Steep Parallax Mapping

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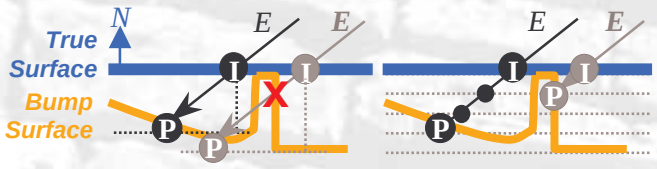

Parallax Mapping *Steep Parallax Mapping*

The viewer perceives an intersection at **(P)** from shading, although the true intersection occurred at **(I).**

Overview

- Real-time, appropriate for games
- Parallax
- Self-occlusion
- Self-shadowing
- Realistic grass and fur in one pass
- Uses existing art tools and assets

Bump Mapping *Parallax Mapping* *Steep Parallax Mapping*

Pixel Shader

```
// tsE = tangent space eye vector
void main(void) {
  const int numSteps = 30;
  float height = 1.0, step = 1.0 / numSteps;

  vec2 offset = texCoord.xy;
  vec4 NB = texture2D(bumpMap, offset);

  vec2 delta = vec2(-tsE.x, tsE.y) * bumpScale /
                   (tsE.z * numSteps);
  while (NB.a < height) {
     height -= step; offset += delta;
     NB = texture2D(bumpMap, offset);
  }

  // Choose the color at the location we hit
  const vec4 color = texture2D(texMap, offset);

  // Use the normals out of the bump map
  vec3 tsN = NB.xyz * 2.0 – 1.0;

  ... Apply illumination algorithm
}
```

Details

Avoid repeated MIP-computation with texture2DLod. LOD bias of –1.5 and 4x or 8x FSAA acta s low-pass filters to avoid undersampling. Self-shadowing by tracing shadow rays to the light Approximate self-shadowing as increasing with depth [3] for fur.

Performance

Renders a full 1024×768 screen of fur at 30 fps on GeForce6800 with 4× super-sampling and 30 ray-marching iterations. Typical scenes with are faster, where not all pixels use steep parallax mapping.

We unroll the loop (up to 7 iterations) for older PS 2.0 cards, which do not have branch instructions.

Related Work

Parallax Mapping extends bump mapping with self-occlusion, but breaks down for steep bumps [1] and can produce texture swim due to the offset limiting. **Shell Fur** [3] instead rasterizes a 3D voxel grid by multiple alpha-blended passes. A pixel shader implementing a **voxel ray tracer** [2] avoids the slow blending.

Our heightfield ray tracer achieves similar results using **2D textures**, which are compatible with existing art assets and allow high enough resolution to describe fine details like hair.

[1] Walsh, Parallax Mapping with Offset Limiting, Infiniscape Tech Report, 2003

[2] Donnelly, Per-Pixel Displacement Mapping with Distance Functions, *GPU Gems 2*, 2005

[3] Lengyel, Praun, Finkelstein, and Hoppe. Realtime fur over arbitrary surfaces, *I3D*, 2001