A 3d curvilinear skeletonization algorithm
with application to path tracing

a story by
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produced by
Once upon a time...
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Path-tracing

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The BRDF function of an object tells how light tends to reflect on this object.

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Some rays never reach any bright area of the scene: these rays collect little information on the scene and don’t contribute much to the final result.

Reducing the number of these non-contributing rays is a way to make the computation faster without changing the output quality.
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To be efficient, we need a skeleton which « looks » like the original object and contain as few spurious branches as possible.
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A face is free if it « touches » exactly one face of higher dimension.
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This line touches exactly one square : it is free.
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Thinning is achieved by removing a free face and the face of higher dimension it touches.

- This line touches two squares: it is not free
- This line touches exactly one square: it is free
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Our algorithm performs thinning in parallel: all free faces have a given direction and dimension are removed simultaneously (the algorithm iterates the directions and dimensions).
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The 6-distance map of the object

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The time our algorithm needs to «reach» a face and delete it.

The algorithm is entirely automatic: it does not need any user input to perform the filtering.
Curvilinear skeletonization algorithm
Skeleton path-tracing

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The object’s BRDF \textit{(realistic result)}. 
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The object’s BRDF (*realistic result*).

The skeleton node which is closest to a light source and still visible from the hit spot (*help the rays go towards bright areas*).
Skeleton path-tracing

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The object’s BRDF (*realistic result*).

The skeleton node which is closest to a light source and still visible from the hit spot (*help the rays go towards bright areas*).

These two elements must be carefully averaged in order to still obtain photorealistic images and reduce the number of non contributing rays.
Skeleton path-tracing

Workflow

```c
DEF arc_floor_small Transform {  
  translation 0.00724 0.09331 0.90149  
  rotation 1.0 0.0 -1.571  
  children {  
    Shape {  
      appearance Appearance {  
        material Material {  
          diffuseColor 0.7451 0.7098 0.6745  
          ambientIntensity 0  
          specularColor 0.0 0 0  
          shininess 0.002  
          transparency 0  
        }  
        texture imageTexture {  
          "./images/arc.png"  
        }  
      }  
    }  
  }  
}
```
Skeleton path-tracing

Workflow

voxelization

```
DEF arc_floor small Transform {
  translation 0.20724 0.09331 0.90149
  rotation -1.0 0.0 -1.571
}
Shape {
  appearance Appearance {
    material Material {
      diffuseColor 0.7451 0.7098 0.6745
      ambientIntensity 0
      specularColor 0.0 0
      shininess 0.532
      transparency 0
    }
    texture ImageTexture {
      "../images_arc_L.jpg"
    }
  }
}
Skeleton path-tracing

Workflow

voxelization

thinning
Skeleton path-tracing

Workflow

voxelization

thinning

skeleton path-tracing

DEF arc_floor_small Transform { translation 0.02024 0.03314 0.00144 rotation 1.0 0.0 -1.571 (radius) Shape { appearance Appearance { material Material { diffuseColor 0.741 0.7098 0.6745 ambientIntensity 0 specularColor 0.9 0.9 0.9 shininess 0.92 transparency 0 } texture imageTexture { vt "../images/uk.JPG" } } } }
Skeleton path-tracing

Results:

For a same amount of rays sent in the scene, our method produces more rays reaching bright areas (useful rays).
Results:

Our method is faster than classical path-tracing to produce same quality images.

Computation time (in sec.) to obtain an image with an MSE of 40 against ground truth:

- Corridor: 260, 434 seconds
- Sponza 1: 628, 924 seconds
- Sponza 2: 2570, 2678 seconds
Skeleton path-tracing

Results:

Our method produces less noisy images.

classical path-tracing  
skeleton path-tracing
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