



TRESSFX 3.X 

PART OF THE GPUOPEN INITIATIVE
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HIGH-LEVEL CONTENTS

- ▲ Brief TressFX overview
- ▲ TressFX 3.x library
 - Update to AMD's TressFX example implementation
 - Maya plugin
 - Viewer and runtime library (with full source)
 - Fur support
 - Skinning
 - Future optimizations
 - New memory-friendly OIT method (ShortCut)



A BRIEF HISTORY

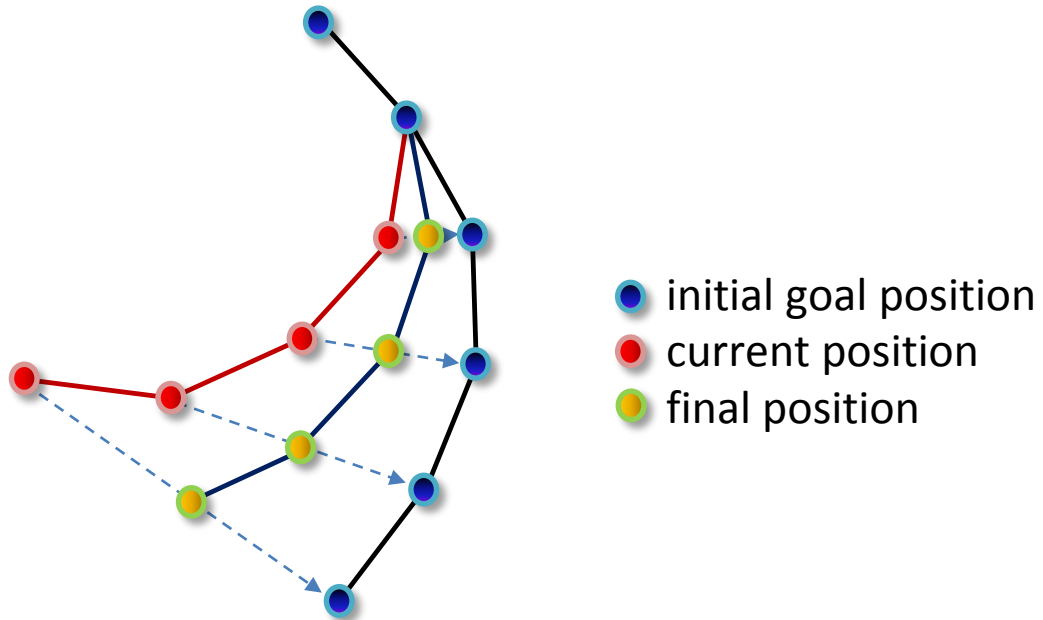
- ▲ TressFX began as a collaboration between AMD and Crystal Dynamics
- ▲ First used in Tomb Raider
 - PC and consoles
 - Set new quality bar for hair in games
- ▲ Optimized for AMD GCN architecture
 - Radeon HD 7000 or later
 - Consoles
- ▲ AMD is now also collaborating with Eidos-Montréal
 - Started with Tomb Raider code
 - Improvements and additions integrated into Dawn Engine™
 - Will be used in future Deus Ex Universe projects

**CRYSTAL
DYNAMICS**
SQUARE ENIX



TRESSFX OVERVIEW

- ▲ Two parts to TressFX
 - Physics simulation on the GPU using compute shaders
 - High-quality rendering
- ▲ Simulates and renders individual hair strands

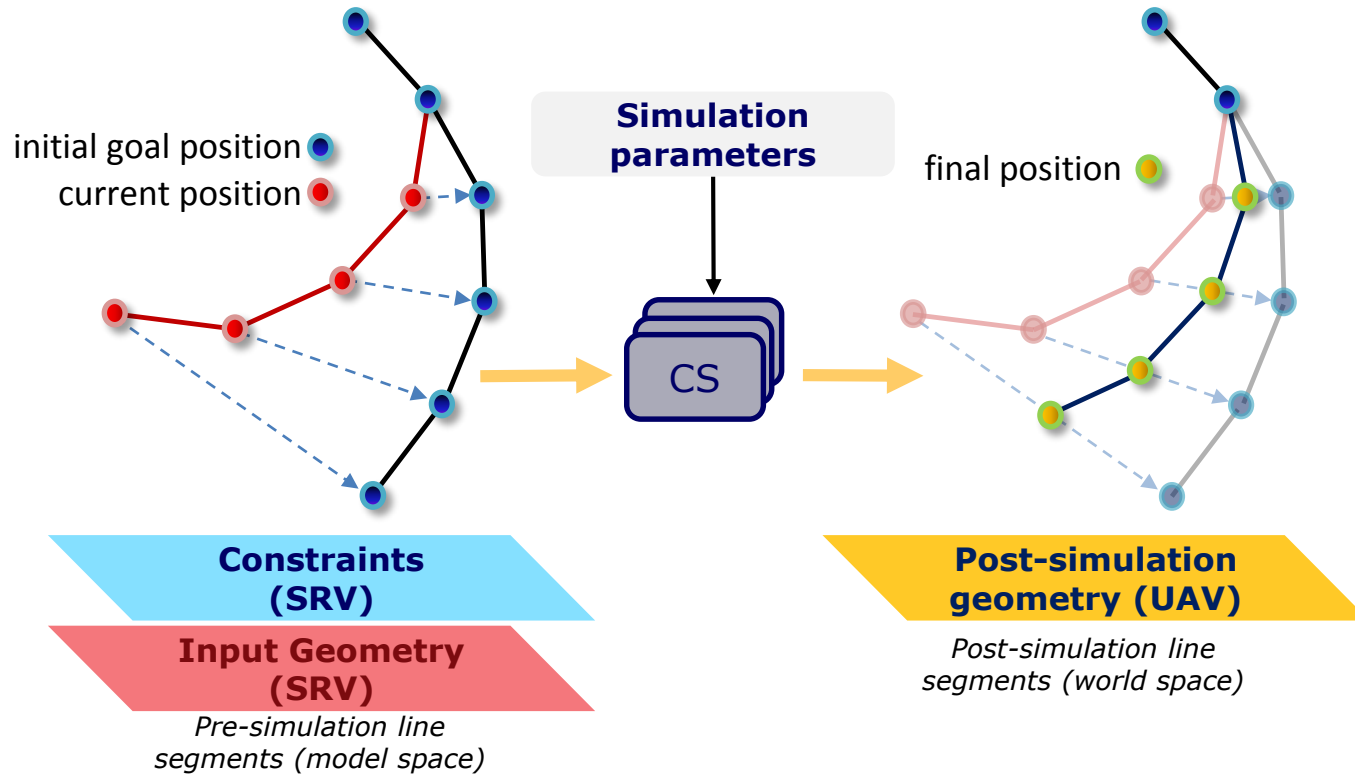


SIMULATION



RENDERING

TRESSFX SIMULATION



- ▲ **SIMULATION COMPUTE SHADERS**
- Edge length constraint
 - Local shape constraint
 - Global shape constraint
 - Model Transform
 - Collision Shape
 - External Forces (wind, gravity, etc.)



Good Lighting + Anti-Aliasing

+ Volume Shadows

+ Transparency



TRESSFX 3.X LIBRARY

TRESSFX SAMPLE HISTORY

▲ TressFX 1.0

- Example implementation (with full source)

▲ TressFX 2.x

- Simulation performance improvements
 - Master and slave strands
 - Compute shader optimizations
 - 1.6 ms → 0.3 ms
- Rendering performance improvements
 - Deferred rendering
 - Distance adaptive LOD
 - Pixel shader optimizations
 - 1.7 ms → 1.2 ms
 - With LOD, 0.3 ms (or lower) at a distance



TRESSFX 3.X

▲ TressFX 3.0

- Maya plugin
 - with full source
- Viewer and runtime library
 - with full source
- Fur support
- Skinning
- Free

▲ TressFX 3.1

- New ShortCut OIT method
 - Lower memory
 - Potentially better performance
 - But at slightly reduced quality vs. standard PPLL TressFX



TRESSFX 3.X VIEWER AND RUNTIME LIBRARY

- ▲ Viewer provided
 - Preview TressFX assets
- ▲ Runtime reorganized into a library
 - Easier integration
- ▲ Full source
 - Free
 - No black boxes

```

//-----
// RenderHair
//
// Renders the hair in two passes. The first pass fills an A-buffer by rendering the
// hair geometry into a per-pixel linked list which keeps all of the overlapping fragments.
// The second pass renders a full screen quad (using a stencil mask set in the first pass
// to avoid unnecessary pixels) which reads fragments from the per-pixel linked list
// and blends the nearest k fragments (K-buffer) in back to front order.
//-----
void TressFXRender::RenderHair(ID3D11DeviceContext* pd3dContext)
{
    // Get original render target and depth stencil view
    TIMER_Begin( 0, L"ABufferFill" );
    ID3D11RenderTargetView* pRTV = DXUTGetD3D11RenderTargetView();
    ID3D11DepthStencilView* pDSV = DXUTGetD3D11DepthStencilView();

    // render hair

    const UINT dwClearDataMinusOne[1] = {0xFFFFFFFF};
    pd3dContext->ClearUnorderedAccessViewUint(m_pHeadPPLL_UAV, dwClearDataMinusOne);

    // Clear stencil buffer to mask the rendering area
    // Keep depth buffer for correct depth and early z
    pd3dContext->ClearDepthStencilView(pDSV, D3D10_CLEAR_STENCIL, 1.0, 0);

    ID3D11UnorderedAccessView* pUAV[] = {m_pHeadPPLL_UAV, m_pPPLL_UAV, NULL, NULL, NULL, NULL, NULL};
    UINT pUAVCounters[] = { 0, 0, 0, 0, 0, 0, 0 };
    pd3dContext->OMSetRenderTargetsAndUnorderedAccessViews(1, &pRTV, pDSV, 1, 7, pUAV, pUAVCounters);

    // disable color write if there is no need for fragments counting
    pd3dContext->OMSetBlendState(m_pColorWritesOff, 0, 0xffffffff);

    // Enable depth test to use early z, disable depth write to make sure required layers won't be clipped out in early z
    pd3dContext->OMSetDepthStencilState(m_pDepthTestEnabledNoDepthWritesStencilWriteIncrementDSS, 0x00);

    // Pass 1: A-Buffer pass
    if(m_hairParams.bAntialias)
    {
        if(m_hairParams.strandCopies > 1)
            RenderHairGeometry(pd3dContext, m_pVSRenderHairAAstrandCopies, m_pPSABuffer_Hair, m_hairParams.density, false, m_hairParams.strandCopies);
        else
            RenderHairGeometry(pd3dContext, m_pVSRenderHairAA, m_pPSABuffer_Hair, m_hairParams.density, false, 1);
    }
    else
    {

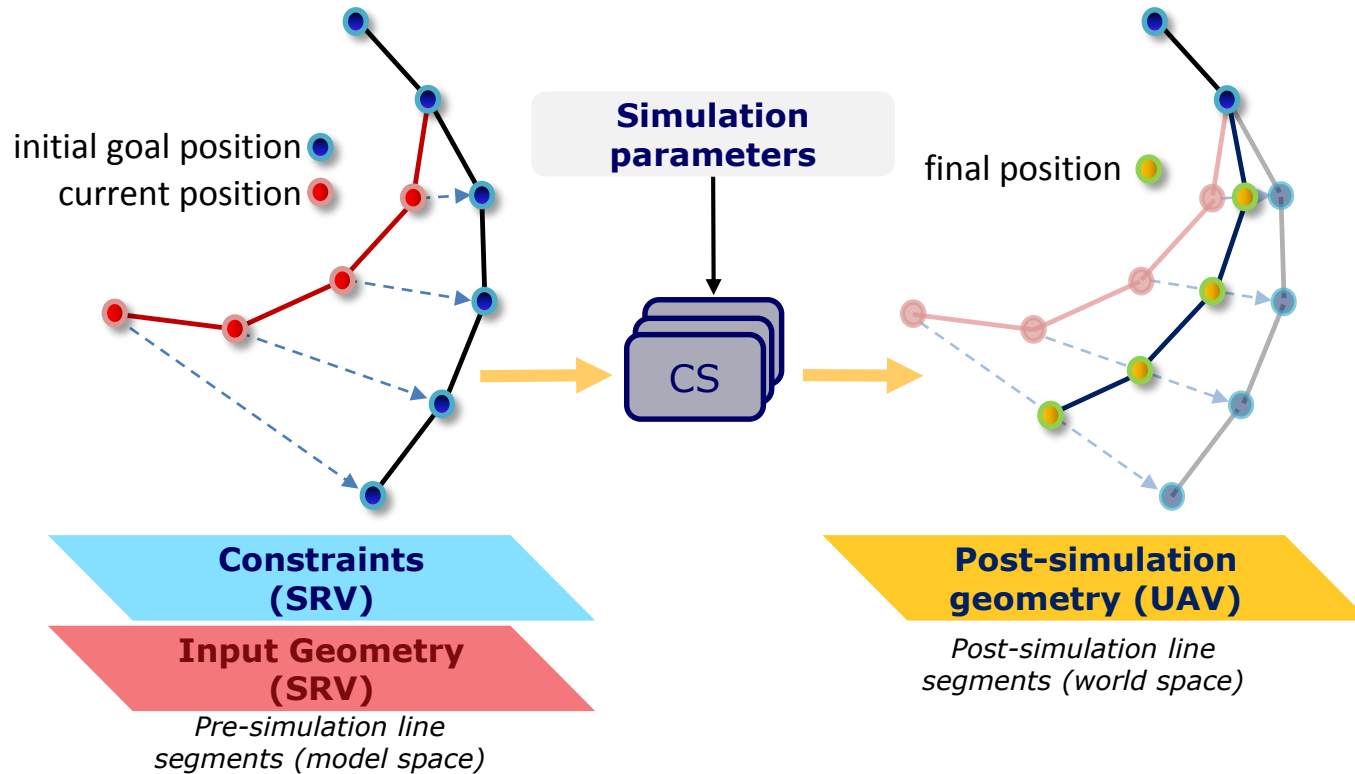
```

TRESSFX 3.X FUR SUPPORT

- ▲ Core principles are the same
 - Simulation on GPU using compute
 - Good lighting
 - Anti-aliasing
 - Volume shadows
 - Transparency
- ▲ Texture coordinates
 - Allows variation in fur color
- ▲ Skinning
 - A simple head transform was enough for human hair
 - Fur requires skinning support

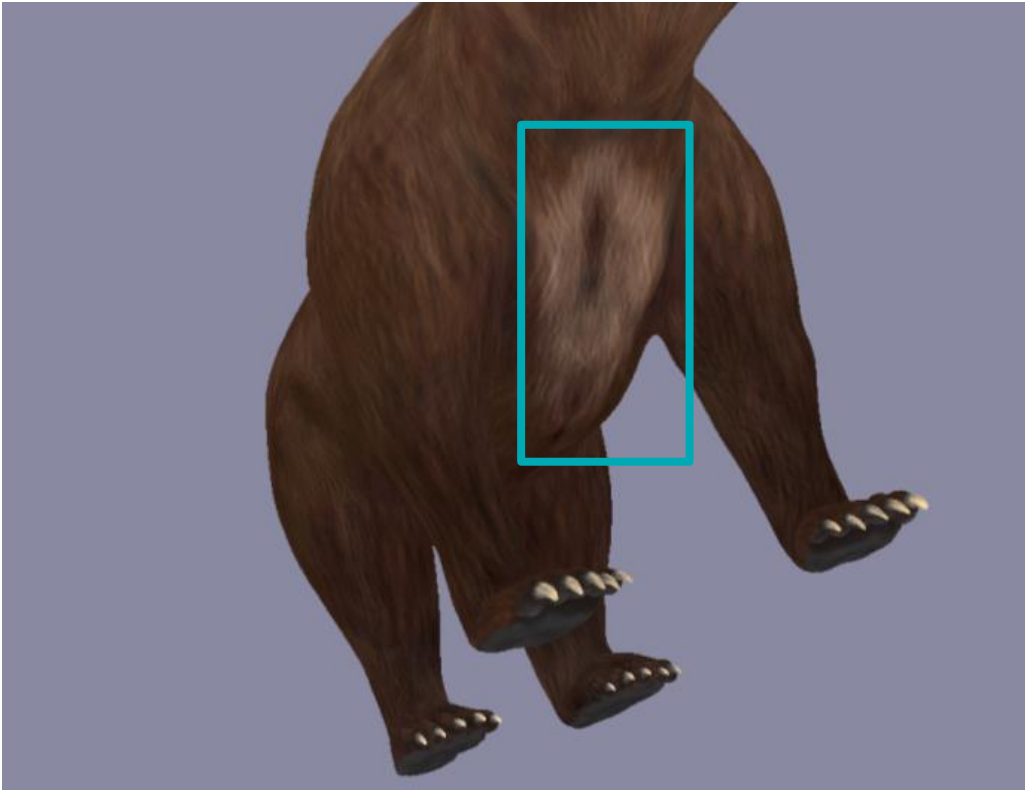


TRESSFX 3.X FUR SIMULATION

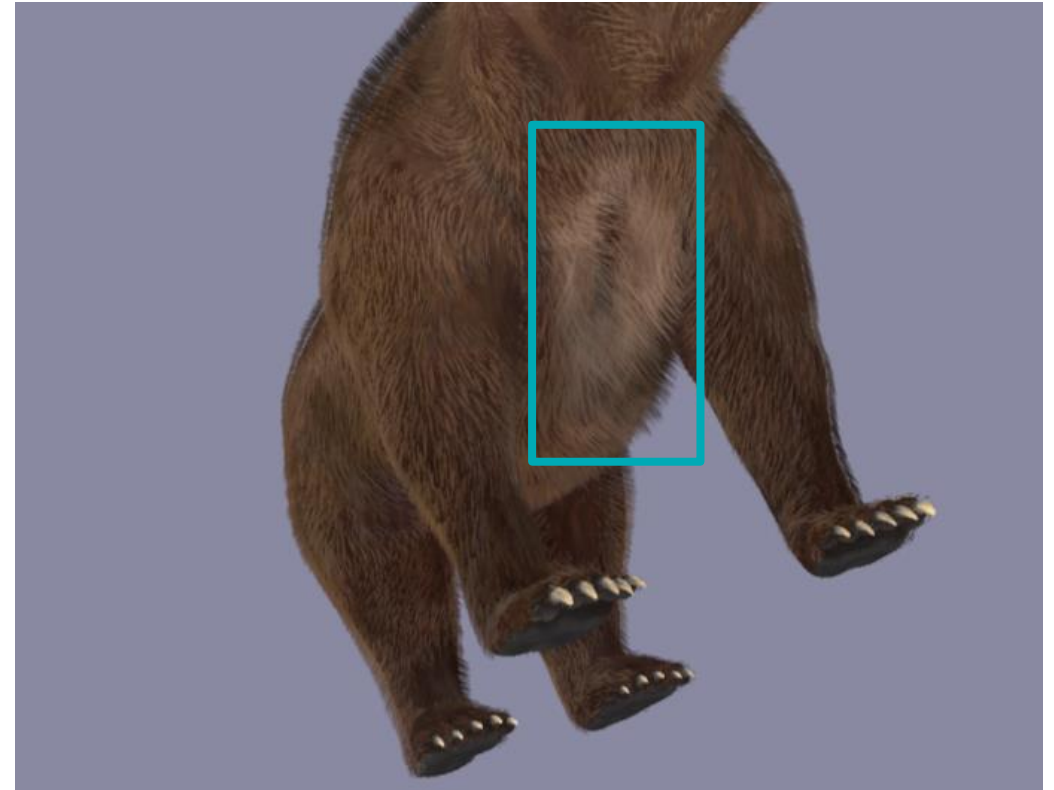


- ▲ SIMULATION COMPUTE SHADERS
- Edge length constraint
 - Local shape constraint
 - Global shape constraint
 - Model Transform
 - Collision Shape
 - External Forces (wind, gravity, etc.)

TRESSFX 3.X TEXTURE COORDINATES

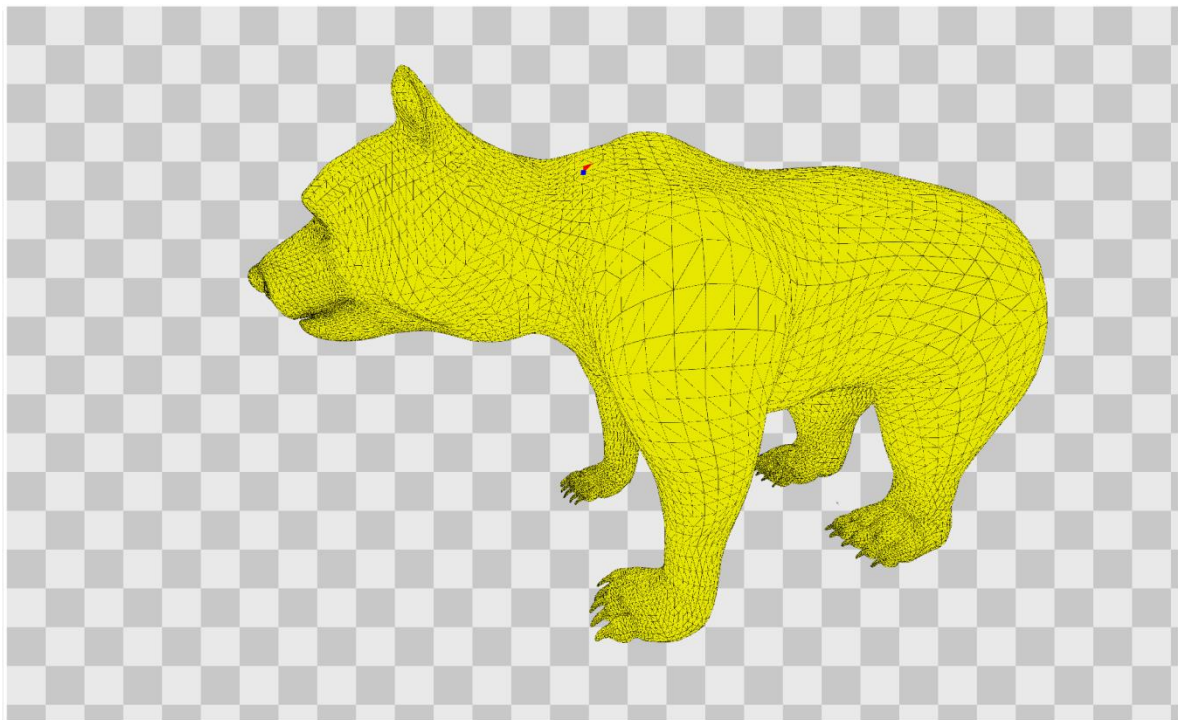


TEXTURED MESH



FUR PICKS UP COLOR VARIATION FROM TEXTURE

TRESSFX 3.X SKINNING



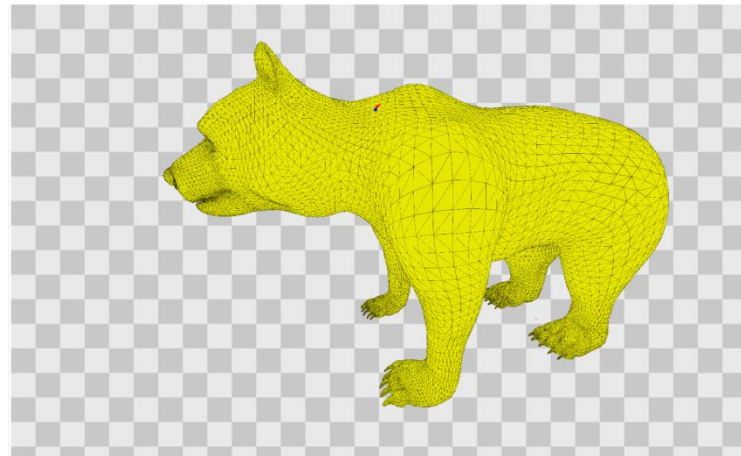
BIND POSE



SKINNED

TRESSFX 3.X SKINNING

- ▲ How to get skinned vertex position data to TressFX library?
- ▲ Up to you
- ▲ TressFX viewer currently uses Stream Out
 - DirectX 11
 - No geometry shader
 - See “Getting Started with the Stream-Output Stage” on MSDN
- ▲ UAVs at vertex shader stage
 - DirectX 11.1
 - DirectX 12

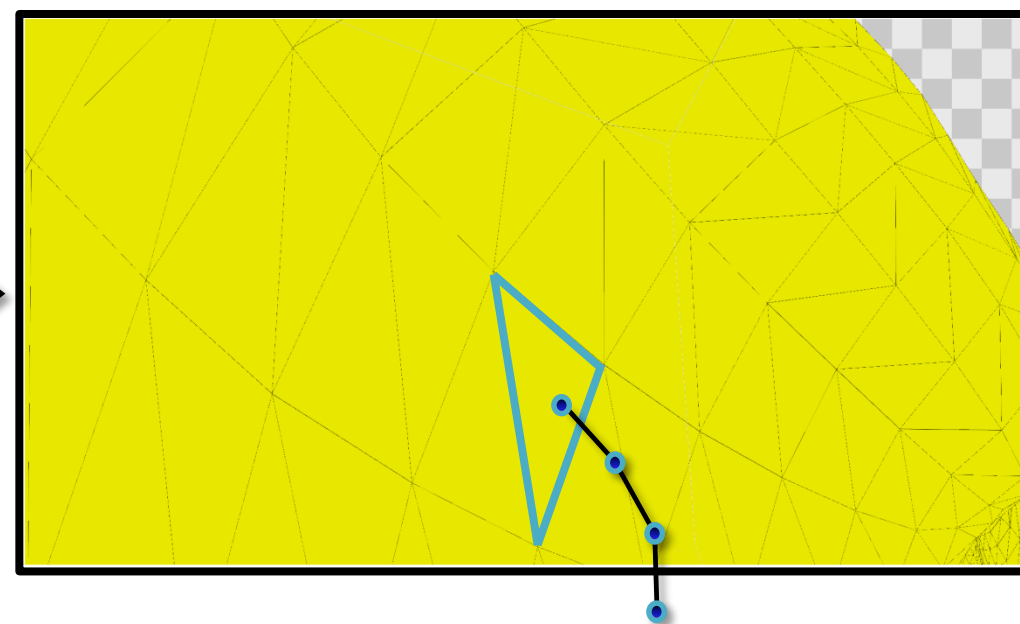
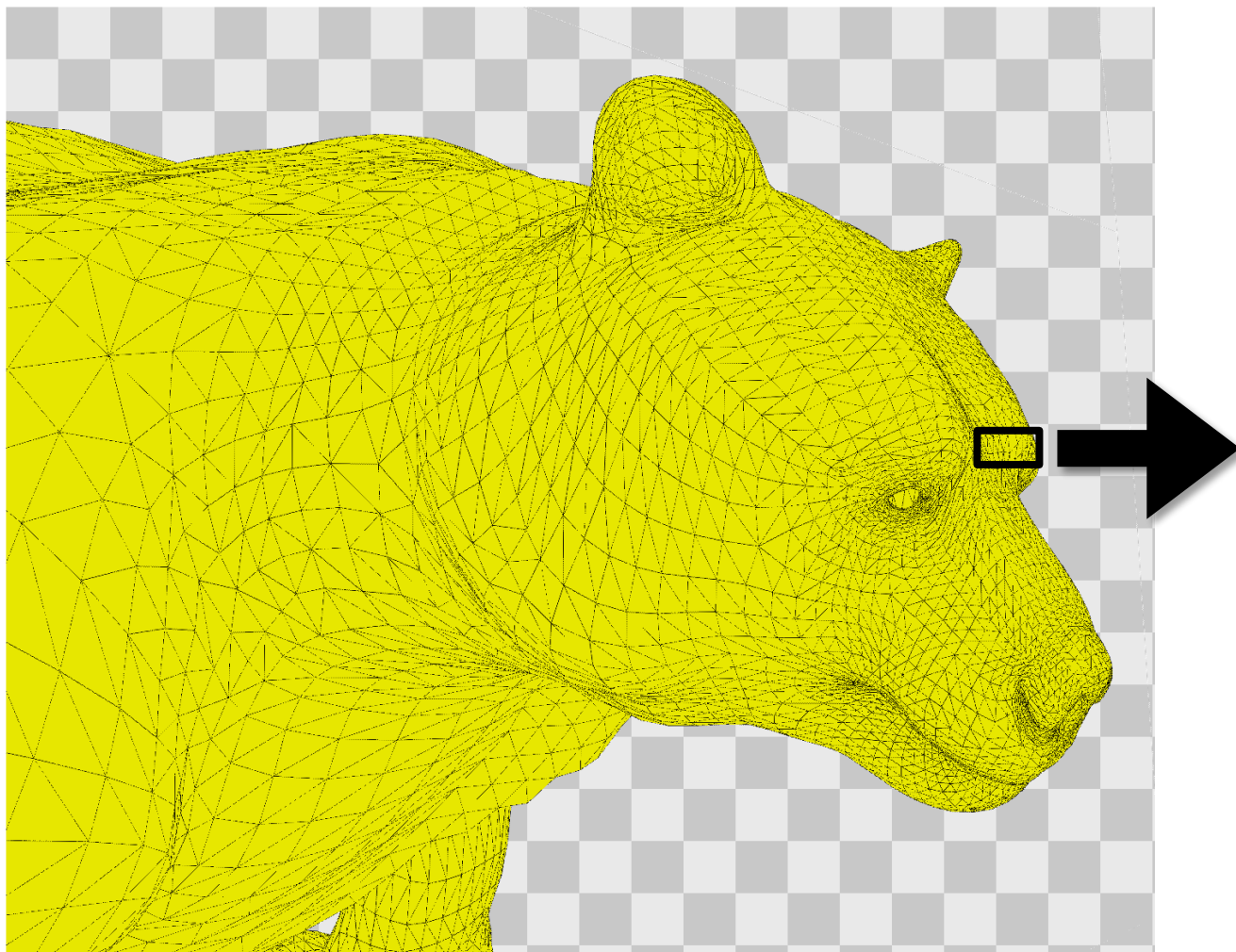


BIND POSE



SKINNED

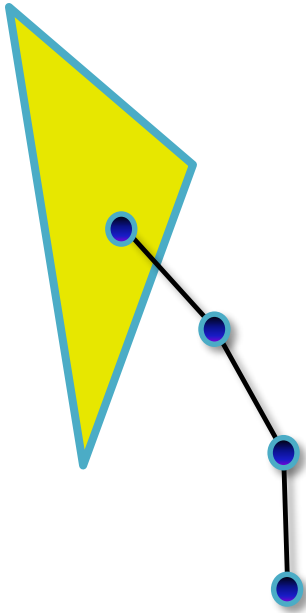
TRESSFX 3.X SKINNING



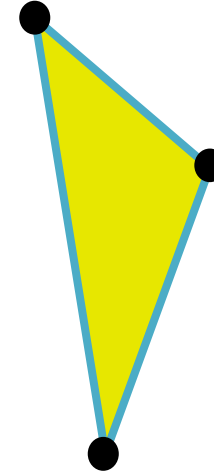
- ▲ Hair-to-mesh mapping
 - Exported from Maya plugin

TRESSFX 3.X SKINNING

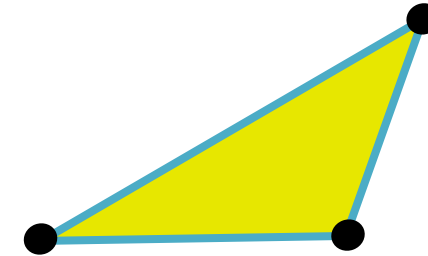
- ▲ Use hair strand index to get triangle index



- ▲ Use triangle index to get bind-pose verts and skinned verts



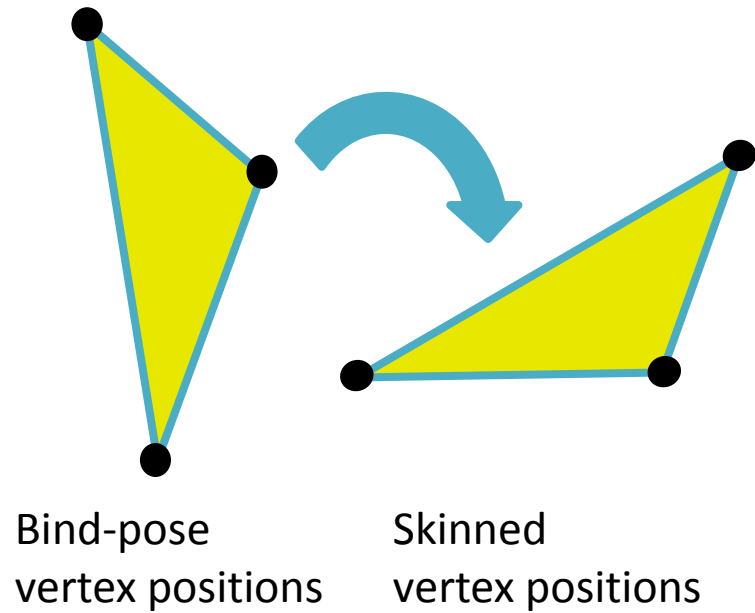
Bind-pose
vertex positions



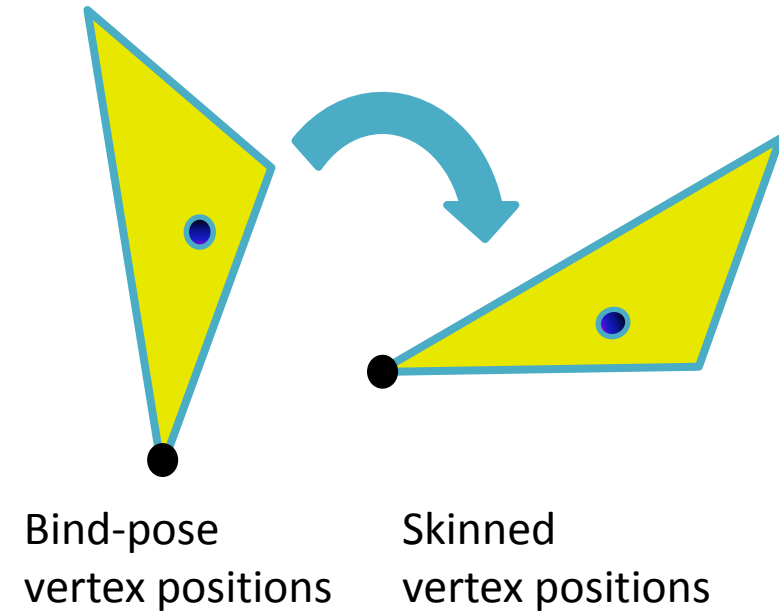
Skinned
vertex positions

TRESSFX 3.X SKINNING

- ▲ Calculate transform from bind-pose to skinned

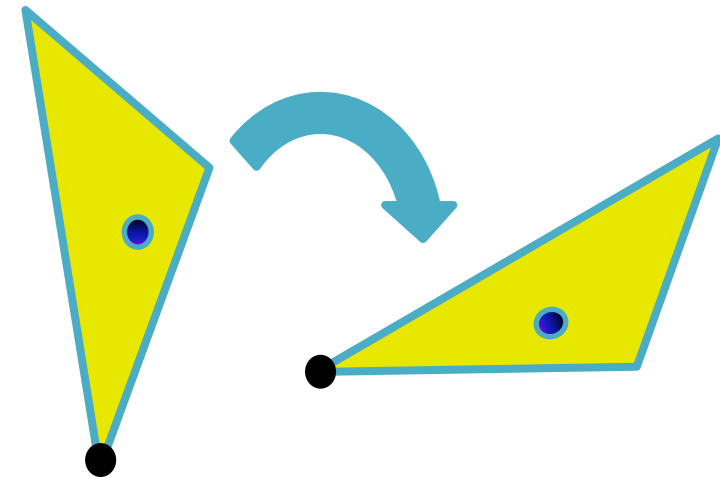


- ▲ Use barycentric coordinates for hair root to calculate final hair transform



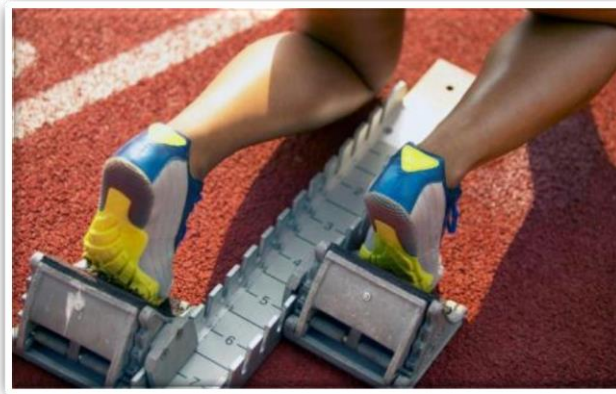
TRESSFX 3.X SKINNING

- ▲ Yeah, okay, but why not just skin the hair directly?
- ▲ This way doesn't impose any requirements on how the game engine does the animation update
 - Morph targets/blend shapes
 - Whatever, we just need the updated vertex positions
- ▲ But may code a fast path for ordinary skinning with max 4 bones



TRESSFX 3.X OPTIMIZATIONS

- ▲ Already in TressFX 2.2
 - Master and slave strands
 - Distance adaptive LOD
 - Deferred rendering
 - Lots of shader optimizations
- ▲ Coming in TressFX 3.x
 - Depth pre-pass
 - Adjust K_{overdraw}
 - More shader optimizations



TRESSFX 3.1 *SHORTCUT* RENDERING

- ▲ A second OIT implementation provided with the 3.1 release
 - Inspired by Eidos-Montréal's GDC 2015 talk
 - Enabled in the sample with the ShortCut checkbox
- ▲ Alpha is computed from all hair fragments, while color is based on shading K front layers
 - Implementation uses $K = 3$ by default
- ▲ Comparison with current PPLL method
 - Has fixed memory requirements proportional to K
 - Relative performance depends on depth complexity
 - Requires an extra geometry and screen pass
 - Potential savings from processing fewer layers
 - Result not quite the same quality as PPLL method



SHORTCUT DETAILS: MEMORY REQUIREMENTS

▲ Resources required

- FragmentDepthsTexture: Screen-sized texture array that stores K FP32 values per pixel for the front layer depth values
- AccumInvAlpha: Screen-sized R16F texture that accumulates total alpha for hair pixels
- FragmentColorsTexture: Screen-sized FP16 RGBA texture containing hair color and alpha sums

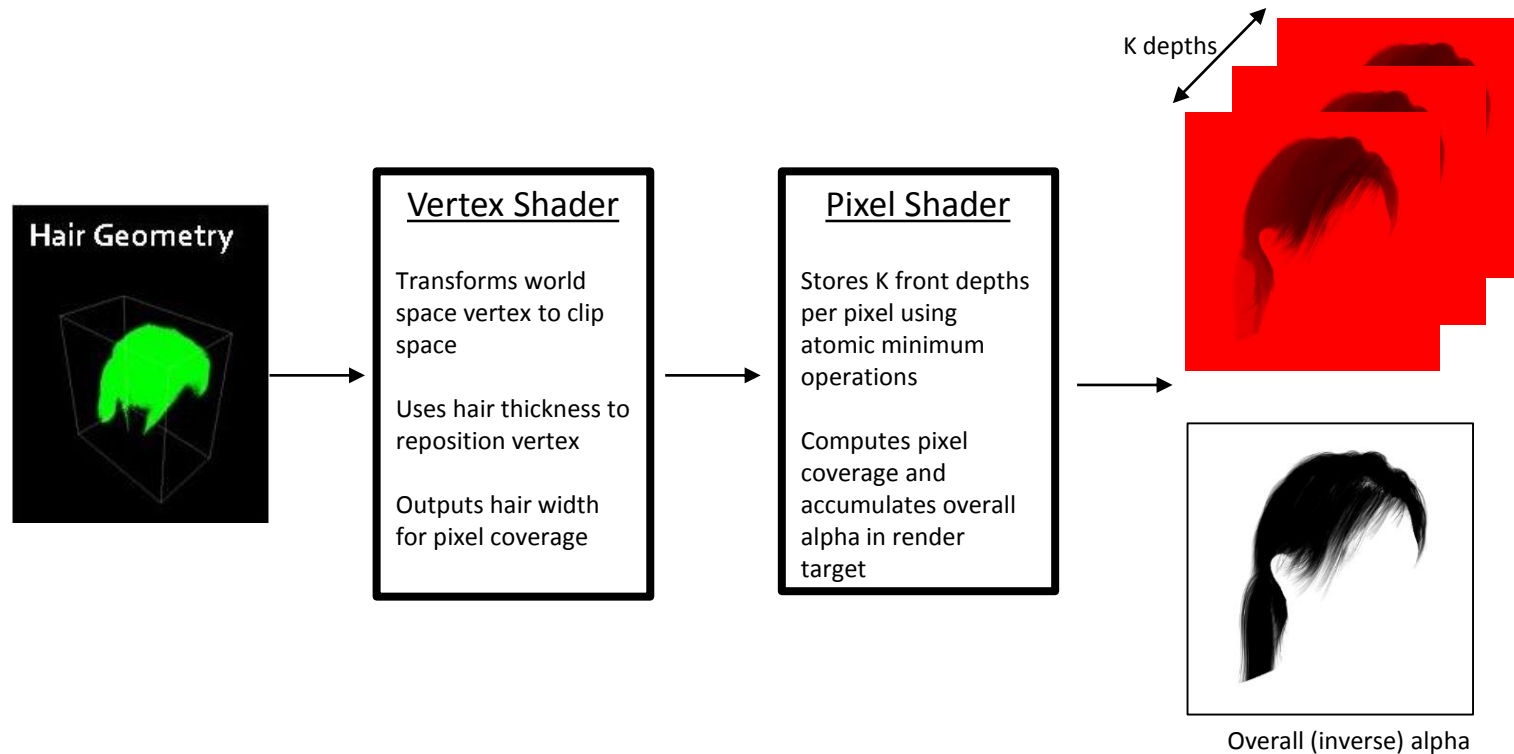
▲ Total added memory cost is width x height x (K x 4 + 10) bytes

- Given K = 3, added memory is 22 bytes per pixel

SHORTCUT DETAILS: RENDER PASSES

▲ First pass: Alpha and K Front Depths

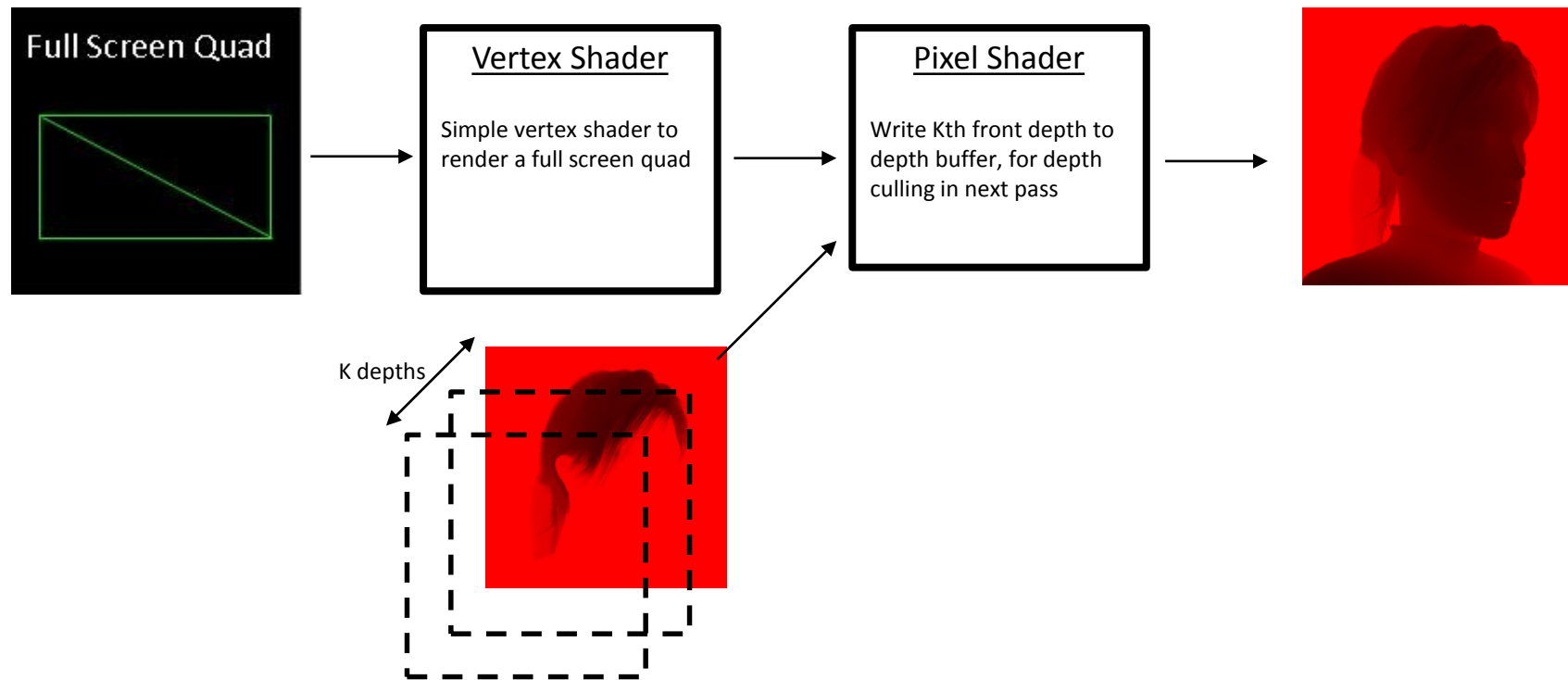
- Render hair geometry to find K front depth values and accumulate overall alpha
 - K minimum depth values found using sequence of InterlockedMin operations
 - Multiplicative blend of $(1 - \alpha)$ into render texture



SHORTCUT DETAILS: RENDER PASSES

▲ Second pass: Write Depth Buffer

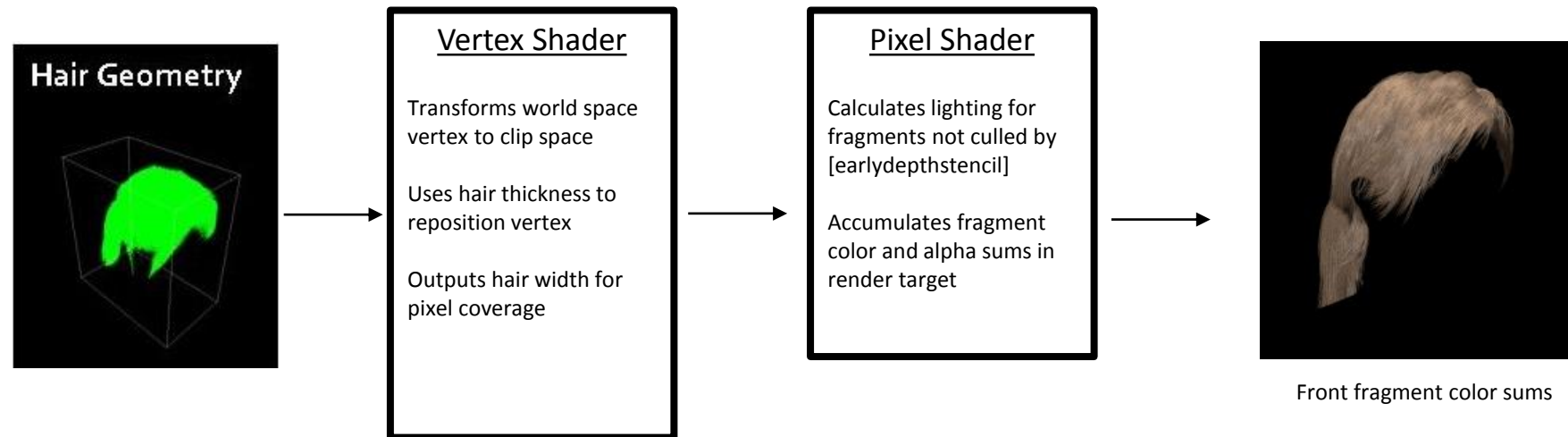
- Render full-screen quad to write Kth depth value into depth buffer for culling in the next pass



SHORTCUT DETAILS: RENDER PASSES

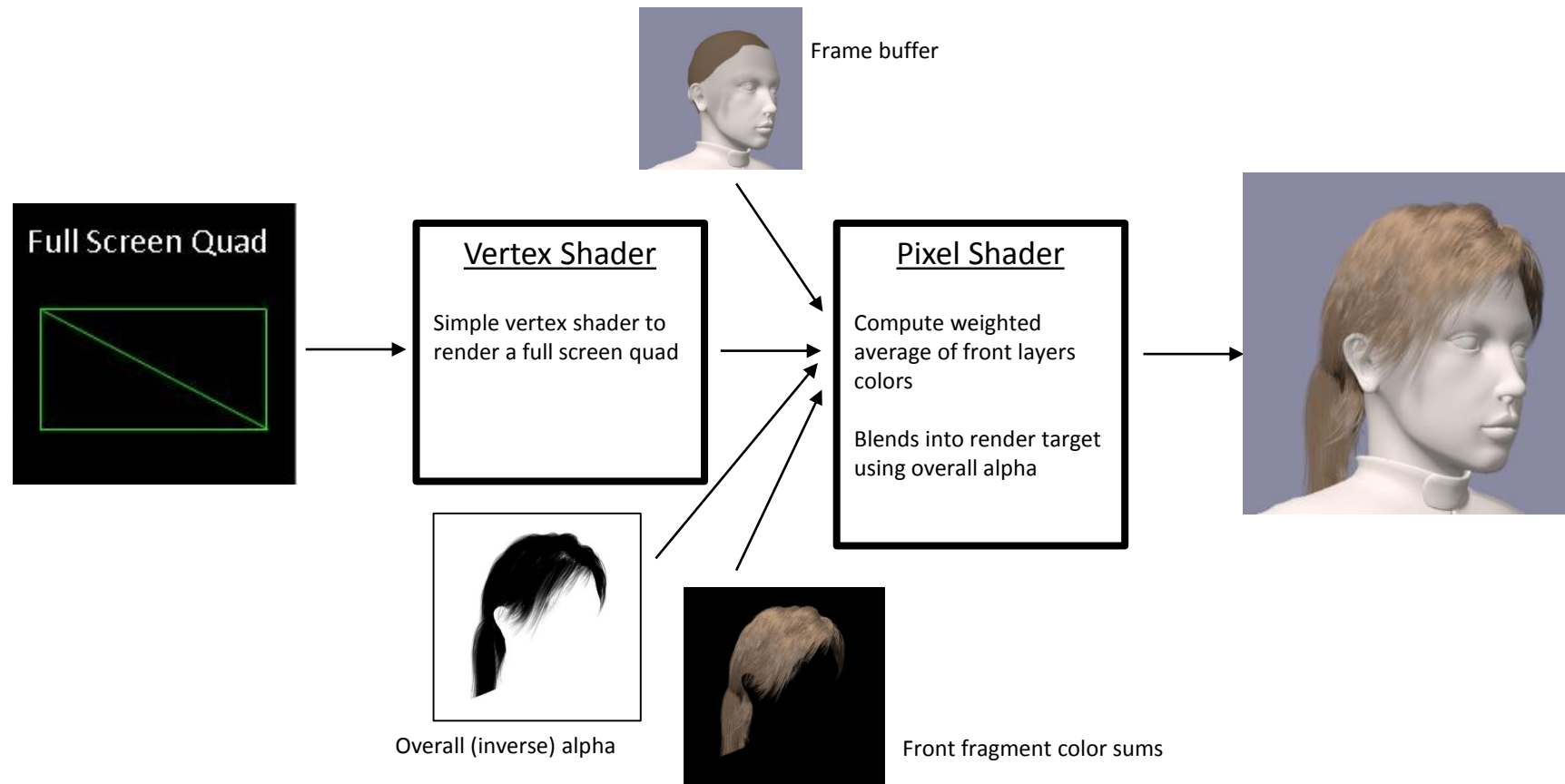
▲ Third pass: Shade Front Fragments

- Render hair geometry and shade fragments
 - Uses [earlydepthstencil] to cull all but front K layers
 - Blends fragment colors to compute weighted average in final pass



SHORTCUT DETAILS: RENDER PASSES

- ▲ Fourth pass: Blend with Frame Buffer
 - Render full-screen quad to composite hair into scene



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