

Hardware Implementation

- Saffron – V0 (Biquadratic cells only)



Hardware Implementation

- Saffron – V0 (Biquadratic cells only)
 - 156K gates on an FPGA
 - Includes memory controllers for accessing fonts and frame buffers
 - Includes compositing (triple buffered)
 - Renders 100,000 glyphs per second at 100 MHz for 10 point, 96 dpi, LCD rendering (3 samples per pixel)
 - Current implementation has a single component pipeline
 - Designed for a 3 component pipeline (3x as fast at a cost of 20K-30K additional gates per pipeline)

Patents

- Detail-Directed Hierarchical Distance Fields: **U.S. Patent No. 6,396,492**
- Method for Antialiasing an Object Represented as a Two-Dimensional Distance Field in Image-Order
- Method for Antialiasing an Object Represented as a Two-Dimensional Distance Field in Object-Order: **Allowed**
- Method for Animating Two-Dimensional Objects
- Method for Converting Two-Dimensional Objects to Distance Fields
- Method for Converting a Two-Dimensional Distance Field to a Set of Boundary Descriptors
- Method for Converting Two-Dimensional Pen Strokes to Distance Fields
- Method for Generating a Two-Dimensional Distance Field within a Cell Associated with a Corner of a Two-Dimensional Object

Patents

- Method and Apparatus for Antialiasing a Set of Objects Represented as a Set of Two-Dimensional Distance Fields in Image-Order
- Method and Apparatus for Antialiasing a Set of Objects Represented as a Set of Two-Dimensional Distance Fields in Object-Order: **Allowed**
- Method for Generating a Composite Glyph and Rendering a Region of the Composite Glyph in Image-Order
- Method for Generating a Composite Glyph and Rendering a Region of the Composite Glyph in Object-Order
- Methods for Generating an Adaptively Sampled Distance Field of an Object with Specialized Cells
- Method and Apparatus for Rendering Cell-Based Distance Fields Using Texture Mapping: **Allowed**
- Method for Typesetting a Set of Glyphs Represented as a Set of Two-Dimensional Distance Fields

Patents

- Method, Apparatus, and System for Rendering Using a Progressive Cache
- Pipeline and Cache for Processing Data Progressively
- Modeling and Combining Multiple Graphics Objects
- System and Method for Generating Adaptively Sampled Distance Fields with Bounded Distance Trees
- Method for Traversing Quadtrees, Octrees, and N-Dimensional B-trees: **U.S. Patent No. 6,868,420**

Patents

- Distinction from prior art
 - Distance fields vs. images
 - Distance-based anti-aliasing vs. coverage-based anti-aliasing
 - Sampling discrete space vs. sampling continuous space
 - Derive alignment zones for grid fitting from distance field, not from hinted outlines
 - For typesetting, adjustments are made to advance widths using distance fields after iso-contour selection

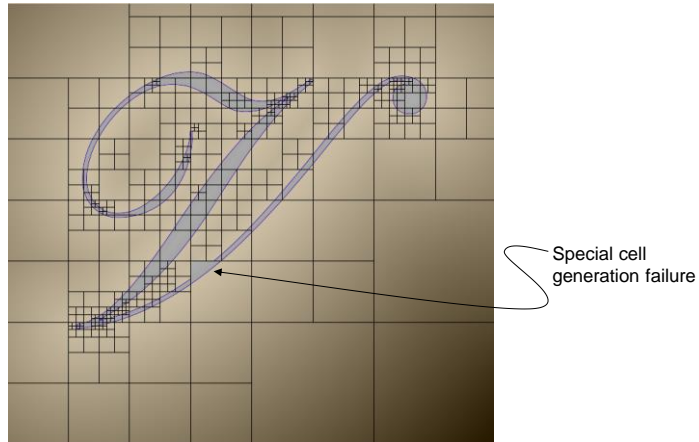
Limitations of Saffron – V1

Alignment Zones

- Current alignment zones include baseline, x-height or cap-height, and two vertical stems
- Some Latin glyphs would benefit from more alignment zones
 - Glyphs with 2 vertical or horizontal zones (e.g., e, F, m)
 - Glyphs with descenders (e.g., p, q, y)
- Need multiple alignment zones or new approach for best results in complex characters
 - e.g., CJK fonts

Issues and Unproven Features

- The predicate test used for special cell generation is not fail proof



Issues and Unproven Features

- Non-uniform scale in x and y distorts the filter region
- Some markets may require additional hint-level fine tuning to provide ultimate control
- Rendering bitmaps from ADFs untested/unproven
 - 2-bit rendering for eInk was successful

Memory and Processing

- Memory constrained devices
 - ADFs may be too big
 - 2D Distance field representation will always be bigger than 1D outline representation
- Processor constrained devices
 - Generation may be too slow

Saffron Roadmap

Saffron Roadmap

- Direct rendering
 - Solution for memory and processor constrained systems
- Hardware implementations
 - Special cell rendering
 - Direct rendering
 - Low power requirements?
 - Market potential? (Mitsubishi internal vs. broader markets)

Saffron Roadmap

- High quality small CJK
 - High quality stroke-based fonts with
 - Variable stroke weight
 - Various endcaps
 - Rounded, square, mitered, beveled, brushed
 - Alignment zones and grid fitting
 - Direct rendering
 - Automatic generation from outlines
 - Design tool

Saffron Roadmap

- Enhancements and extensions
 - CSM profile builder
 - Alignment zones for non-latin fonts
 - Hindu, Arabic
 - More general approach (e.g., multiple alignment zones) for CJK
- GPU implementation of direct rendering
- Extend library to support alternative pixel patterns
- Performance and size enhancements for Saffron – V1

Direct Rendering

Direct Rendering

- See separate presentation

Advantages Over
Traditional Approaches

Advantages

- Sub-pixel rendering patent issues
 - Saffron's IP is comprehensive and patently-distinct from Microsoft's ClearType
 - Traditional, coverage-based anti-aliasing approaches encroach on Microsoft's extensive patent portfolio

Advantages

- Hinting
 - Saffron achieves high quality without hinting
 - Some markets are encumbered by hinting (e.g., Flash and SVG)
 - Markets with size constraints (bandwidth, disk space, memory space)
 - Dynamic environments where applications have no control over font quality (e.g., hints may not be available)
 - Hinting new fonts is labor intensive and expensive
- Sub-pixel hinting
 - Hinting fonts for sub-pixel rendering is even worse
 - Legacy bug in hinting of certain glyphs (e.g., Arial 'x')

Advantages

- Hardware market
 - Computationally clean rendering pipeline is straightforward to implement in silicon
 - No special casing of type vs. graphics
 - Hardware prototypes
 - Saffron – V0 hardware prototype exists
 - Hardware implementations of Saffron – V1 and direct rendering approach are under development

Advantages

- GPU implementation is straightforward
 - Potential markets
 - Desktop/laptop market (e.g., GPU-centric Longhorn)
 - Console and handheld game market
 - Embedded systems market
 - GPUs will be increasingly incorporated into next generation devices
 - GPUs on today's devices could support Saffron using Gouraud shaded texture mapped triangles

Advantages

- High quality stroke-based CJK
 - Can provide higher quality stroke-based fonts with a small memory footprint
 - Can provide much higher quality than current market offerings
 - Variable stroke weight
 - Designed endcaps

Advantages

- Alternative pixel patterns and displays
 - Saffron adapts easily to different sampling patterns
 - Saffron requires only one sample per pixel component for anti-aliasing
 - Saffron doesn't depend on the topology of the pattern
 - Kodak OLEDs
 - ClairVoyante Pentile
 - Continuous Stroke Modulation (CSM) provides OEMS with unprecedented control to tune type for their specific displays

Advantages

- Special effects
 - CSM control
 - Inexpensive thin and bold typefaces
 - Temporal anti-aliasing
 - Motion blur
 - Using the distance field for special effects such as soft-body deformation and particle systems
 - 3D type