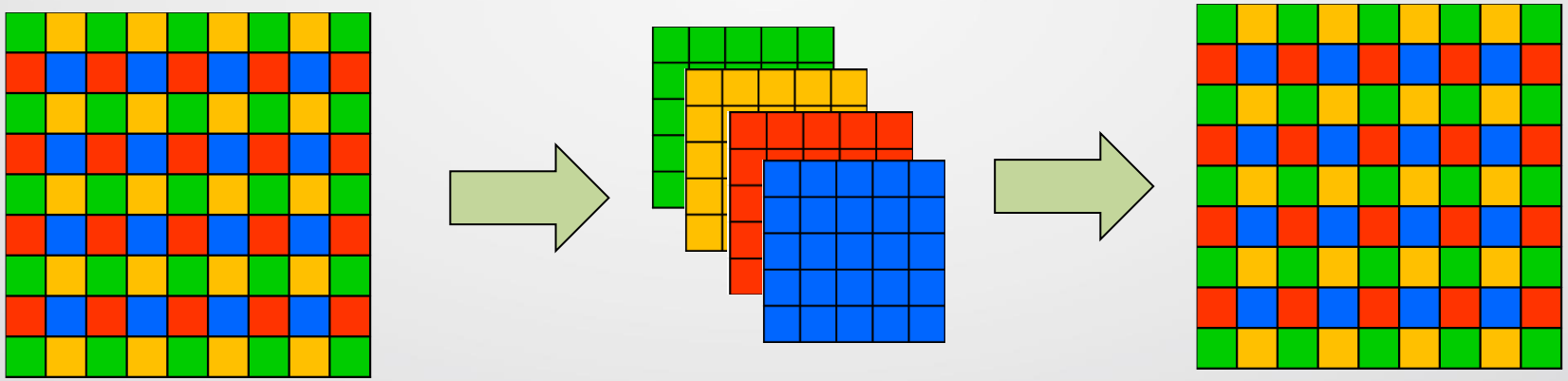
Interleaved Rendering

Render each sampling pattern **separately**,

using **downsampled** input textures



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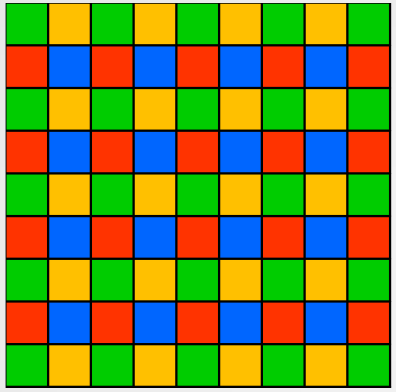
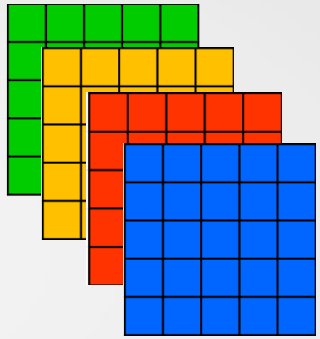
Step1 : Deinterleave Input



Full-Resolution Input Texture

Width = W
Height = H

1 Draw call with 4xMRTs



Half-Resolution 2D Texture Array

Width = iDivUp(W,2)
Height = iDivUp(H,2)

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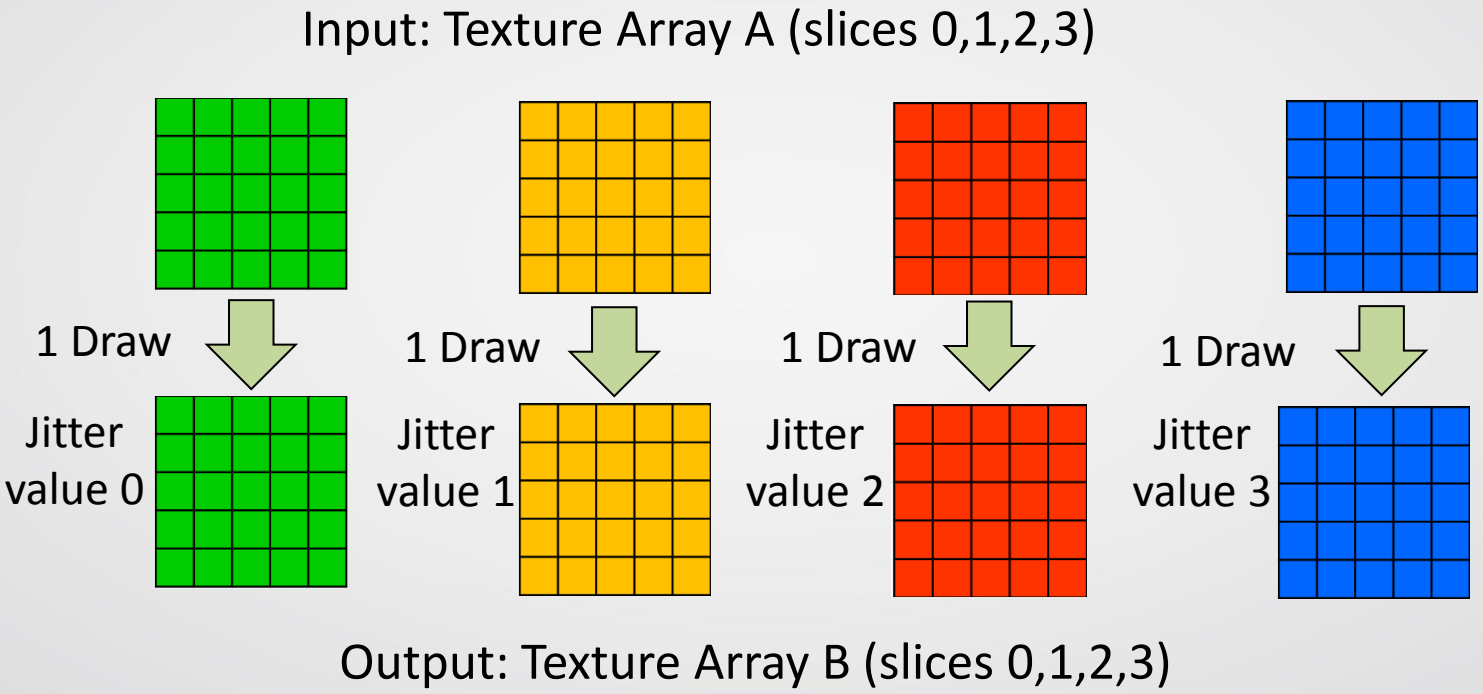
Step2 : Jitter-Free Sampling



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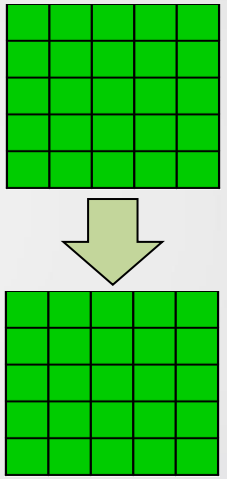
Step2 : Jitter-Free Sampling

1. Constant jitter value per draw call
   ➔ better per-sample locality

2. Low-res input texture per draw call
   ➔ less memory bandwidth needed



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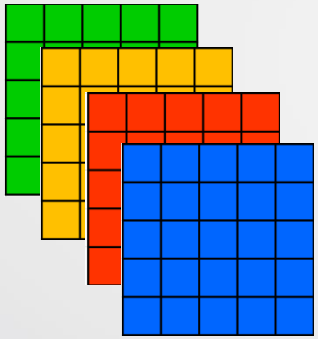
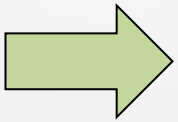
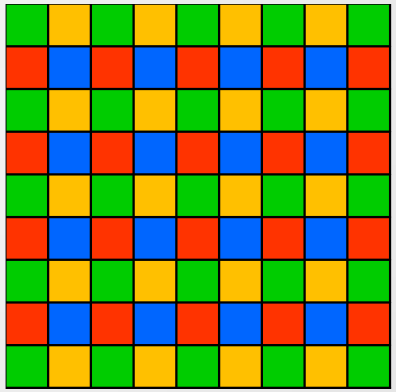
Step3 : Interleave Results



1 Draw call



With 1 Tex2DArray
fetch per pixel



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4x4 Interleaving

4x4 jitter textures are commonly used for jittering large sparse filters

Can use a 4x4 interleaving pipeline

1. **Deinterleaving:** 2 Draw calls with 8xMRTs
2. **Sampling:** 16 Draw calls
3. **Interleaving:** 1 Draw call

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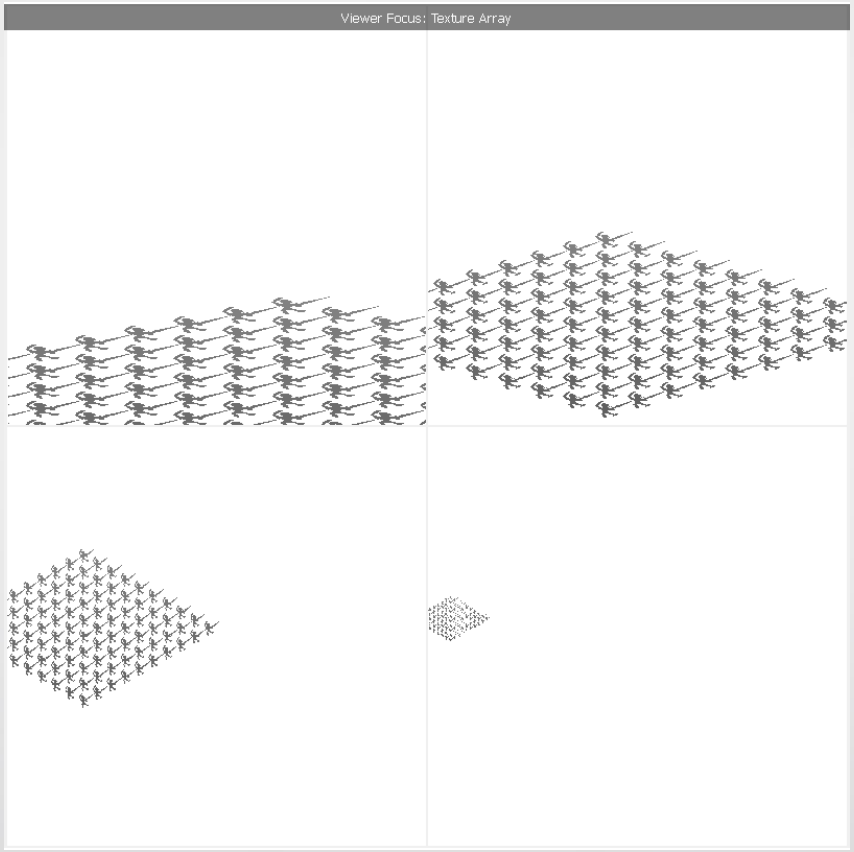
Multi-Projection Acceleration



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Fast GS vs Regular GS

- Fast GS is a special kind of geometry shader
- Fast GS can not "create" new primitives
- Fast GS saves the cost of the geometry expansion

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Fast Viewport Multi-casting

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Use Cases

- Where we only use the geometry shader stage to set per-primitive attributes, instead of changing the primitive topology itself.
- Cube-Map rendering
- Voxelization
- Multi-resolution rendering (for VR)
- Cascaded Shadow Maps

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Implementing CSM with Fast GS

- Generate all of the shadow maps in a single rendering pass, save CPU overhead
- Render the shadow maps with a coarsest view frustum which contains all the frustums of each LOD, setting different view ports for different LOD

LOD=2

LOD=1

LOD=0

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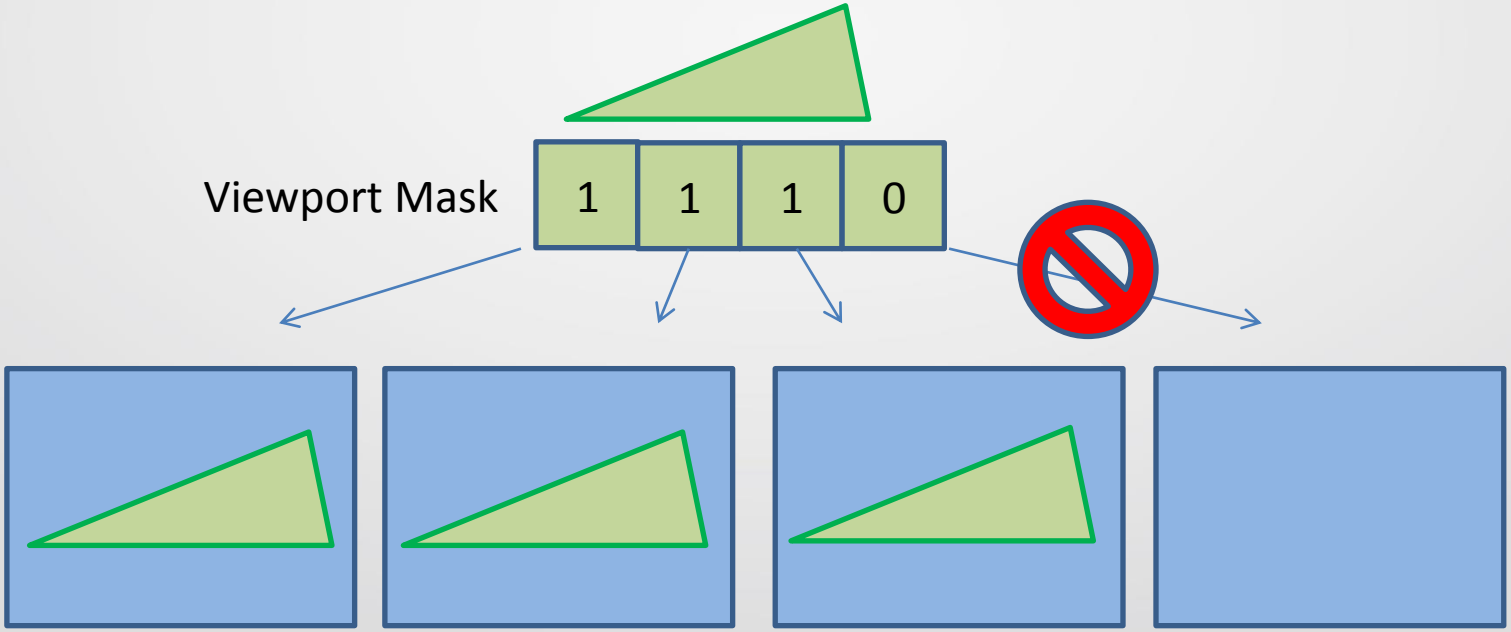
Implementing CSM with Fast GS

- Do view frustum culling in the GS
  - Cast the primitives to desired viewports by setting bits in the viewport mask
  - Primitive is killed if viewport mask equals 0



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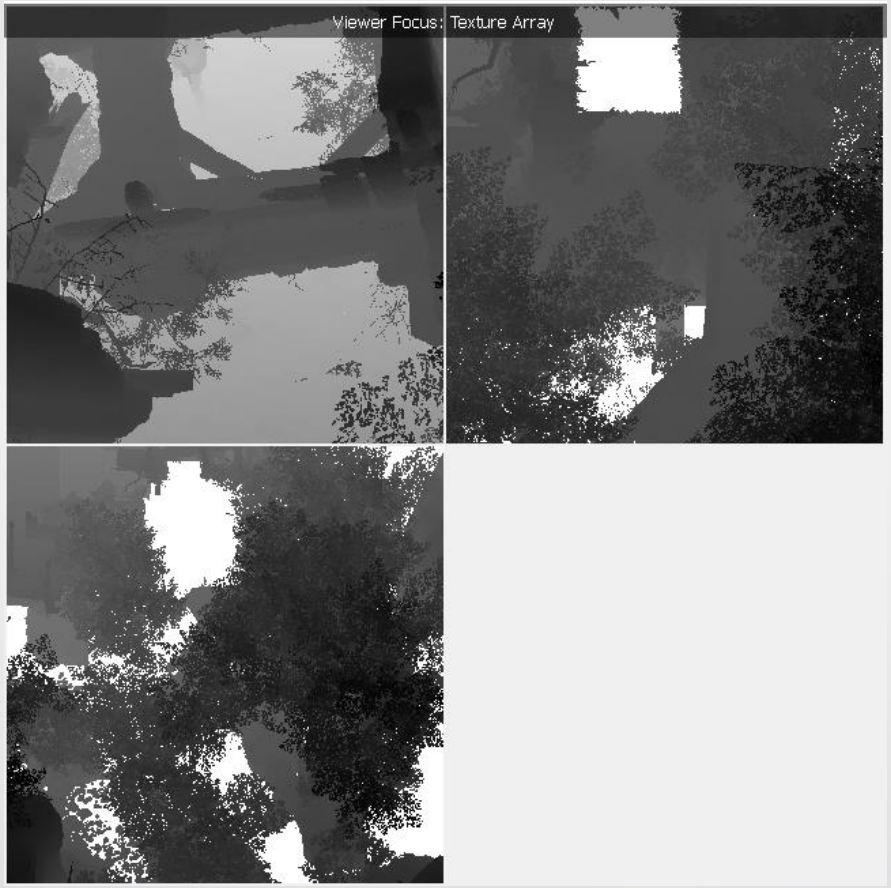
Implementing CSM with Fast GS



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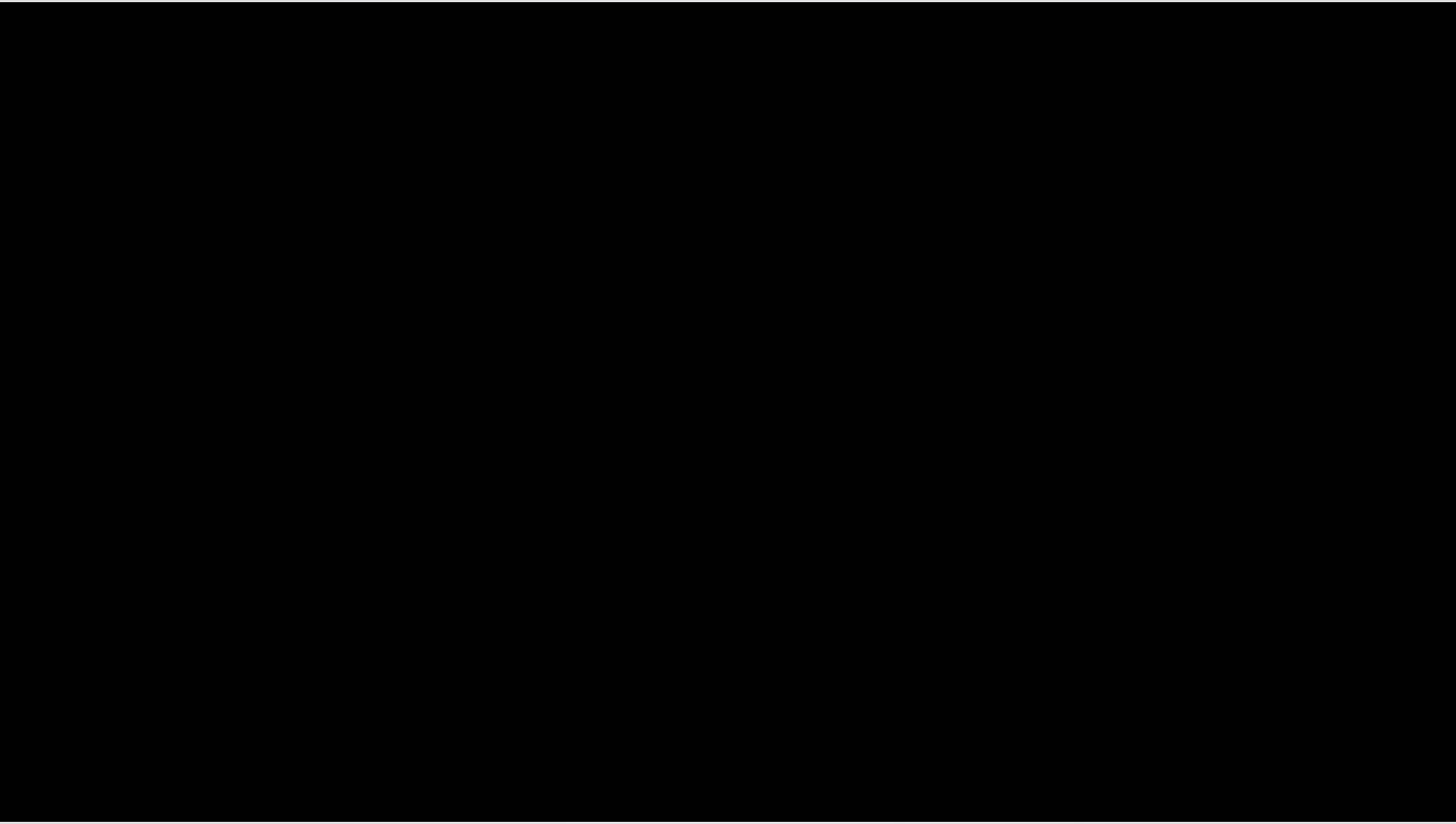
HairWorks & Clothing



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Summary

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Summary

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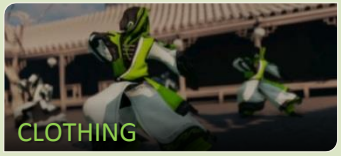
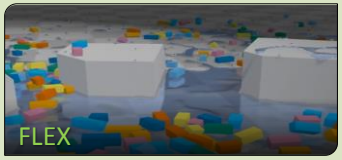
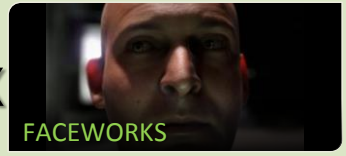
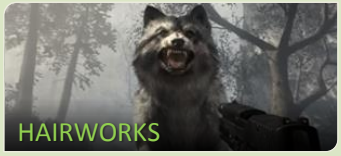
PhysX

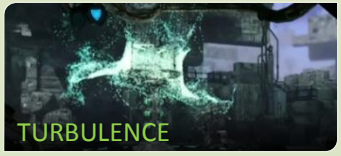


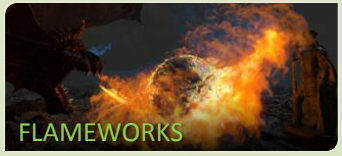


VisualFX

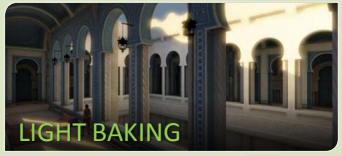








OptiX



Samples

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Summary

- NVIDIA GameWorks
  - SDKs of efficient high-quality graphics & physics effects
  - Samples, documentation & tutorials
  - Developer tools
  - Making game developing easier

  https://developer.nvidia.com/gameworks

- New GPU hardware features
  - More optimization approaches available
  - More new algrithomns

Thank you !

Questions?

youngy@nvidia.com


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CHINA GAME DEVELOPERS CONFERENCE


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