Real-Time Stroke Textures

Bert Freudenberg

Institut für Simulation und Graphik
Universität Magdeburg

isg

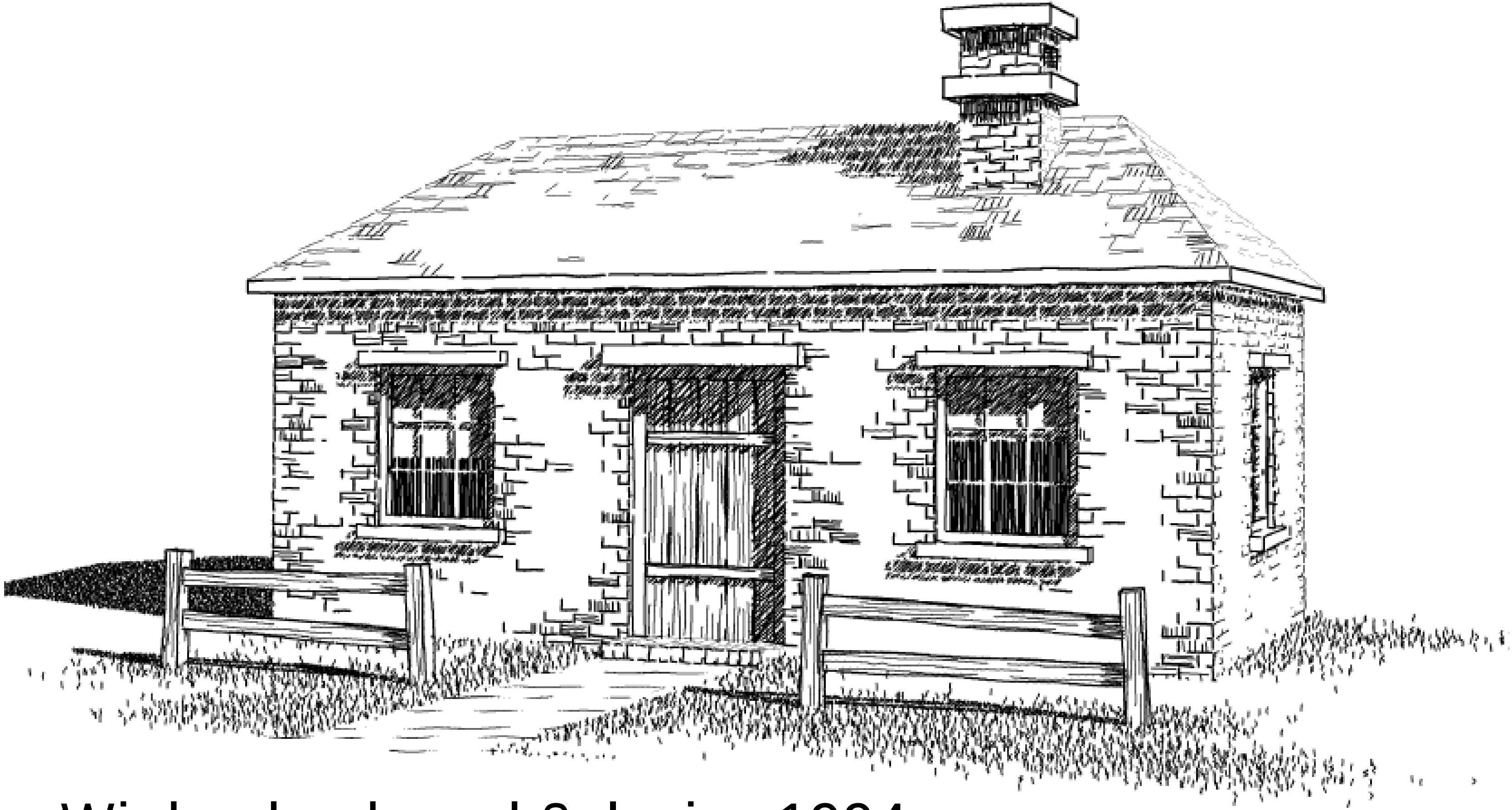
SIGGRAPH 2001 EXPLORE INTERACTION AND DIGITAL IMAGES

Real-Time Stroke Textures

Overview

- Pen-and-ink style in CG
- Texture based real-time approaches
- Basic stroke-map technique
- Extensions
- Conclusion

Pen-and-ink style in CG



Winkenbach and Salesin, 1994

Real-Time Techniques

Line based

- Lines drawn individually
- To slow for shading
- Outline only

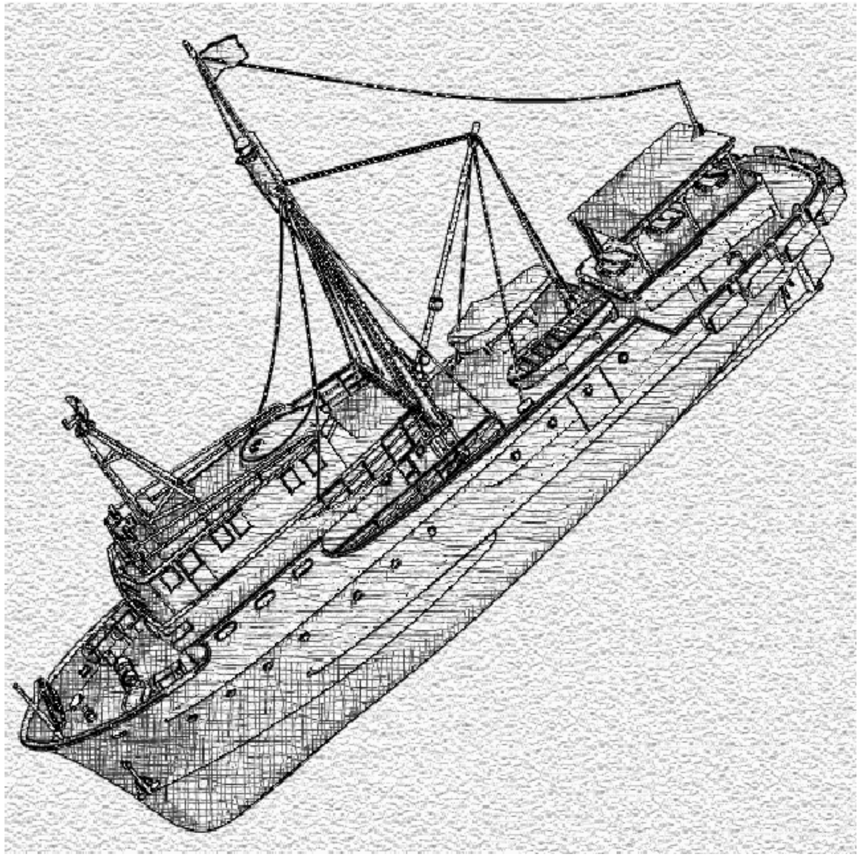
Texture based

- Multiple lines drawn at once
- Suited for shading

Texture based approaches

Lake et al., 2000

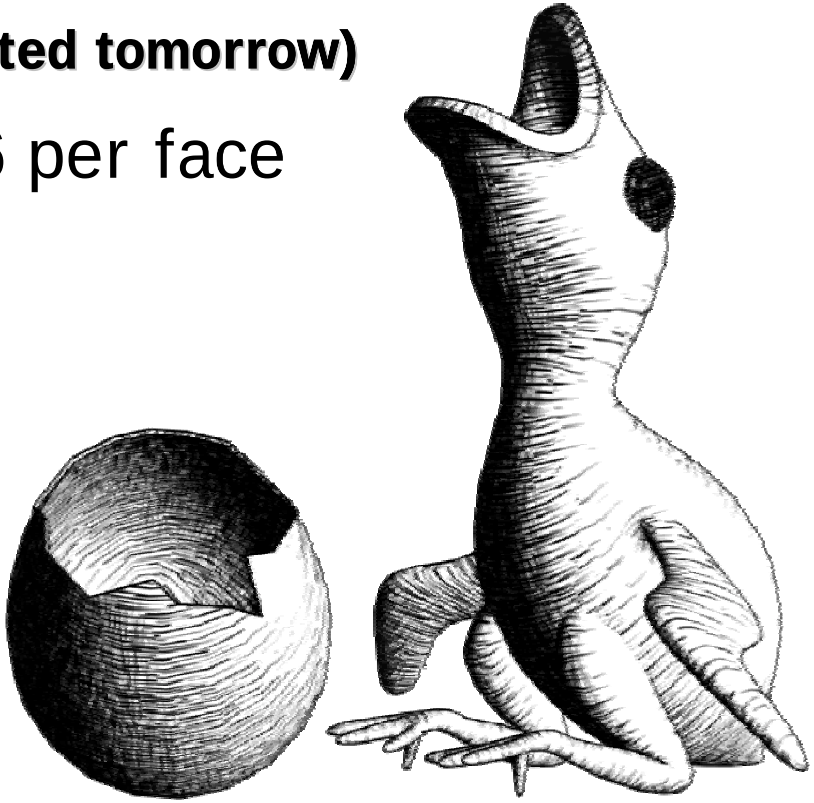
- 1 texture per triangle
- Lit and split by CPU
- Flat shading



Texture based approaches

Praun et al., 2001 (presented tomorrow)

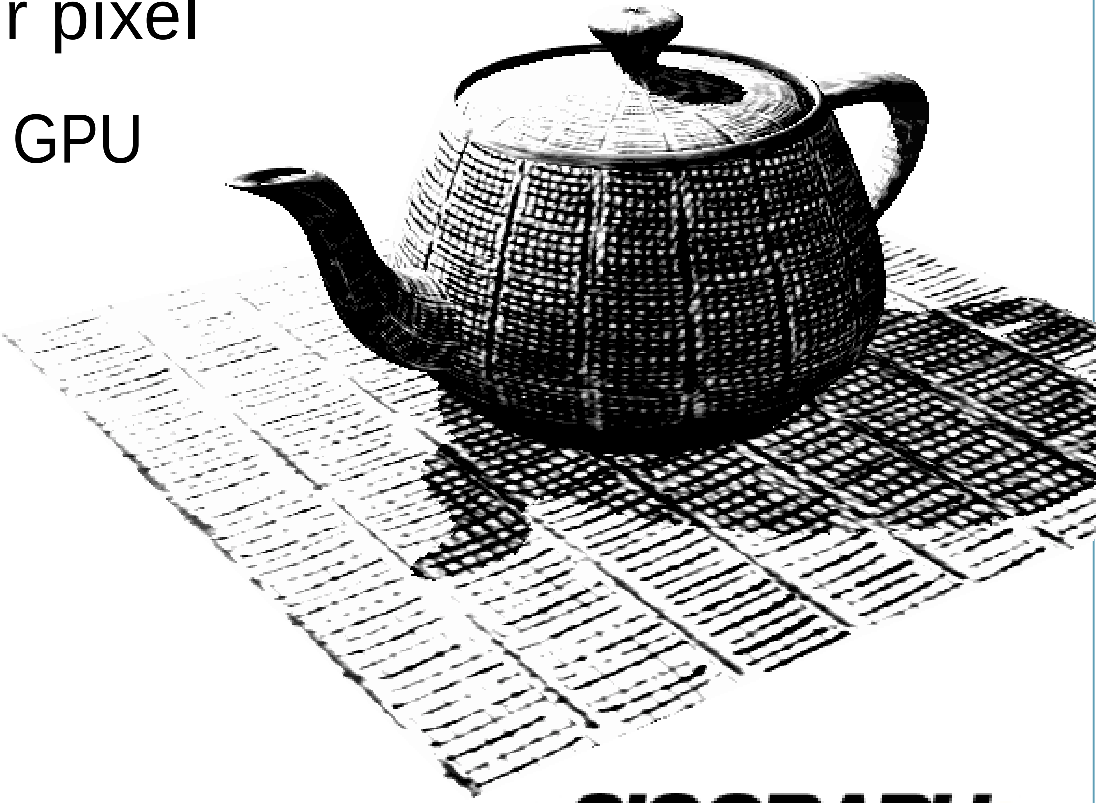
- 2 textures per vertex = 6 per face
- Lit by Vertex Program
- Blended by GPU
- Gouraud shading



Texture based approaches

Freudenberg, 2001 (presented now)

- Multiple layers per pixel
- Lit completely by GPU
- Per-pixel shading

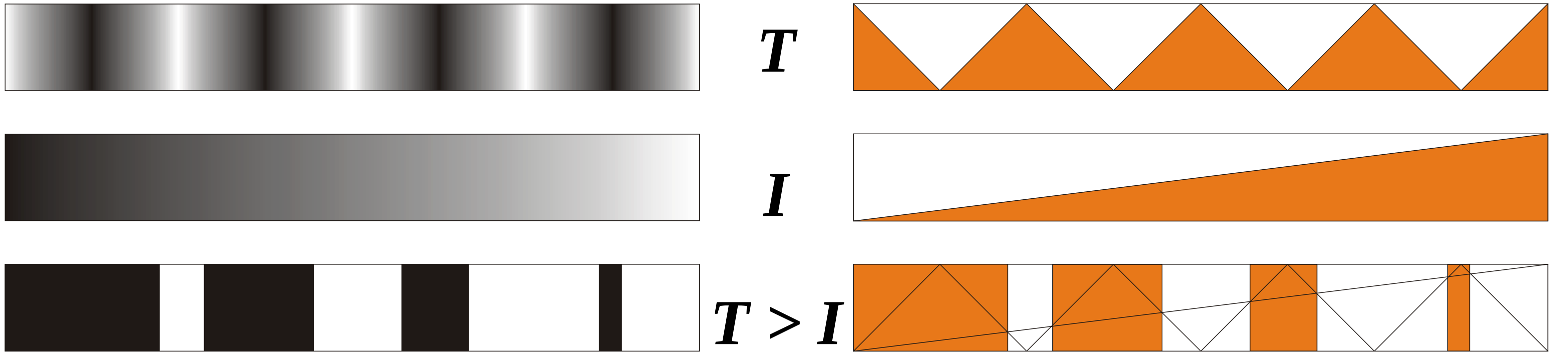


SIGGRAPH 2001 EXPLORE INTERACTION AND DIGITAL IMAGES

Varying Line-Width Shading

Idea

- Create half-toning pattern T
- Per-pixel compare to target intensity I
- Output black or white pixels



Varying Line-Width Shading

Idea

- Create half-toning pattern T
- Per-pixel compare to target intensity I
- Output black or white pixels

Problem

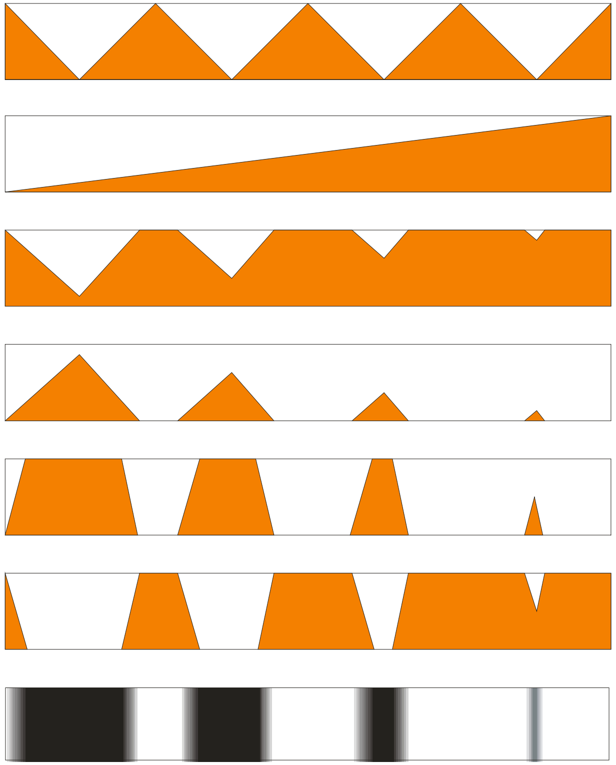
- Aliasing

Solution

- Scaling instead of thresholding

Varying Line-Width Shading

Scaling



T

I

$T + I$

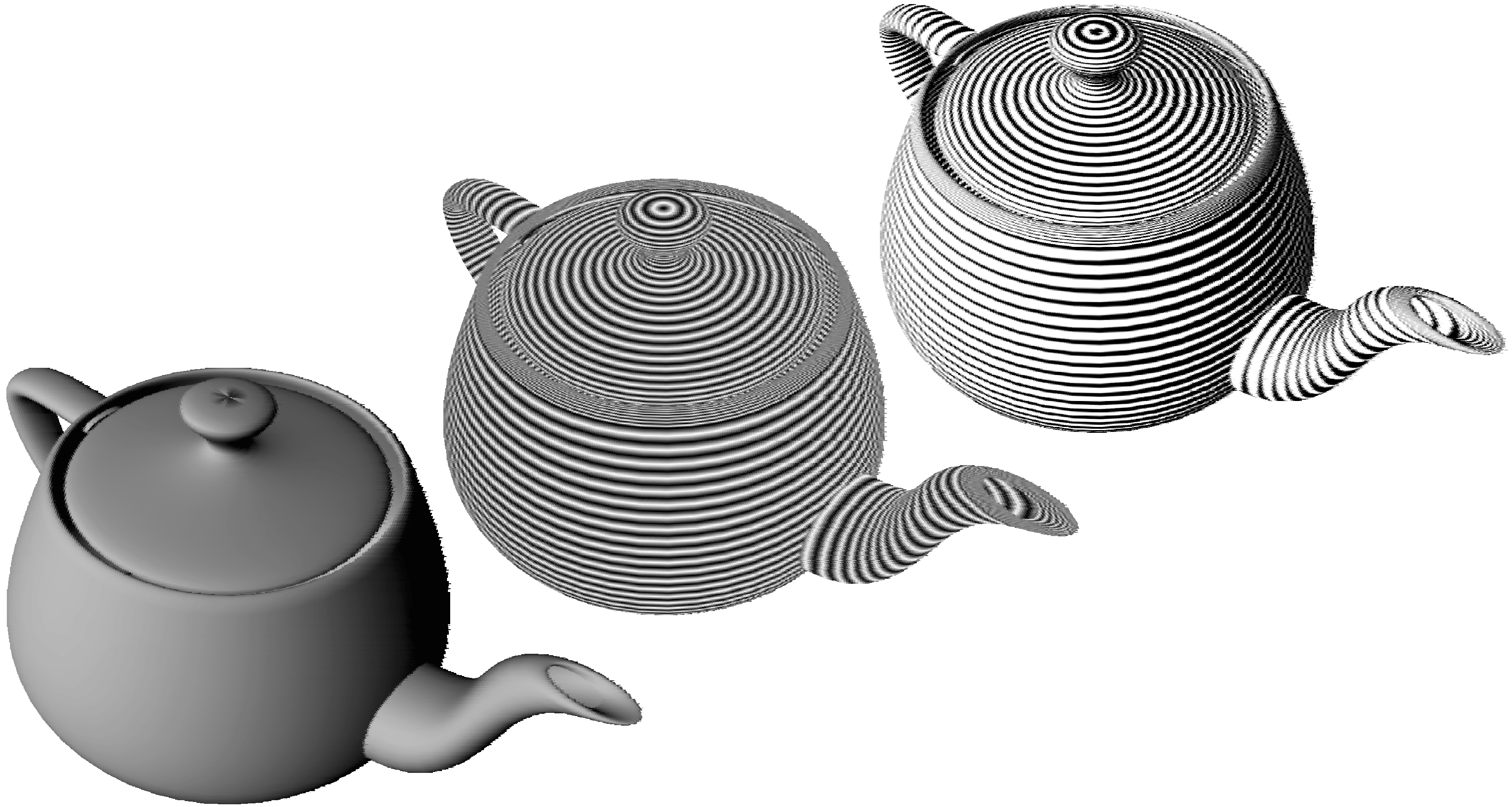
$1 - (T + I)$

$4\ (1 - (T + I))$

$1 - 4\ (1 - (T + I))$

Anti-aliased result

Varying Line-Width Shading



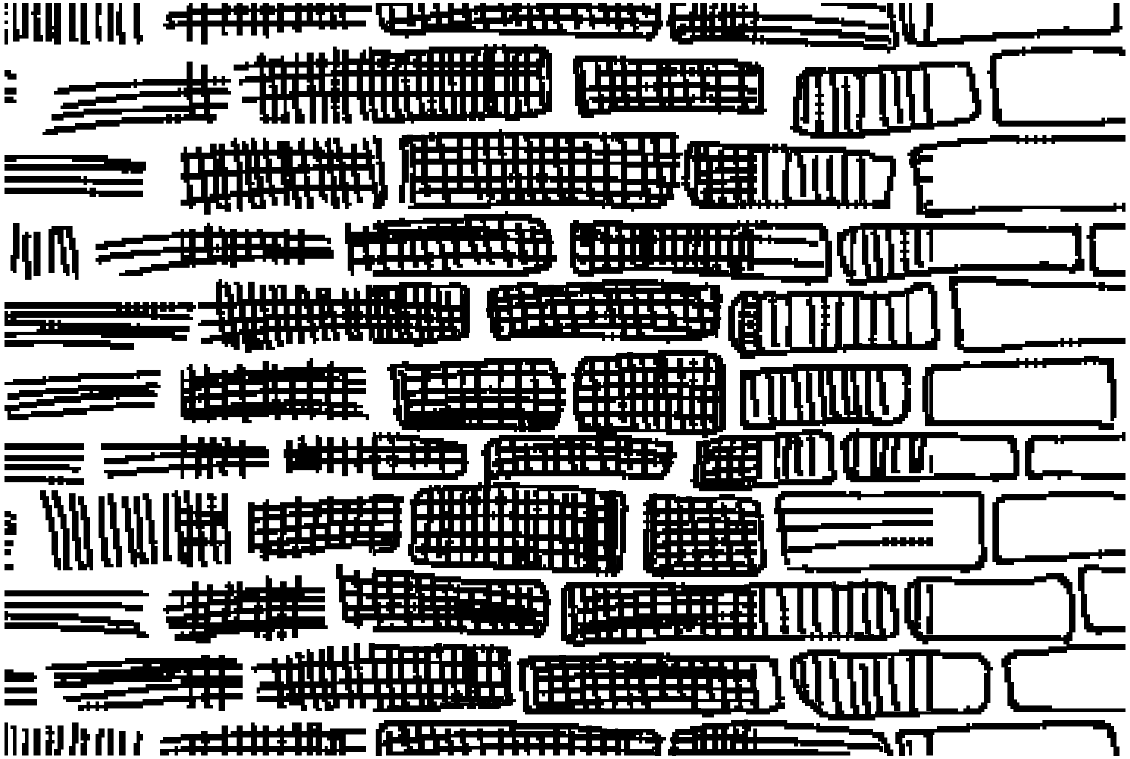
Stroke Maps

Idea

- Strokes are drawn in layers
- Encoded into one texture
- Expanded at run-time
- Selected by reference intensity

Stroke Maps

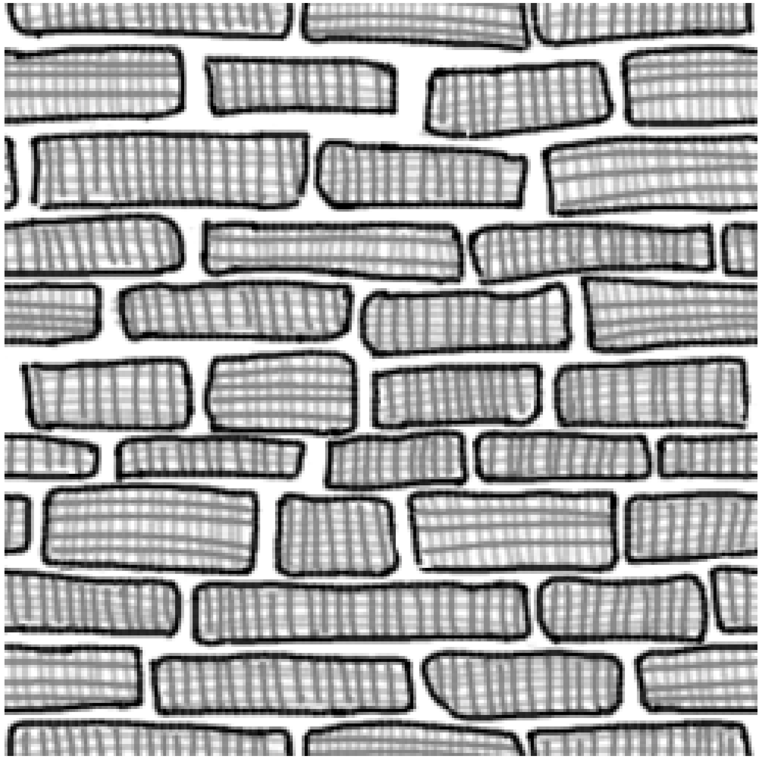
Layering of Strokes



Stroke Maps

Encoding

- Pre-processing step
- Encode layers as gray
  - 1st layer black
  - 2nd layer 66% gray
  - 3rd layer 33% gray
- Paint last-to-first into texture = Stroke Map



Stroke Maps

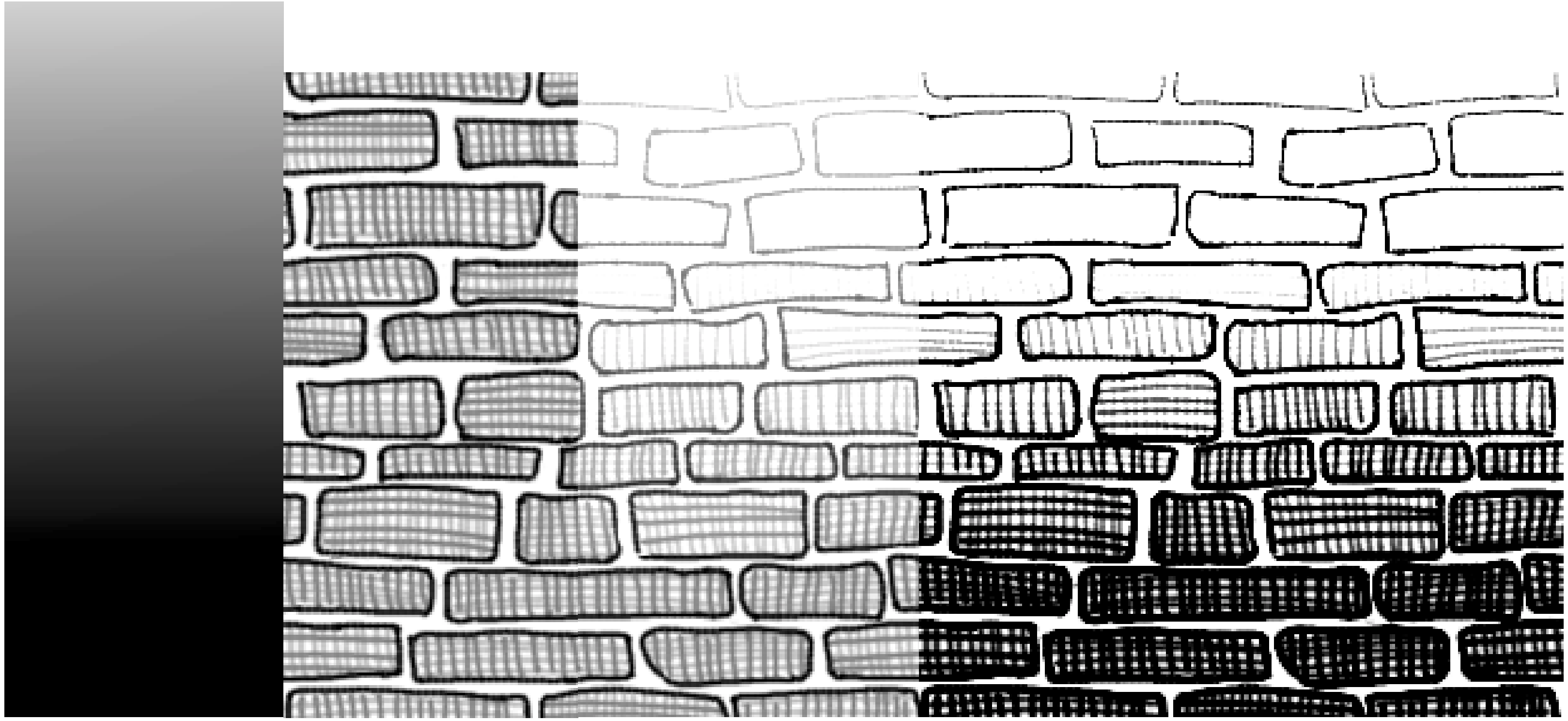
Expansion

- At run-time
- Using per-pixel operations
- EXACT same formula as for line-width variation
  - $\mathbf{1 - 4\,(1 - (\mathit{T} + \mathit{I}))}$
  - General combiner:

    ```
    r0 = scale_by_4( sum( invert( t ) , negate( i ) ) )
    ```
  - Final combiner:

    ```
    out = invert(r0)
    ```

Stroke Maps



I *T* sum scaled

Stroke Maps

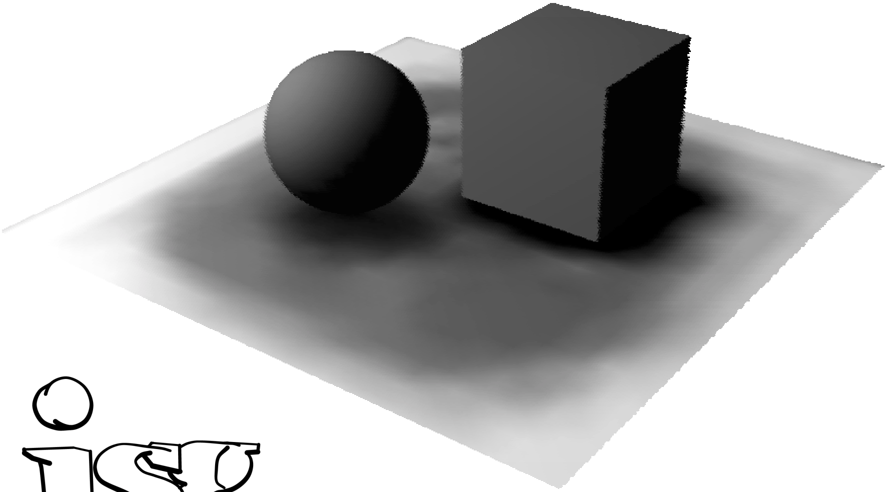
NVPARSE code

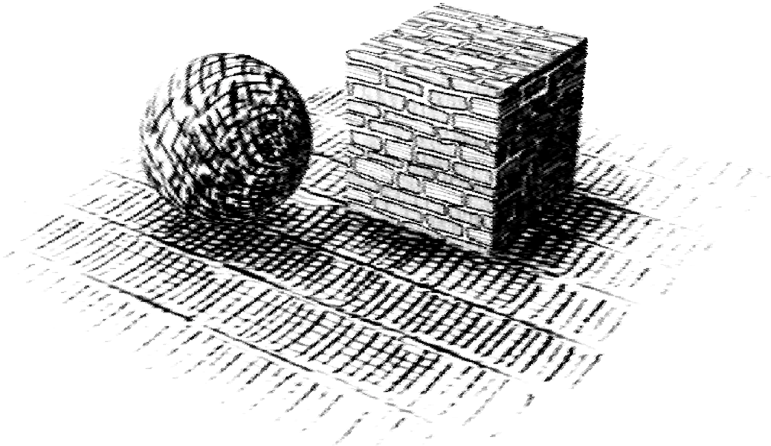
```
{
  rgb {
    discard = unsigned_invert(tex0); // 1-T
    discard = -col0;                 // -I
    spare0 = sum();                  // 1-T-I
    scale_by_four();                 // 4(1-T-I)
  }
}
out.rgb = unsigned_invert(spare0);   // 1-4(1-(T+I))
```

Extensions

Indication Mapping

- Enabled by per-pixel evaluation
- Bias intensity by indication
- Needs one additional combiner stage

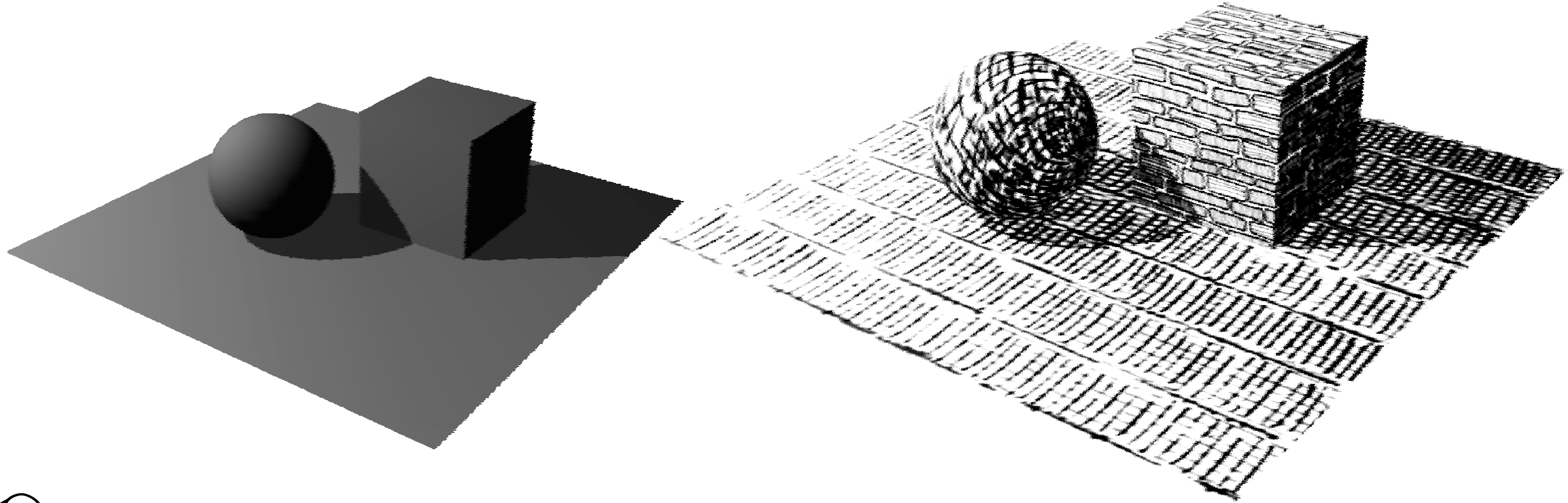




Extensions

Shadows

- Combinable with most shadow algorithms
- Adds greatly to realism



Conclusion

Shortcomings

- Limited accuracy
- Layers not strictly separated
- Only one-pass shading supported
  - Multiple passes via render-to-texture

Conclusion

Advantages

- Cheap:
  - no CPU effort
  - one texture unit
  - one register combiner
  - one pass
- Even works on “old” GeForce
- Well suited for highly interactive environments

Real-Time Stroke Textures

Questions?