Instant Animated Grass

Ralf Habel, Michael Wimmer, Stefan Jeschke

Institute of Computer Graphics and Algorithms
Vienna University of Technology
Motivation

- Render dense short grass in real-time
- Lawns, meadows
- 1st person viewpoint
Challenges

- Full polygon representation too expensive

- Billboard representation
  - Massive overdraw
  - Spatial aliasing
Important visual properties of grass

- Parallax
- Occlusion
- Animation

High frequency structure
  - No need for accuracy
Grass representation

- Dense regular grid of textured billboards
  - Provides approximate parallax and occlusion
- Generate billboard grid and ground plane in the fragment shader
- Polygons act as a carrier
Grass Ray Tracer

- Initialize texture offsets, increments/decrements and first grid planes
  - Dependent on entry point and sign of view direction
- Iterate through different grass billboard textures
- Same texture is seen from both sides
Grass Ray Tracer

- Initialize texture offsets...
- Ray tracing loop
  - Intersect with next axis aligned planes (grass and ground)
  - Increment/decrement hit grid plane
  - Blend current color according to $\alpha$ (“over-operator”)

- 4-5 fixed iterations
- Early loop exit may be faster on certain hardware
Grass Ray Tracer

- Initialize texture offsets…
- Ray tracing loop...
- Fill remaining transparency
  - Fully opaque grass texture
  - Average color
Result
Result

Additional horizontal plane at half the grass depth.
Visibility interactions

- Correct z-buffer required
  - Avoid clipping at carrier polygon
  - Remember depth from ray entry to the point where a threshold opacity is reached
  - Transform into view space, add to carrier polygon depth
    - $\alpha$-testing instead of $\alpha$-blending
    - No modification to render pipeline
Overview

+ Confined to a shader
+ No additional geometry required
+ Front to back compositing
  + Accurate $\alpha$-blending
  + Reduced or no overdraw
+ Performance is not dependent on the number of billboards, but pixels covered and tracing depth

- No silhouettes
- Viewpoint cannot move into the grass
Animating Grass

- Realistic simulation of grass requires two components
  - Gusts of wind cause large areas of grass to bend in the same direction
  - Wind turbulence near the ground causes smaller but erratic movements
Animating Grass

- Simulate this behavior with texture lookup distortion
  - Translate noise map over terrain
  - Offset texture lookups horizontally, scale with height so grass stays fixed on the ground (local shear-transformation)
  - Transport high frequencies

- Noise map
  - low frequencies with high amplitude
  - high frequencies with low amplitude
Instant Animated Grass

Video
Performance

- Half the screen covered
- Full view of terrain
- 5 ray tracing loop iterations
- 3.2 GHz, 1024x786

<table>
<thead>
<tr>
<th></th>
<th>Polys</th>
<th>Raytraced</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA 7900 GT</td>
<td>~90 fps</td>
<td>~140 fps</td>
</tr>
<tr>
<td>NVIDIA 8800 GTS</td>
<td>~120 fps</td>
<td>~300 fps</td>
</tr>
</tbody>
</table>

(α-tested)
Future work:

- Derive wind textures from physical simulation of grass
- Adapt higher order surface approximations for silhouettes
- DirectX 10 geometry shader adaptation
Resources:

HLSL implementation and used textures at:

Thanks for your attention!