Real-Time Texture-Mapped Vector Glyphs

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Motivation

- Raster images easy to use in textures
  - Random access
  - Simple
  - Blurred and pixellated when magnified
- Vector images would be useful here
  - Explicit representation of sharp edges
  - Especially important for text characters

Goals

- Resolution-independent “texture maps”
  - Vector graphics image representation
  - Efficient random access evaluation
  - High image quality (antialiasing)
- Specialized to representation of text
  - Support for many glyphs at once
  - Ability to place and move glyphs easily

Previous work

- P. Sen, *Silhouette Maps for Improved Texture Magnification*, Graphics Hardware, 2004
- J. Tumblin and P. Choudhury, *Bixels: Picture Samples with Sharp Embedded Boundaries*, Eurographics, 2004
- G. Ramanarayanan, K. Bala, and B. Walter, *Feature-Based Textures*, Eurographics, 2004
- C. Loop and J. Blinn, *Resolution Independent Curve Rendering using Programmable Graphics Hardware*, SIGGRAPH, 2005

Previous work

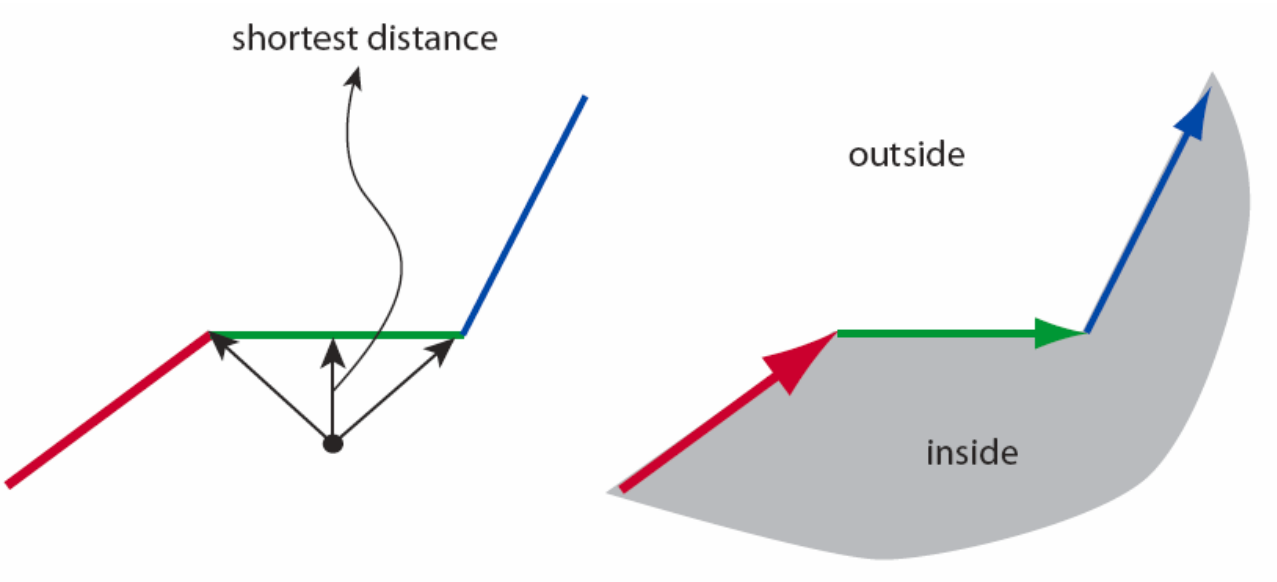
- S. Frisken and R. Perry, *Method for generating an adaptively sampled distance field of an object with specialized cells*, US patent, 2004
- R. Perry and S. Frisken, *Method and apparatus for rendering cell-based distance fields using texture mapping*, US patent, 2004
- S. Frisken, R. Perry, Rockwood, A. P., and Jones, T. R., *Adaptively sampled distance fields: a general representation of shape for computer graphics.* SIGGRAPH, 2000

Summary of approach

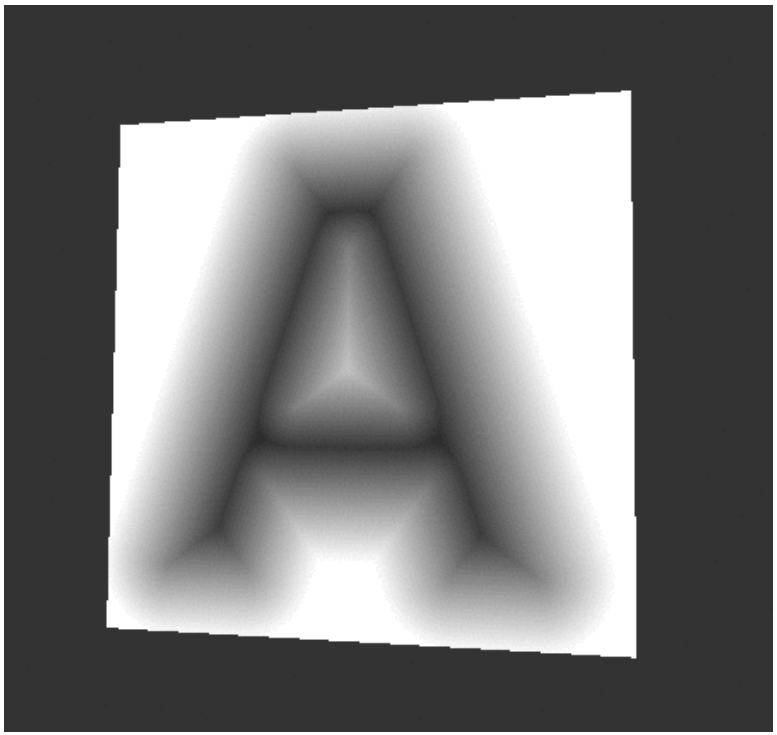
- Approximate curves with line segments
- Distance field representation
- Anisotropic antialiasing
- Sprite bombing

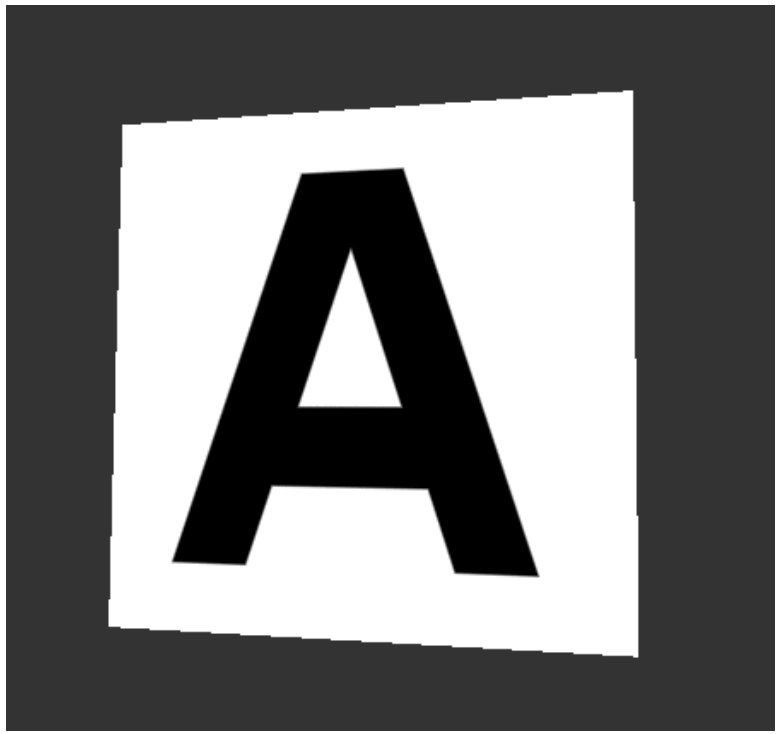
Distance Fields

- Signed distance to contour



Distance Fields



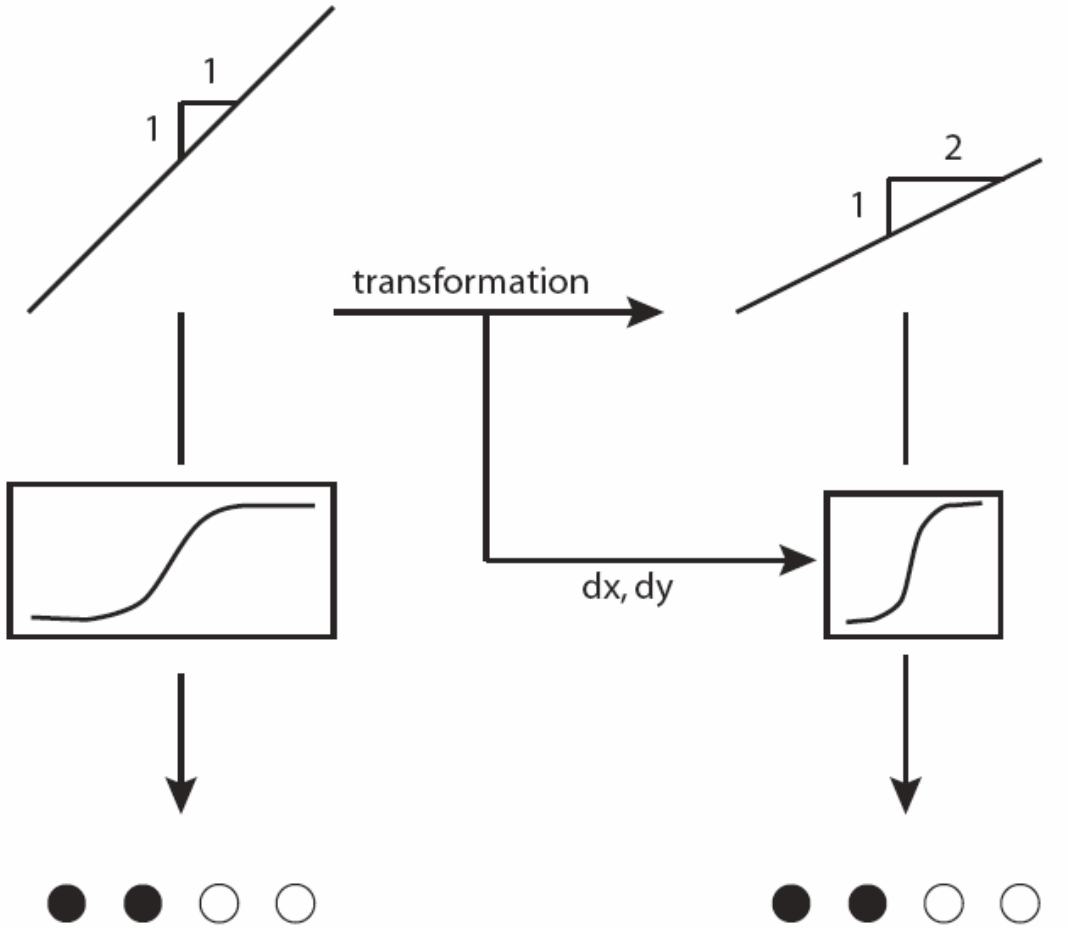


Antialiasing

- Gradient gives direction of maximum variation
- In texture space:
  - Gradient of distance field always has magnitude of 1
- In screen space, after texture mapping:
  - Length of gradient can change
- Use smooth step for antialiasing
  - Variable width transition
  - Correct for scaling of gradient magnitude
  - Get constant width transition in screen space

Result: Cheap anisotropic antialiasing

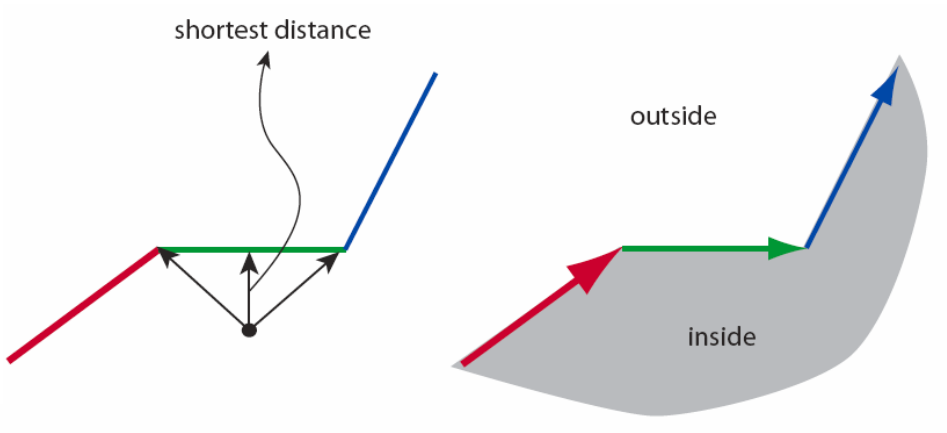
Antialiasing



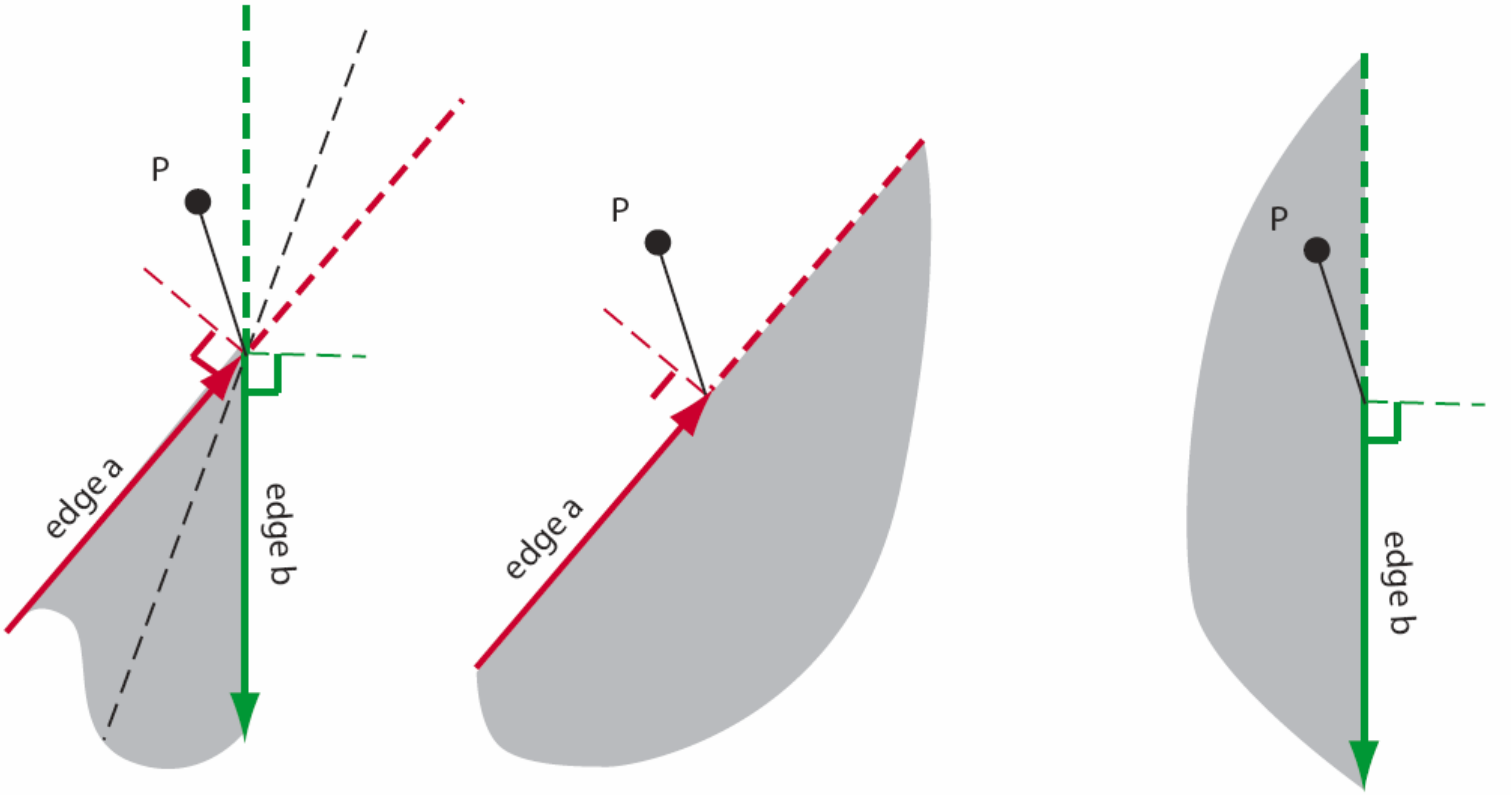
Anisotropic antialiasing results

Signed Contour Distance Computation

- Find closest line segment
  - Compute distance
  - Assign sign using plane equation
- Ambiguity when closest point is endpoint of two line segments



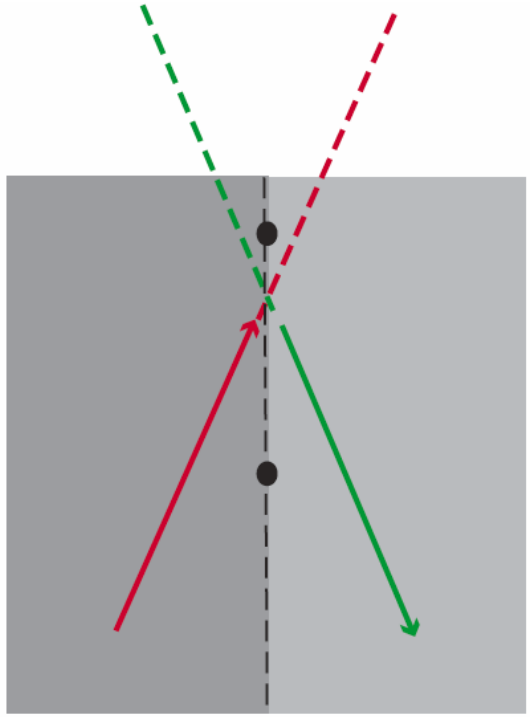
Sign Ambiguity Problem



Sign Ambiguity Artifacts

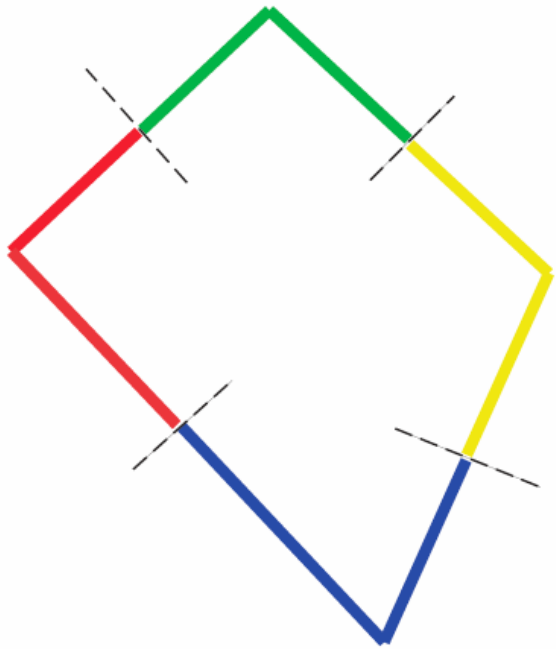
Distance computation: Fix 1

- Use small gaps between line segments
  - No shared endpoints
  - More precision needed
  - Possible artifacts



Distance computation: Fix 2

- Use “corners” as features
  - No ambiguity
  - More computation

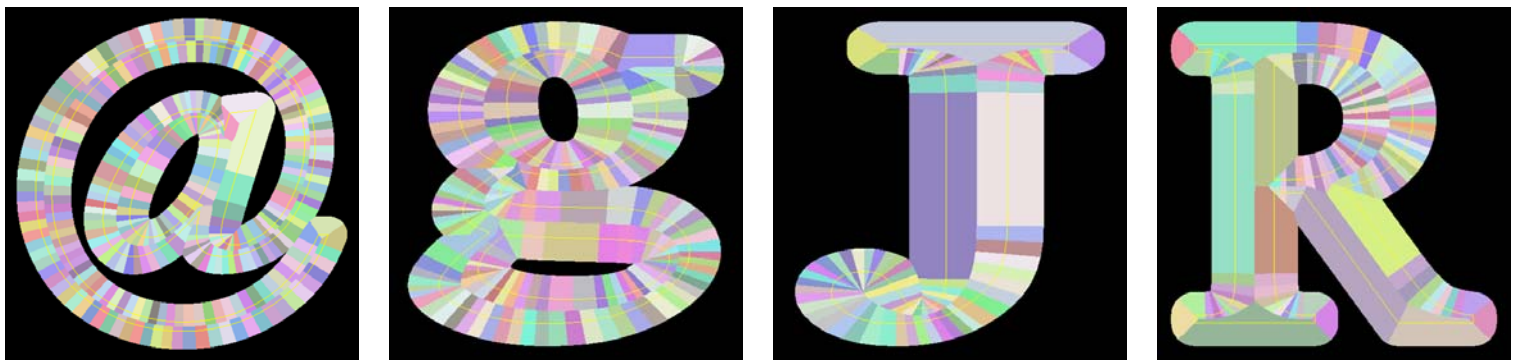


Accelerators

- Testing *all* features too slow
- Want data structure to select candidates
- Should be conservative

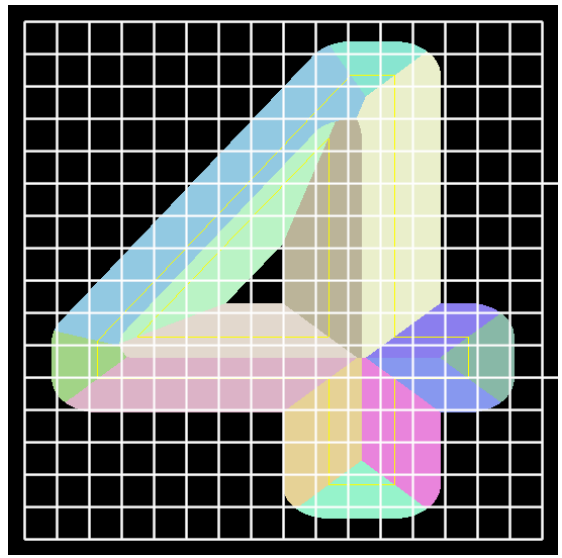
Voronoi Acceleration

- Voronoi diagram gives closest feature
  - Would be optimal accelerator
  - Only compute distance to one feature
- Possible ways to store Voronoi diagram:
  - BSP tree
  - Grids

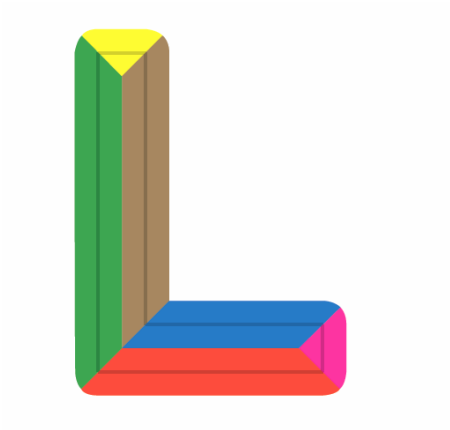


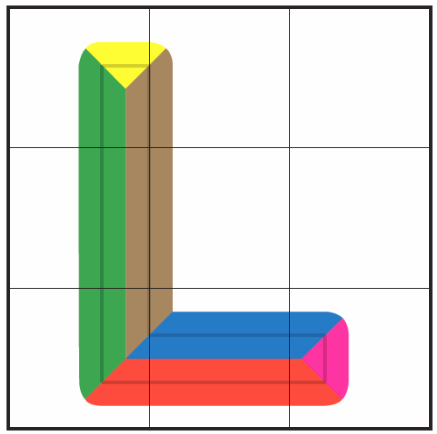
Grid Accelerator

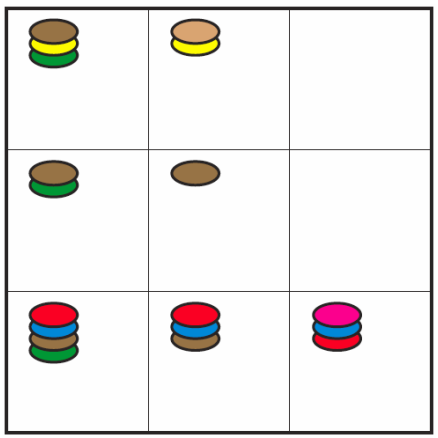
- Superimpose grid on Voronoi diagram
- List features in each cell of grid
- Assume will search local neighborhood
- Pack to avoid redundancy
  - Simulated annealing

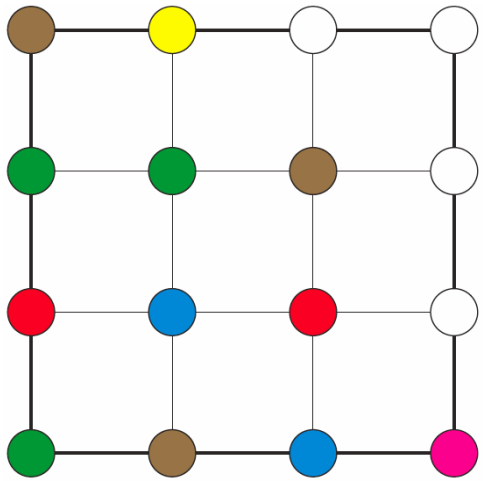


Grid Accelerator: Packing



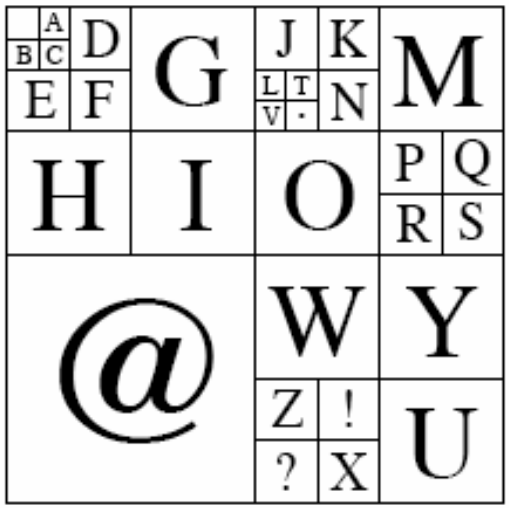






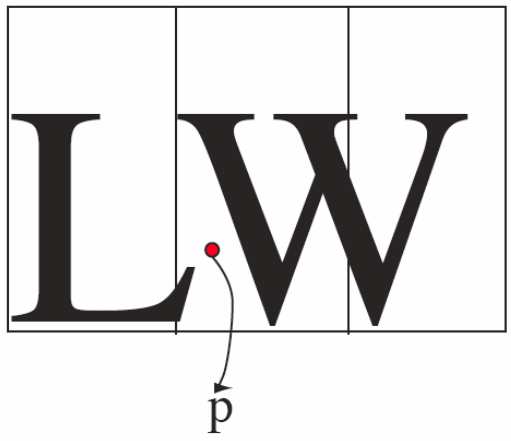
Font Table

- Analyze glyphs in font, store in table
- More resolution for complex glyphs
- Rescale to square

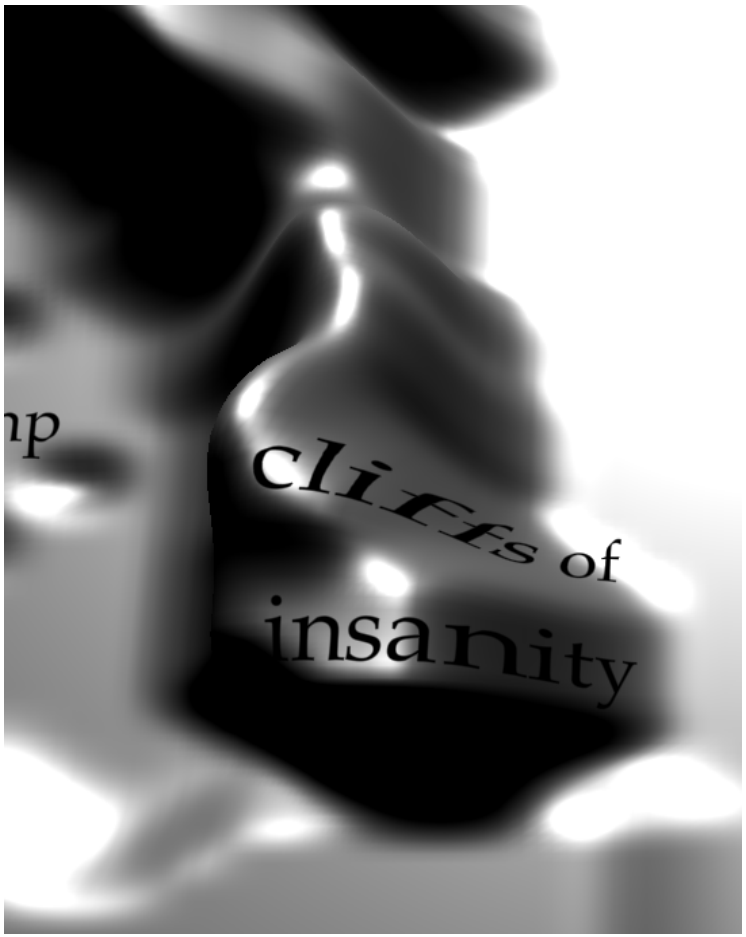


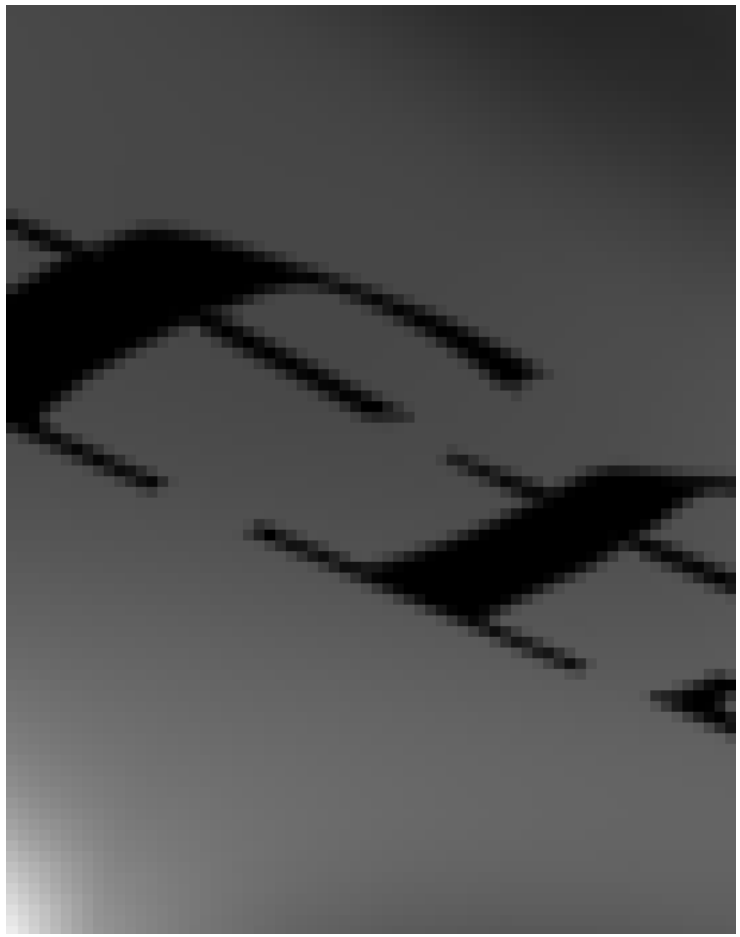
Sprite Table

- Table references one glyph per cell
- Each cell stores offset and scale factors
- Compute min distance to adjacent cells

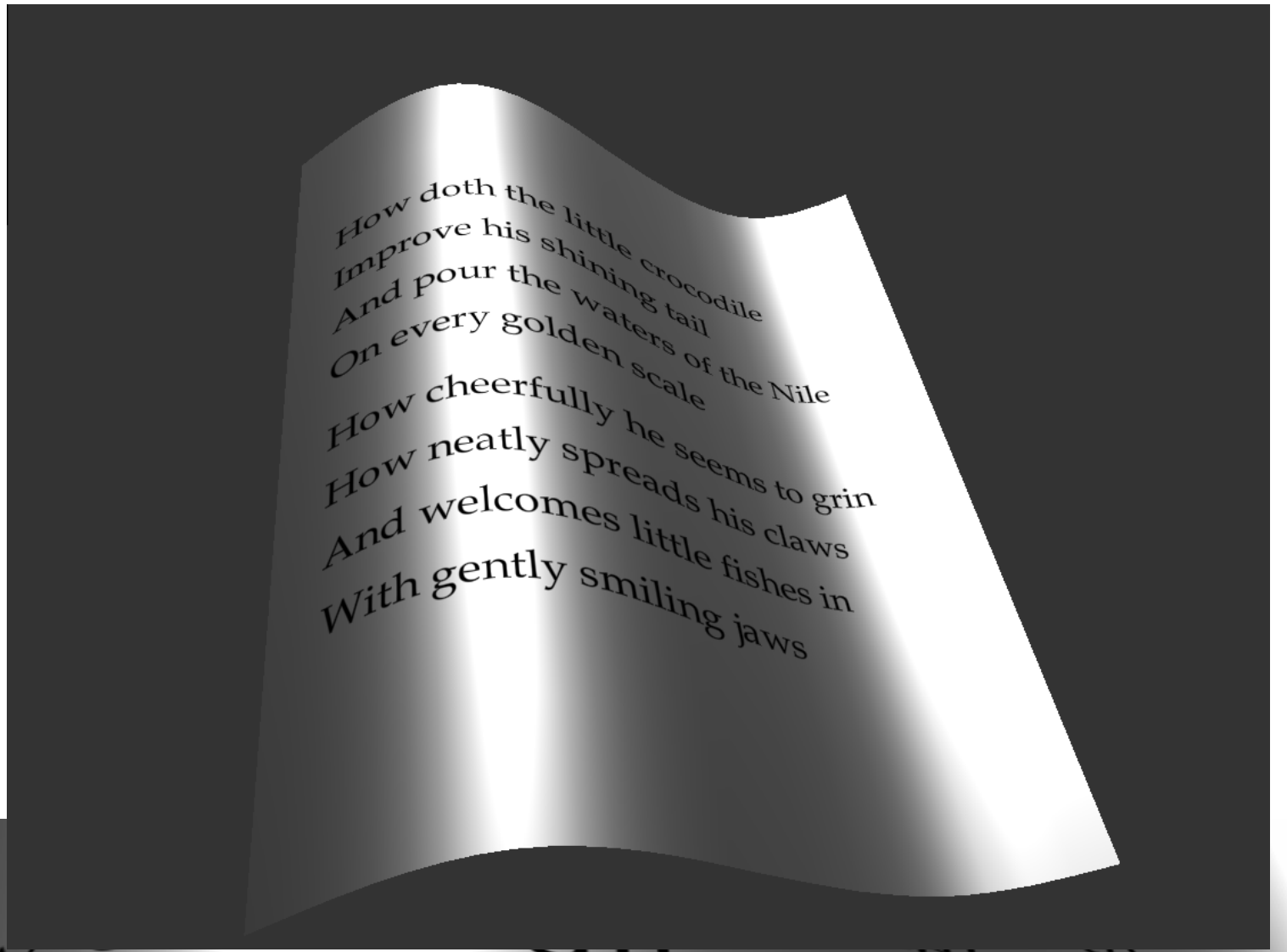


Results: Deformation and antialiasing

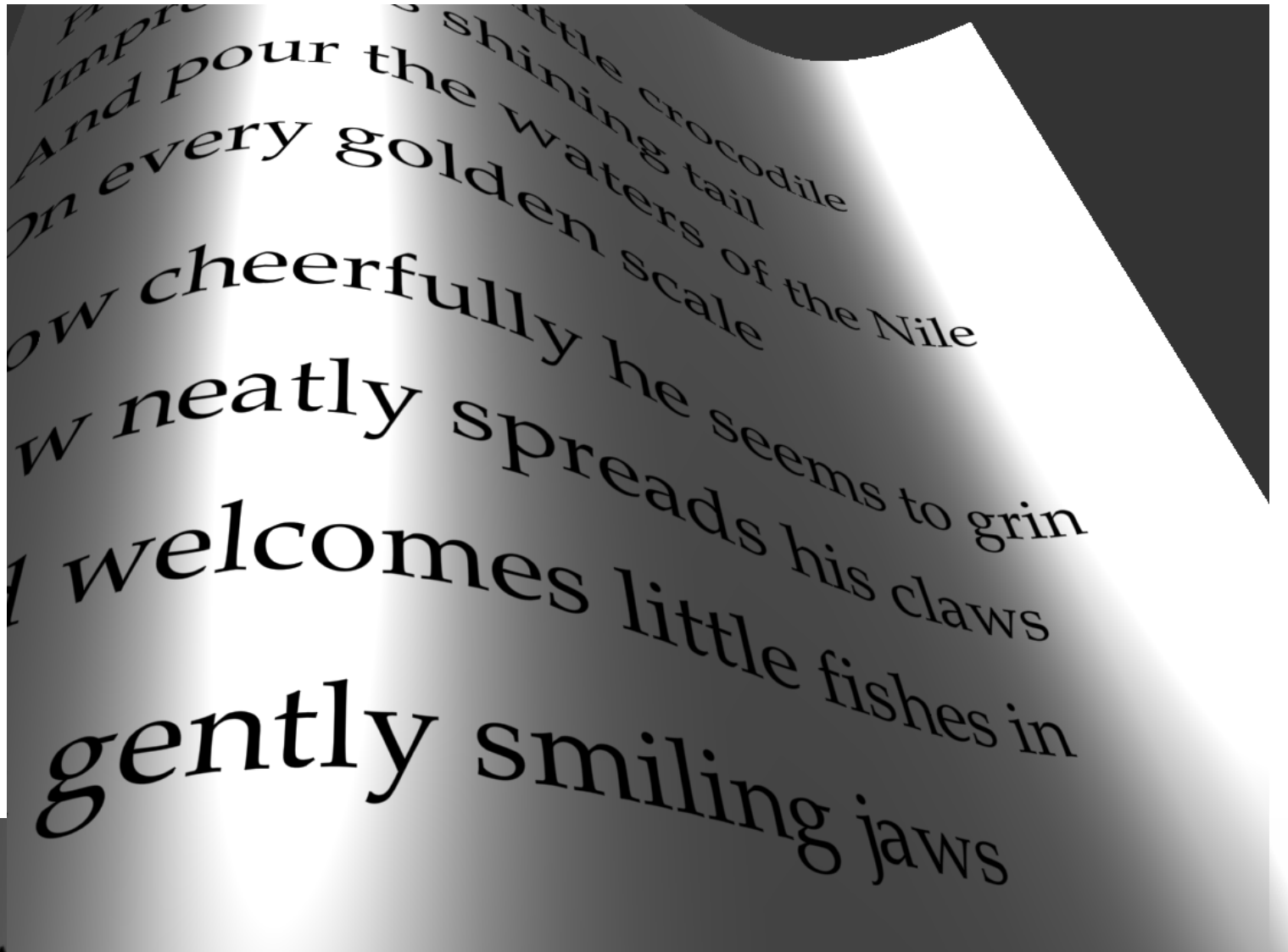




Results: Text pages

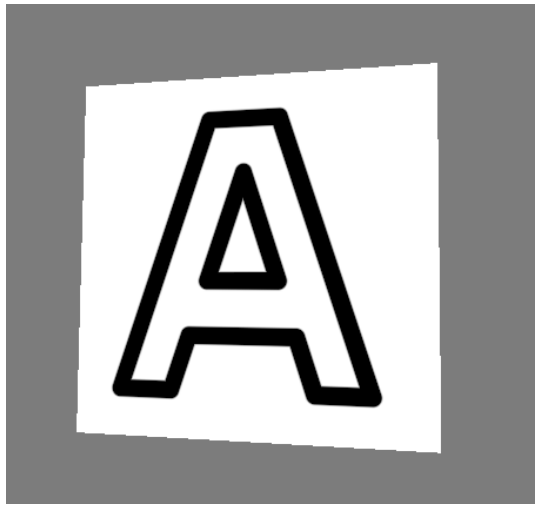


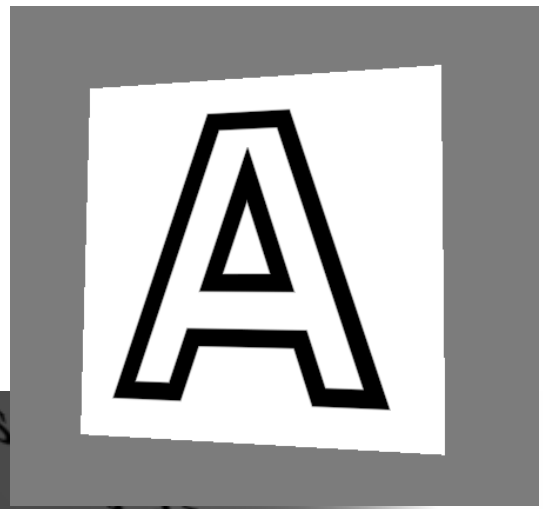
Results: Text pages



Results: Text pages

Results: Special effects





Performance

- Implemented using Sh
  - Gives strong data encapsulation
  - Hide details of representation
  - Object with same interface as texture
- GPU generated Voronoi diagram
- Annealing normally takes 1 to 2 seconds
- Above 80 fps for full 512 by 512 window
- P4 2.6GHz, 7800GT

Contributions and Conclusions

- Semi-procedural representation for real-time rendering of vector glyphs
  - Supports anisotropic anti-aliasing
  - Supports random access
  - Use just like a texture
  - No mesh modification
- Exact distance computation
  - But approximation of curved contours
  - Supports special effects
- Sprite table
  - Dynamically editable text placement
  - Many glyphs

Limitations and Future Work

- Storage size given by most complicated point
  - Use adaptive texture
  - Use multi-resolution textures
  - Use control flow
- Curve approximation causes creases
  - Exploring use of curved features
- Texture is stored in floating point
  - Use integers by transforming to local coordinates
- Working on support for general SVG images
  - Region coloring and gradients