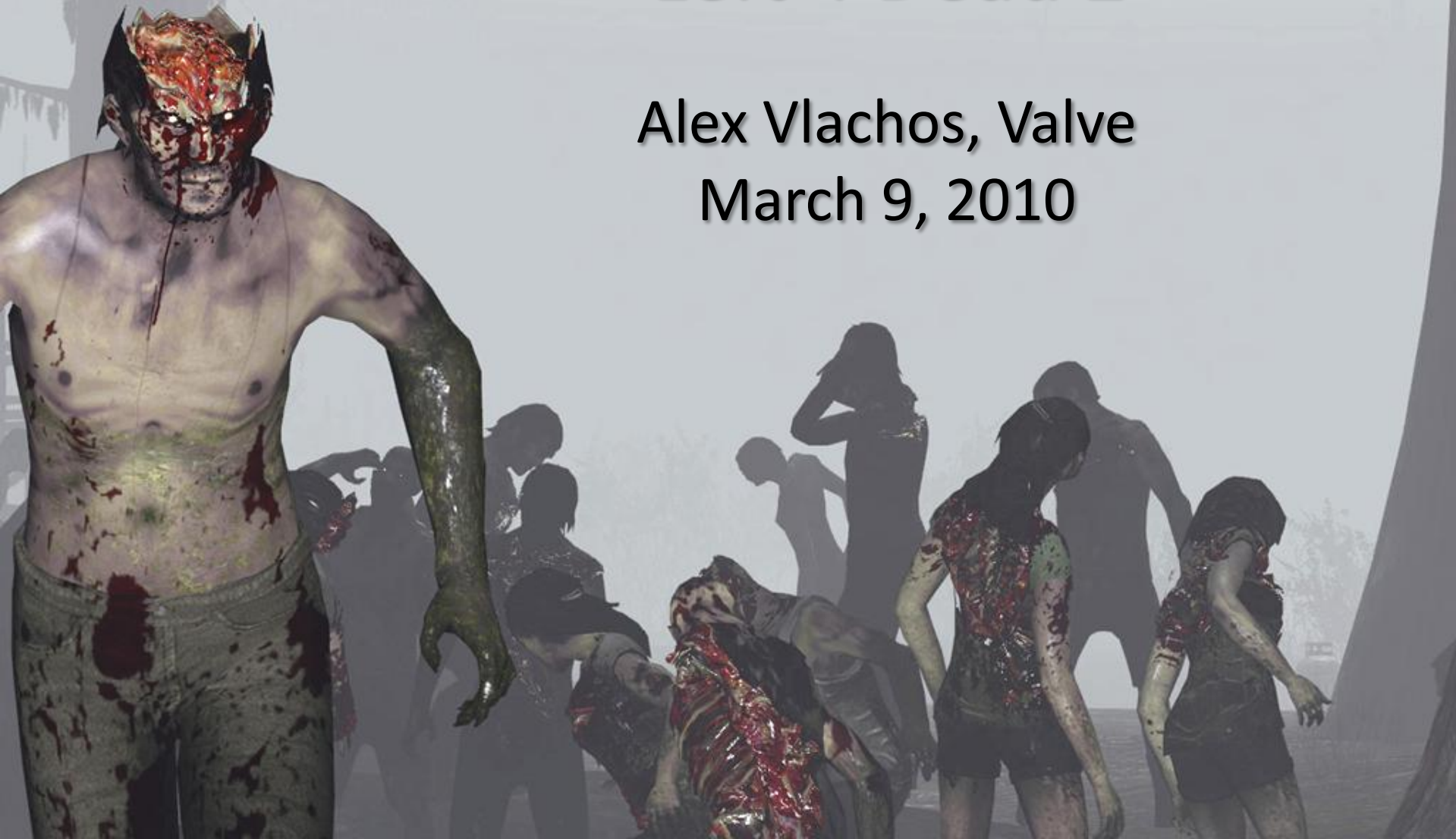


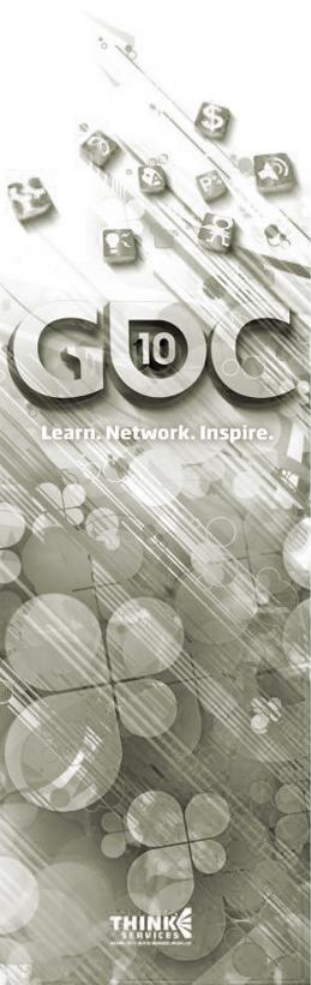
Rendering Wounds in Left 4 Dead 2

Alex Vlachos, Valve
March 9, 2010



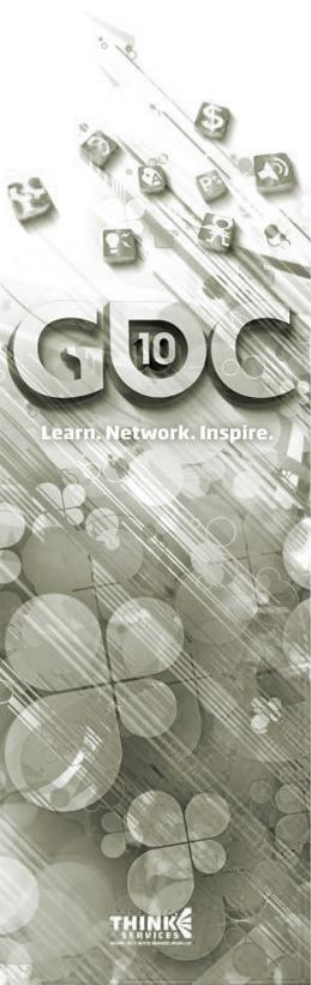
Outline

- Goals
- Technical Constraints
- Initial Prototype
- Final Solution



Left 4 Dead 1 Wounds

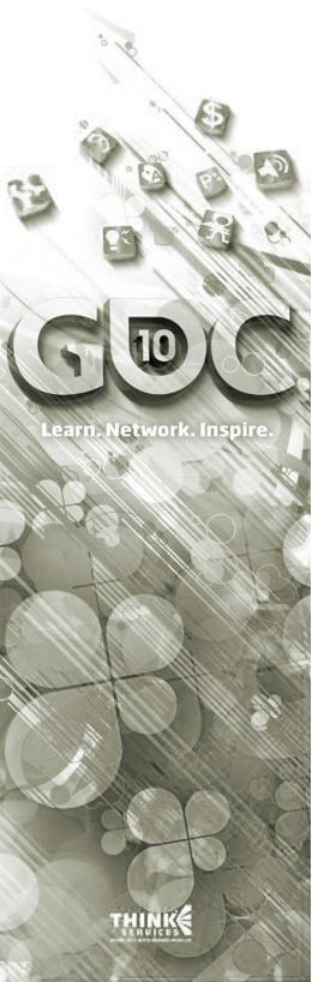
- Built-in
- 5 variations only
- Requires texture support
- Always Fatal



The Pitch

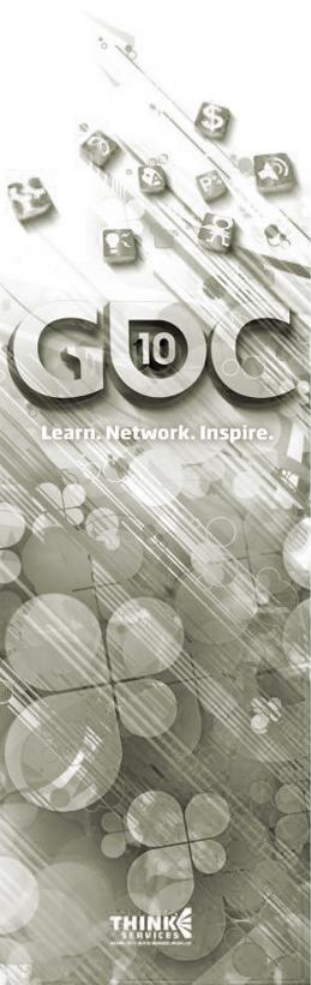
Gray Horsfield lives for destruction

(Gray is a Visual Effects Artist at Valve, previously at Weta)



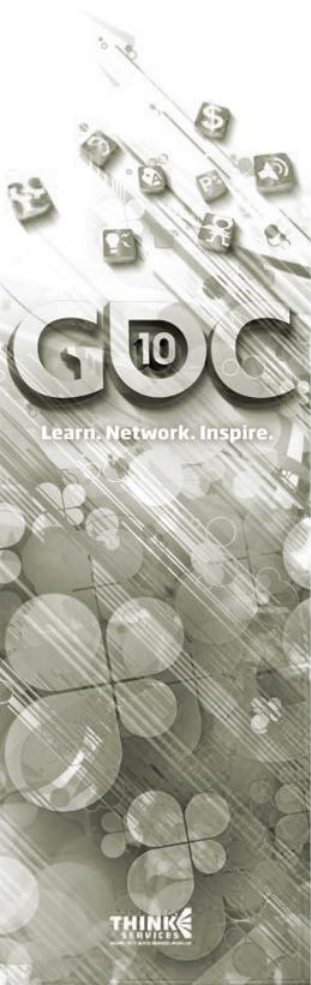
Goals

- Accurate location of wounds
- Wounds match weapon strength
 - Remove limbs, torso, head, half of body
- Separate wound geometry & textures
- Several active/visible wounds per model
 - Shipped up to 2 active wounds



Technical Constraints

- Already at memory limits on the Xbox 360
- Didn't want heavy CPU setup
- Ideally wanted a GPU solution
- No additional base meshes except for wound geometry
 - Better for artists to author
 - Share wound models among many infected

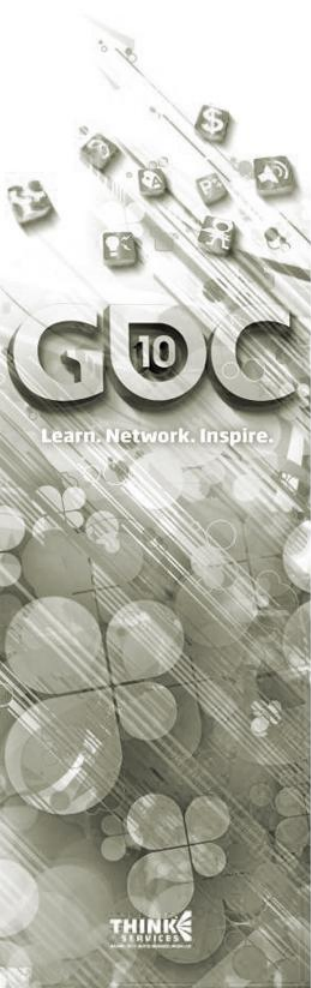


Common Infected Variation

- Simplest infected has over 24,000 variations

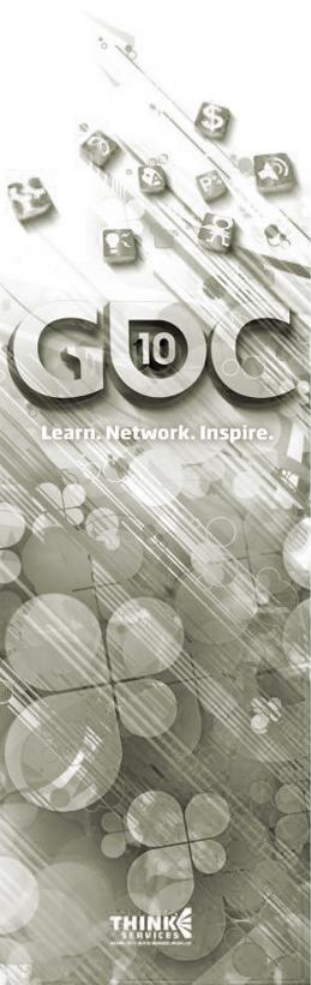


- We didn't want to add another variable to this



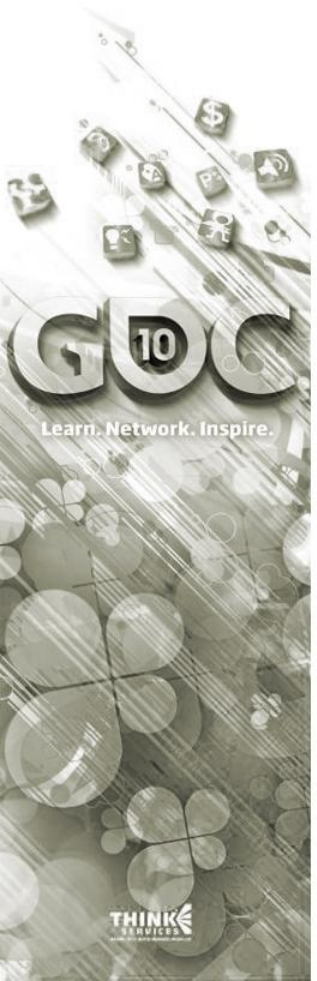
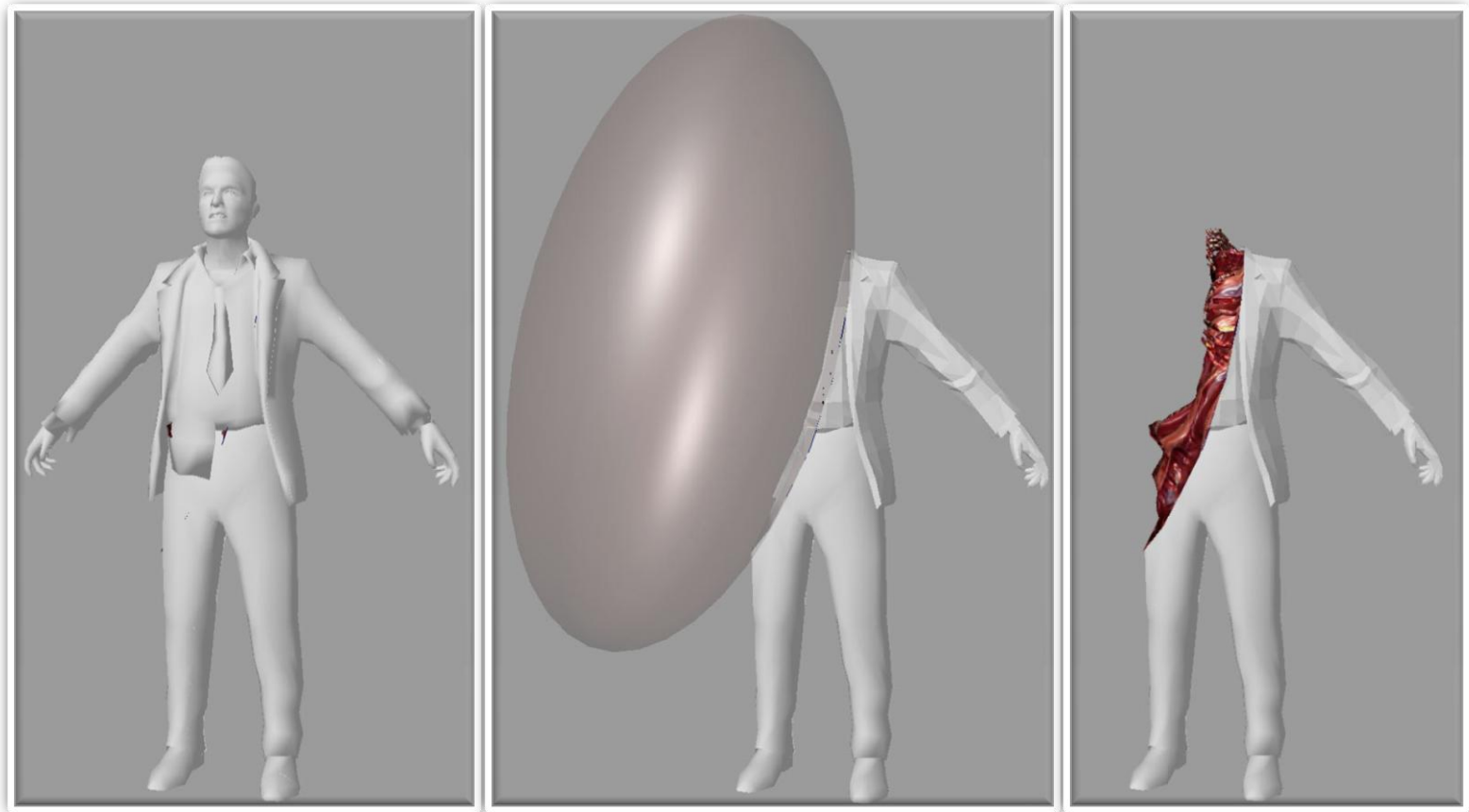
Things We Didn't/Couldn't Do

- Model variations of each infected with all combinations of 1 and 2 wounds
- Use different index buffers to cull polygons – not friendly with LOD and low quality wound silhouettes
- Auto-generate new polygonal meshes with holes cut for wound models
- Author different body parts/sections with different wound variations



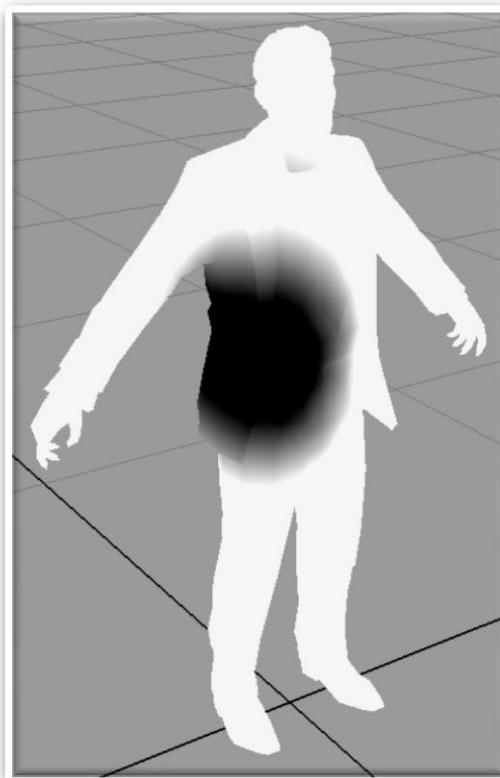
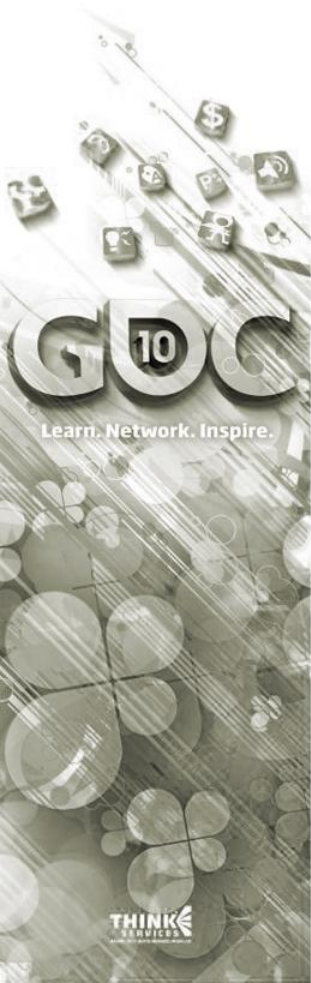
Initial Prototype

- Use pose-space ellipsoids to cull pixels
- Fill hole with wound model



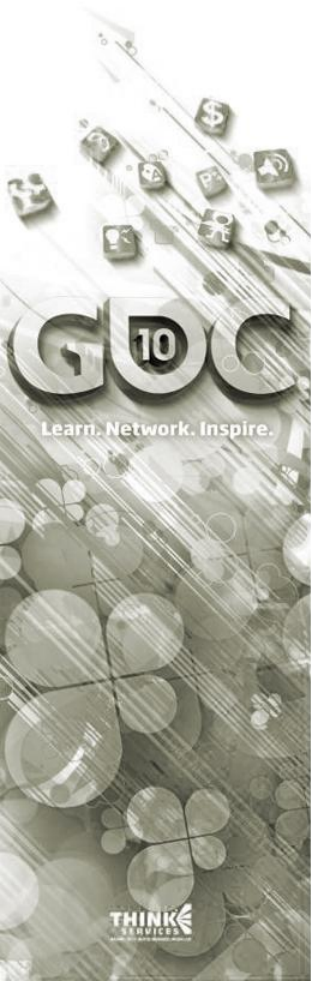
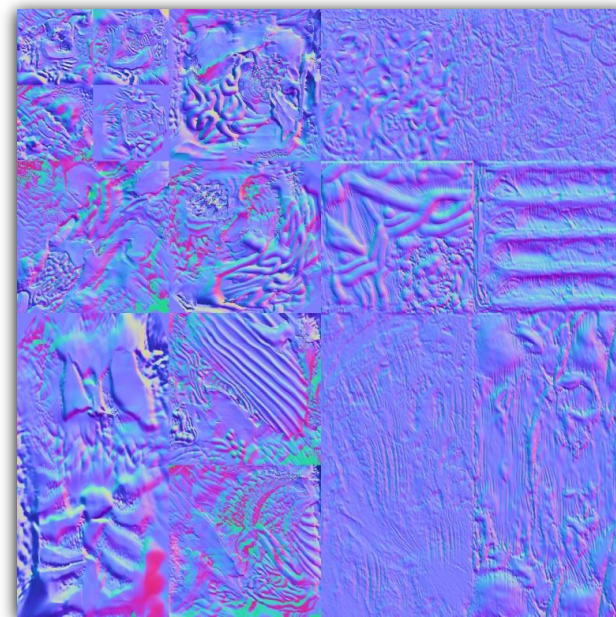
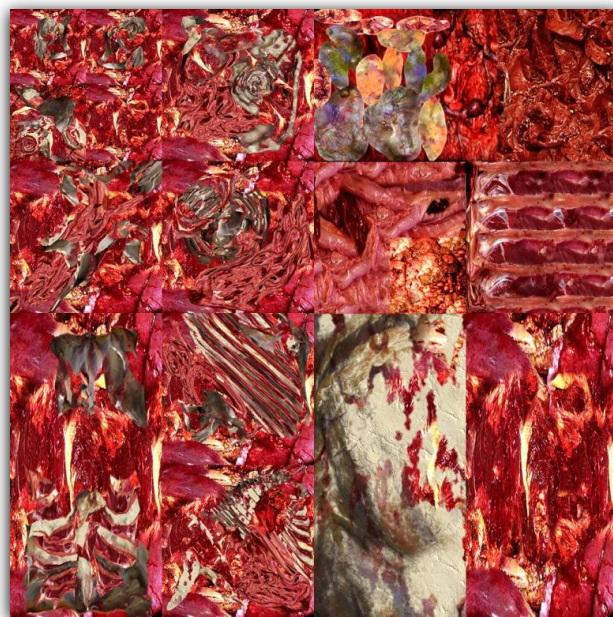
Culling Inside an Ellipsoid

- Vertex Shader calculates relative distance
- Interpolate this value and clip / texkill



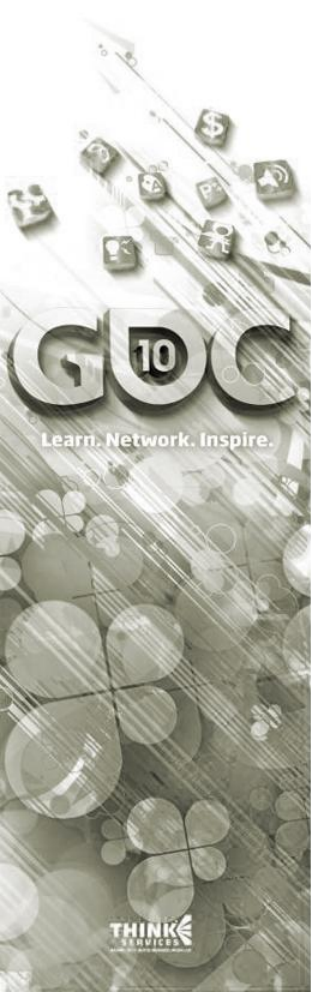
Benefits

- No additional vertex buffer data
- Still only one draw call for full model
- Wounds are a separate draw call with their own textures:



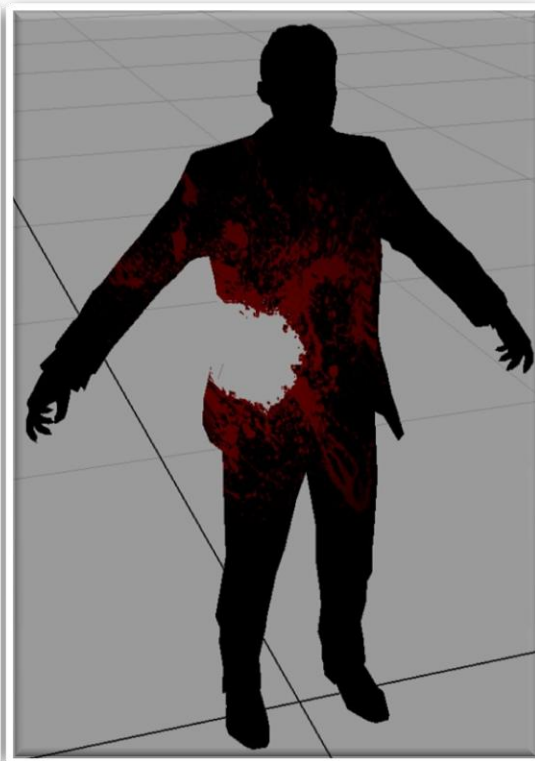
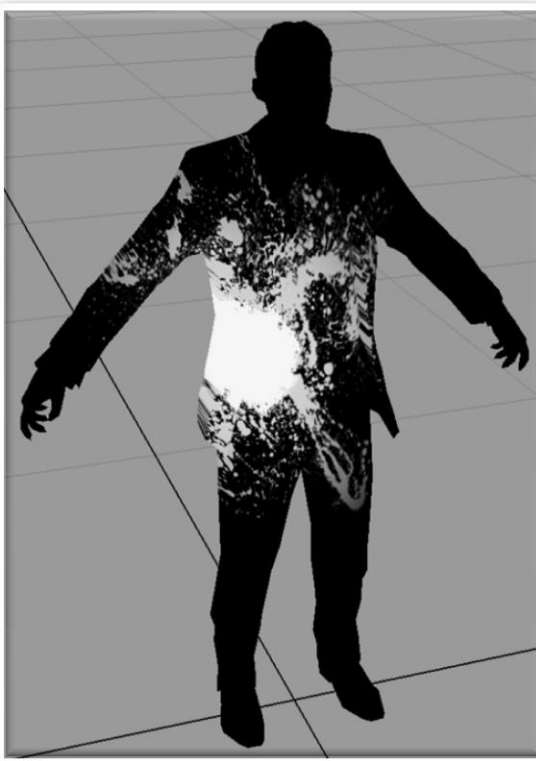
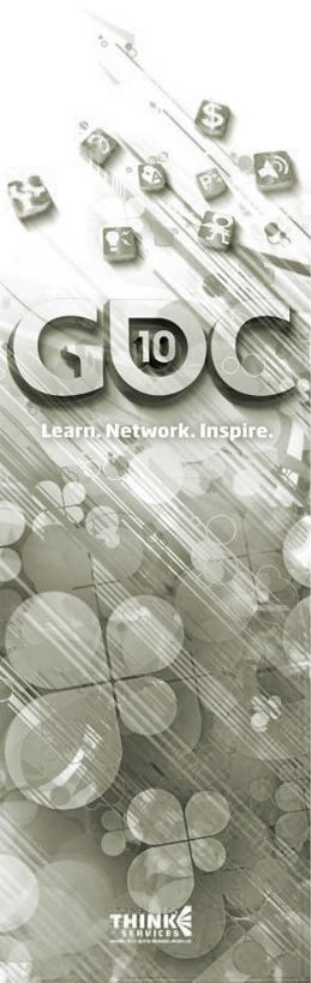
Problems

- Hard cut looked unnatural
- Wound models looked strange because they required a lip around the wound border
- Lacked blood on the clothes and skin near the border of the wound
- Required an exact geometric fit with the model

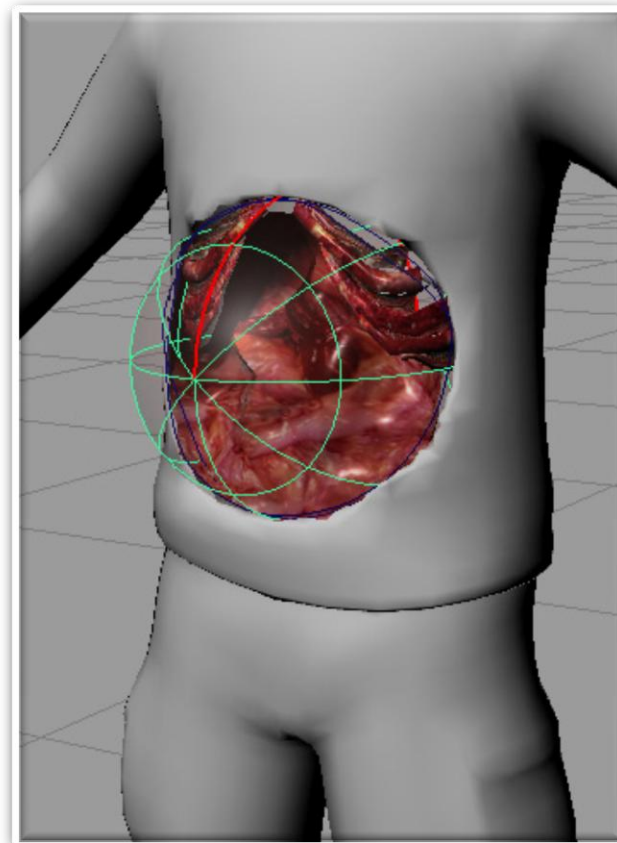


Projected Texture Experiment

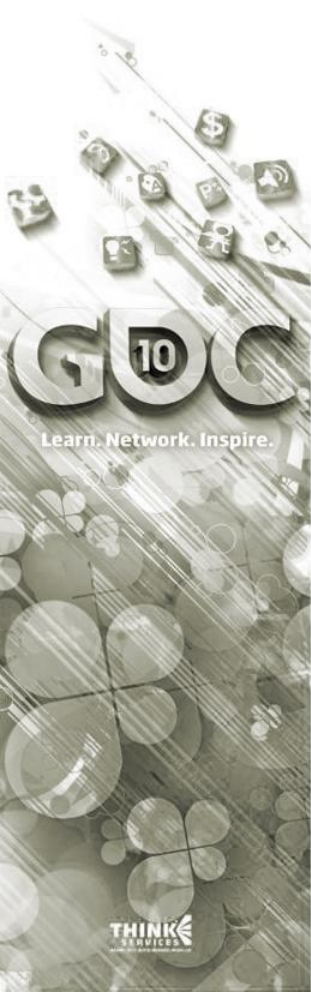
Try using a projected texture and use alpha to kill pixels



Abdominal Wounds

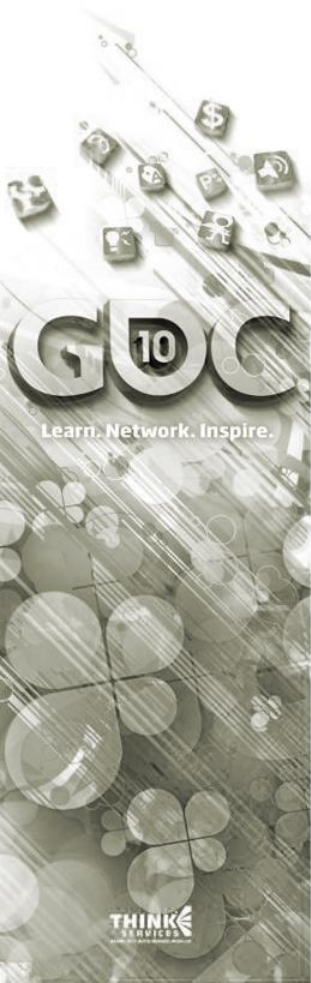


- Projected texture will affect his back
- So let's combine the texture and ellipsoid



Blood Layer

- The texture projection is aligned with an axis of the ellipse
- We multiply the blood layer by a gradient to prevent the blood from spraying too far



Vertex Shader Code

// Subtract off ellipsoid center

```
float3 vLocalPosition = ( vPreSkinnedPosition.xyz - vEllipsoidCenter.xyz );
```

// Apply rotation and ellipsoid scale. Ellipsoid basis is the orthonormal basis
// of the ellipsoid divided by the per-axis ellipsoid size.

```
float3 vEllipsoidPosition;
```

```
vEllipsoidPosition.x = dot( vEllipsoidSide.xyz, vLocalPosition.xyz );
```

```
vEllipsoidPosition.y = dot( vEllipsoidUp.xyz, vLocalPosition.xyz );
```

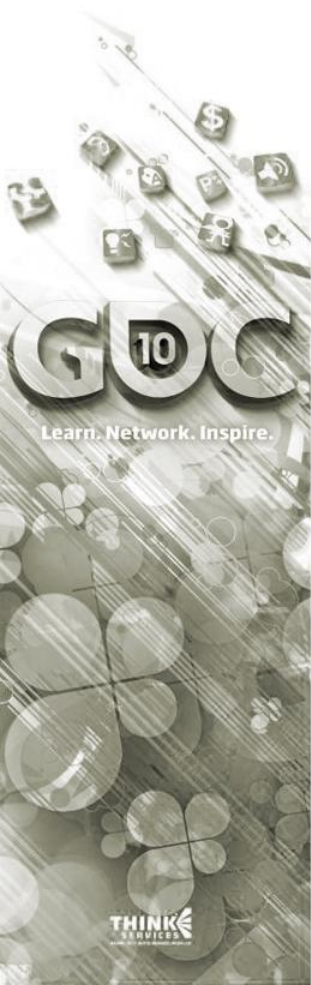
```
vEllipsoidPosition.z = dot( vEllipsoidForward.xyz, vLocalPosition.xyz );
```

// Use the length of the position in ellipsoid space as input to texkill/clip

```
float fTexkillInput = length( vEllipsoidPosition.xyz );
```

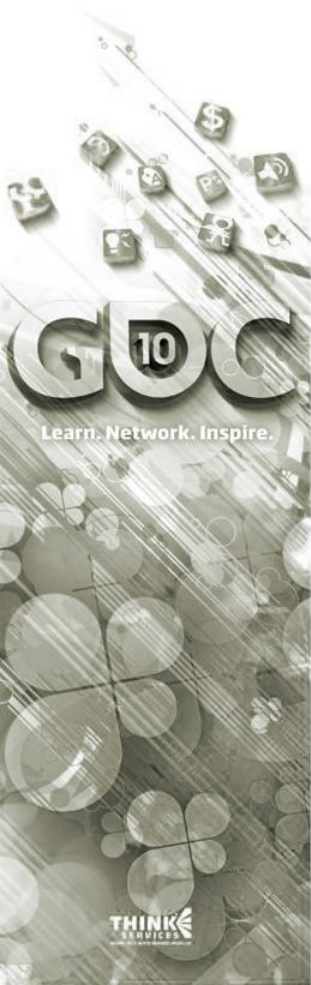
// We use the xy of the position in ellipsoid space as the texture uv

```
float2 vTextureCoords = vEllipsoidPosition.xy;
```



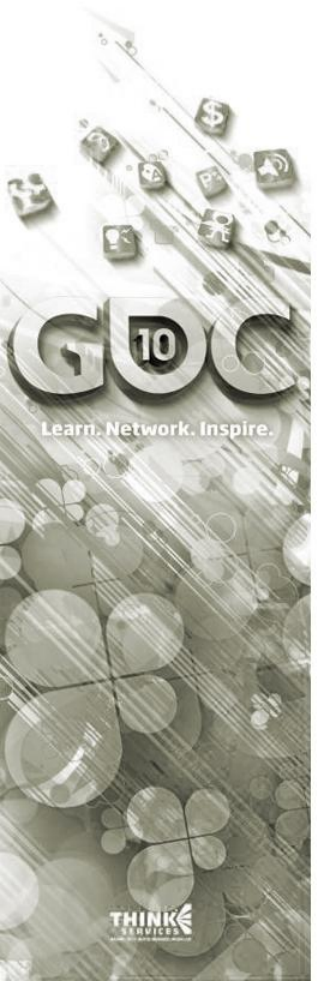
Other

- Depth-only and shadow render passes
 - You don't want phantom shadows
- Hi-Z performance issues
- Wound models are attached to base skeleton of infected model

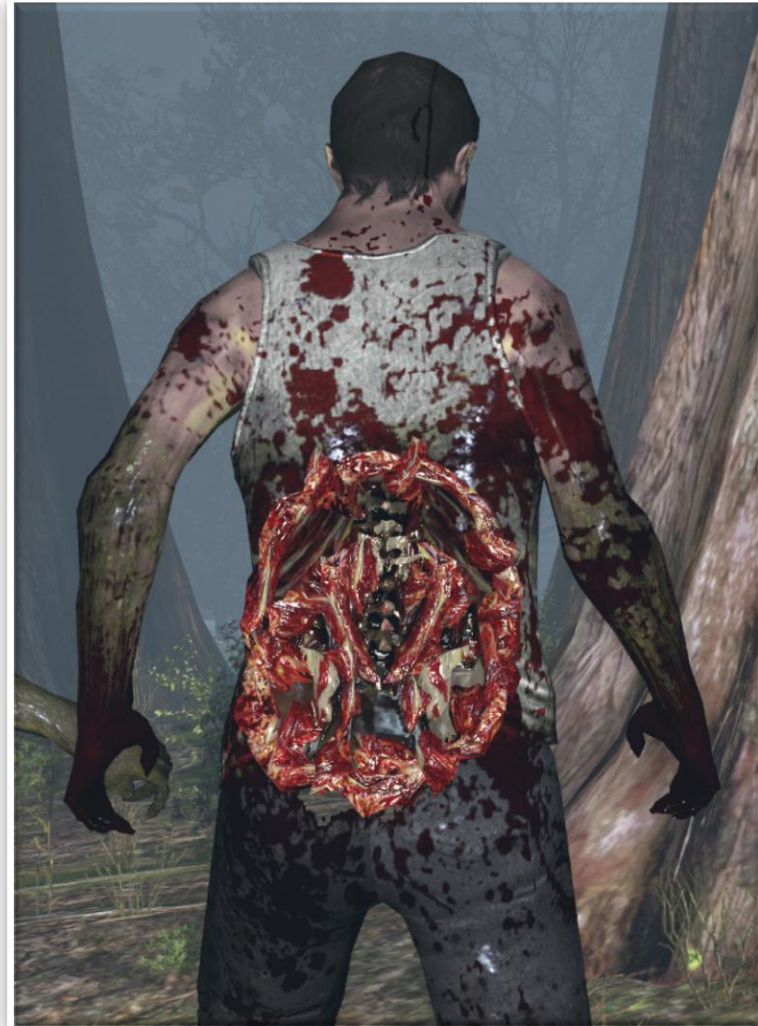


Multiple Wounds

We limited the final solution to 2 active wounds



Upper & Lower Back



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Groin



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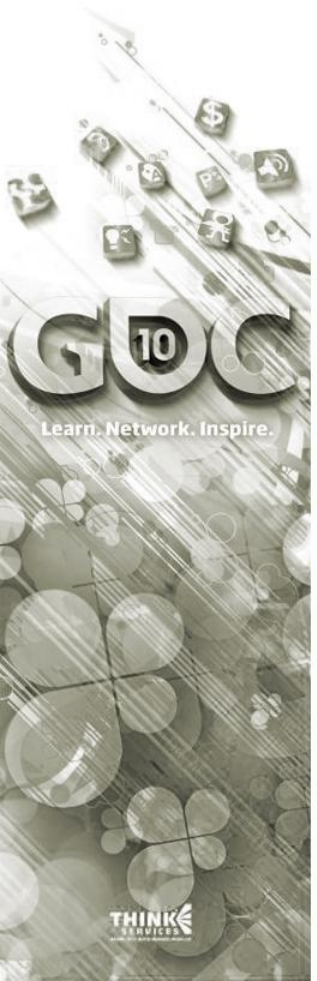


Abdomen

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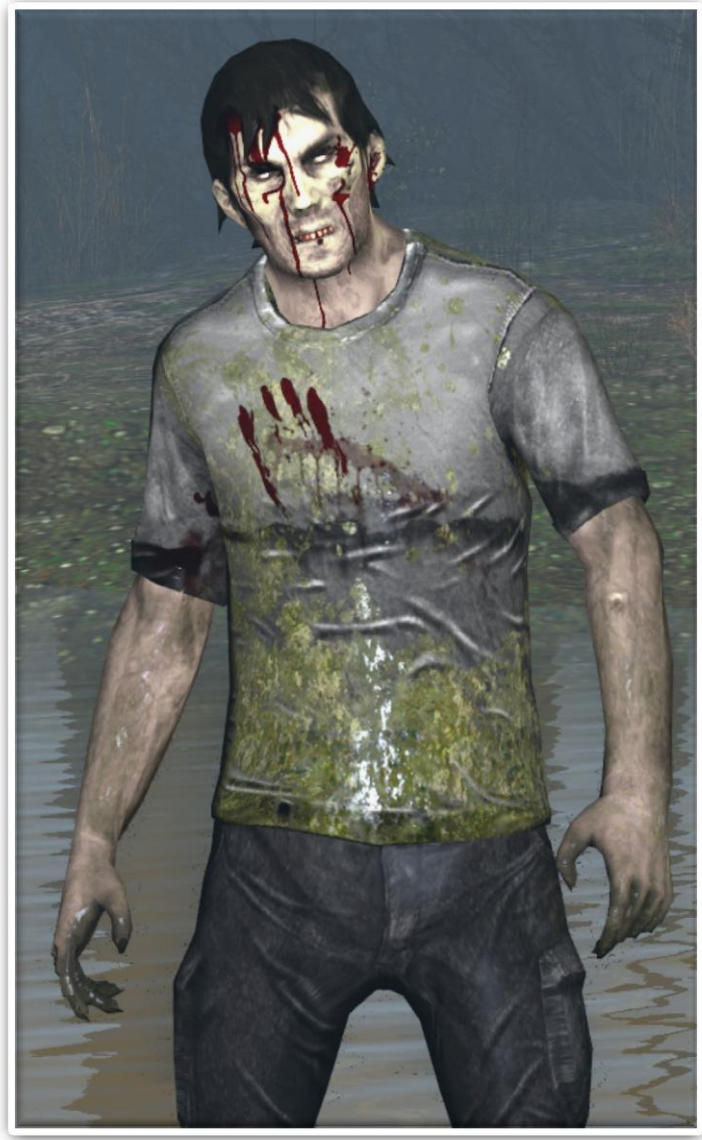


Head Wounds

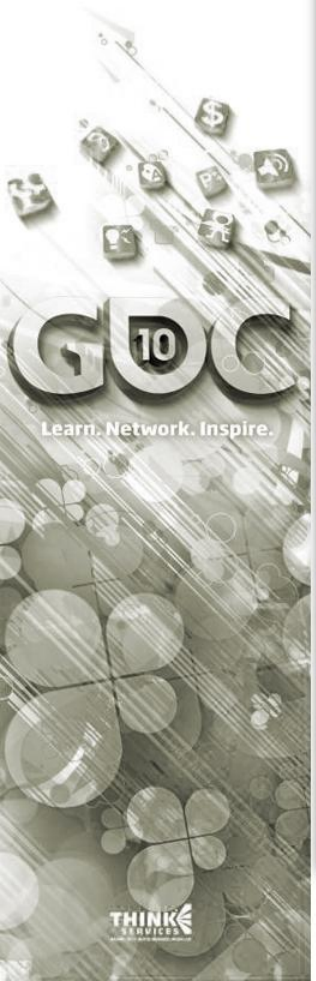


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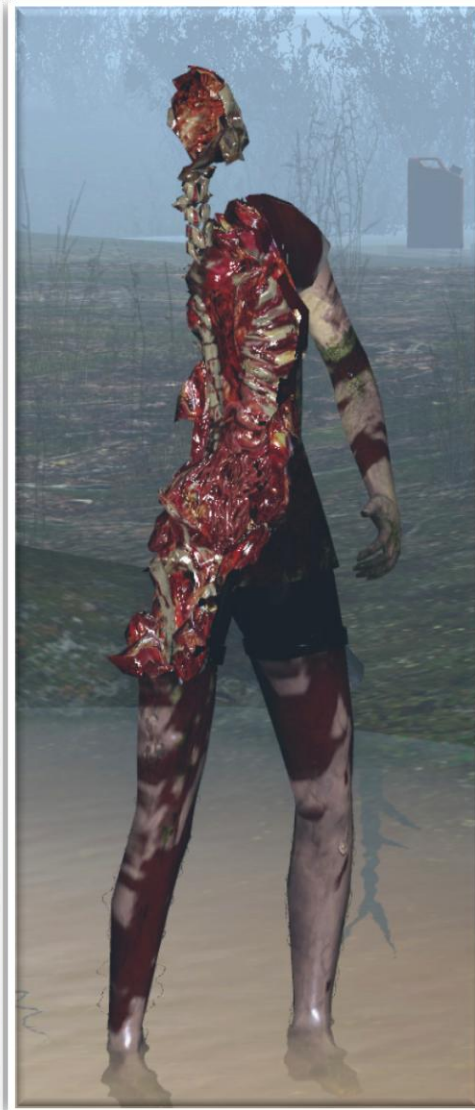


Half Body



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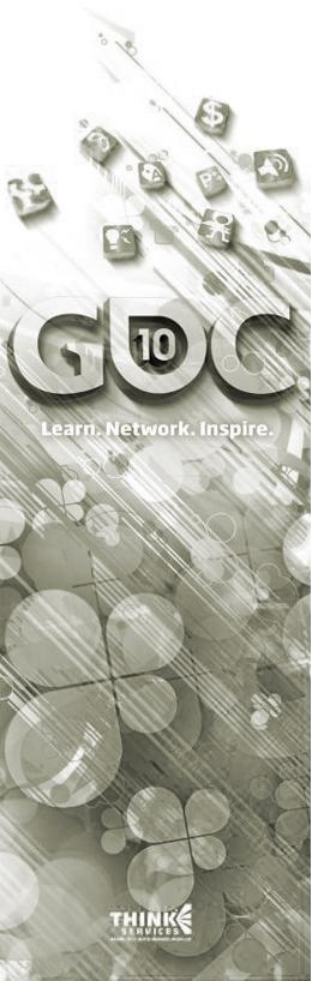


Axe & Sword Slashes



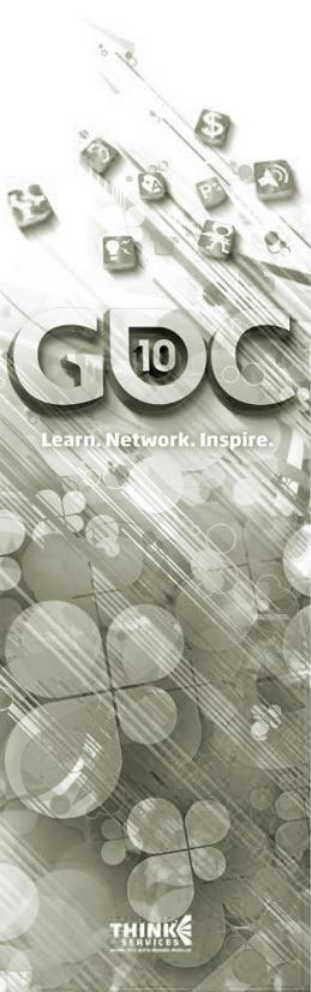
The GDC 10 logo is prominently displayed in the bottom left corner, featuring the text "GDC" in a large, stylized font with "10" inside a circle. Below it, the tagline "Learn. Network. Inspire." is written in a smaller font. The background of this section is a collage of various icons, including a dollar sign, a gear, and a network diagram, set against a pattern of overlapping circles and lines.

Upper Body



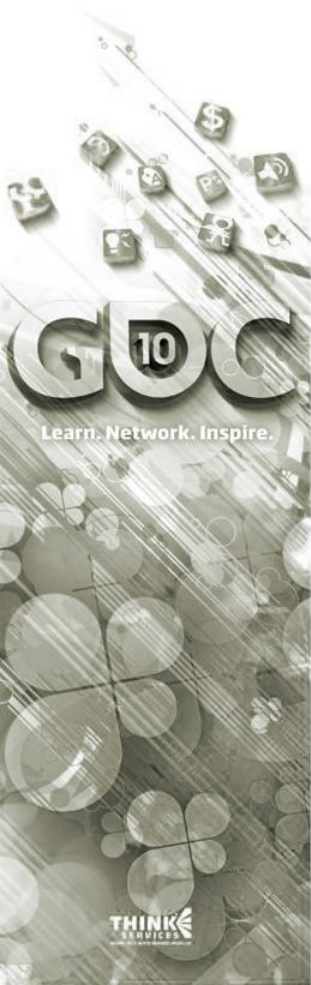
Stats

- Up to 54 unique wounds per model
- Each wound is only 13% of the memory cost of the old system in Left 4 Dead 1
- Vertex shader costs 15 instructions
 - Fill-bound, so rendering perf impacted minimally
- Pixel Shader costs 7 instructions

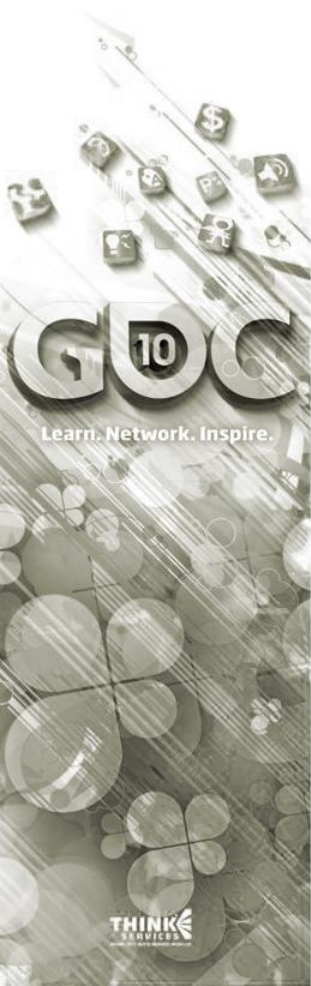


Summary

- Wound models separate from base mesh
- Use pose-space ellipsoids for outer limiting cull volume
- Use projected texture for rough edges and blood layer
- Additional details about our rendering:
<http://www.valvesoftware.com/publications.html>



Thank you!



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