GLyphy

Behdad Esfahbod
behdad@google.com

glyphy.org
behdad.org

Getting your CFP abstract accepted: *A case study (or 2)*

Helps if…

- Established
- ~100s millions users
- *Has* changed the world
- Thriving community
- Many high-profile users
- Booming

HarfBuzz

But if…

- Experimental
- Unused so far
- *Will* change the world
- No community
- No users
- Stale


GLyphy

Submit!

How to *keynote* LCA

Just cut the jokes out *dude*!

GLyphy

An *experiment* in GPU-accelerated text rendering

GLSL ES2

Status quo

- Hint
- Rasterize
- Upload to GPU texture
- Blit

Transformation dependent

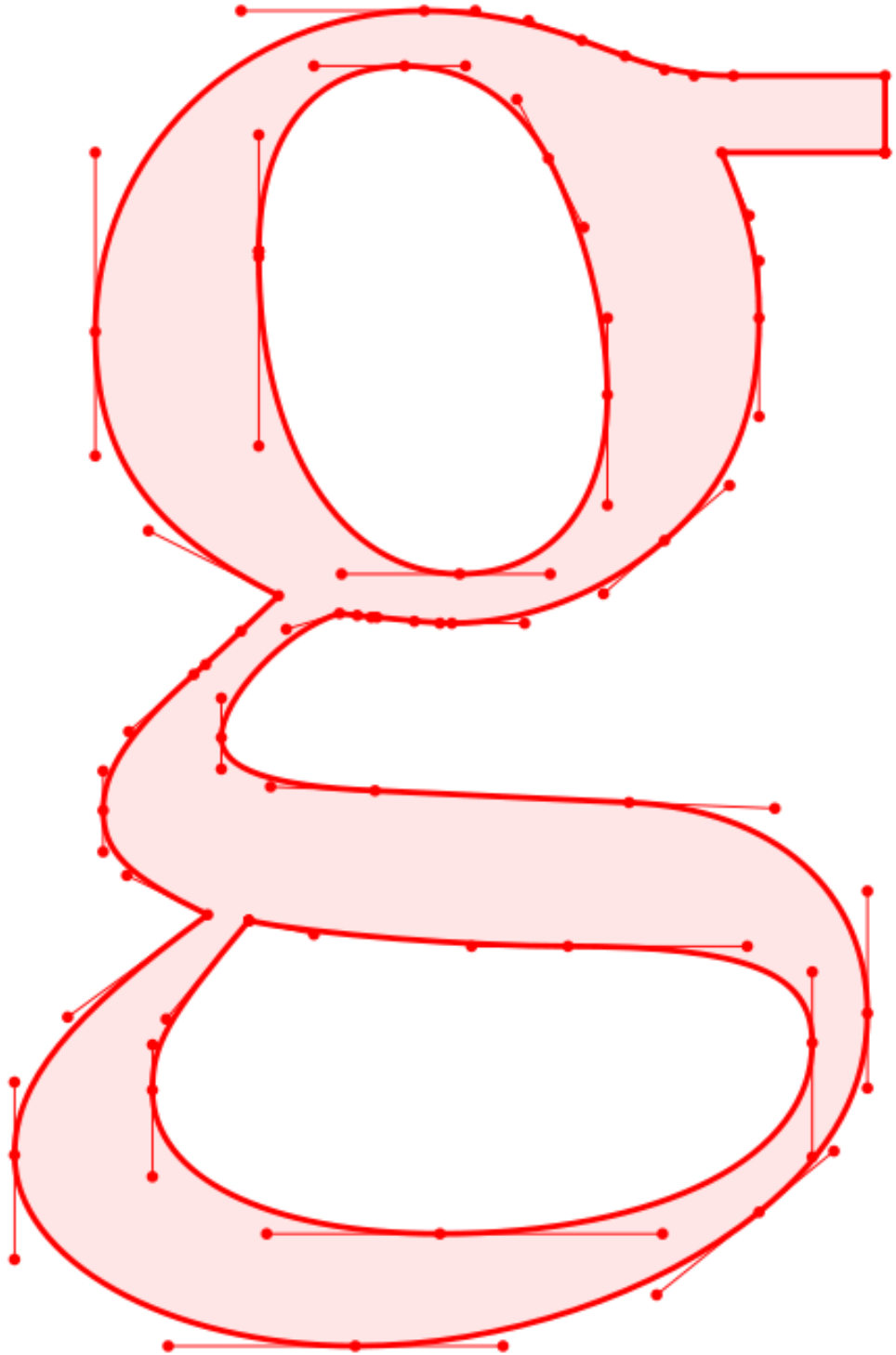
Lets make text beautiful!

lolz

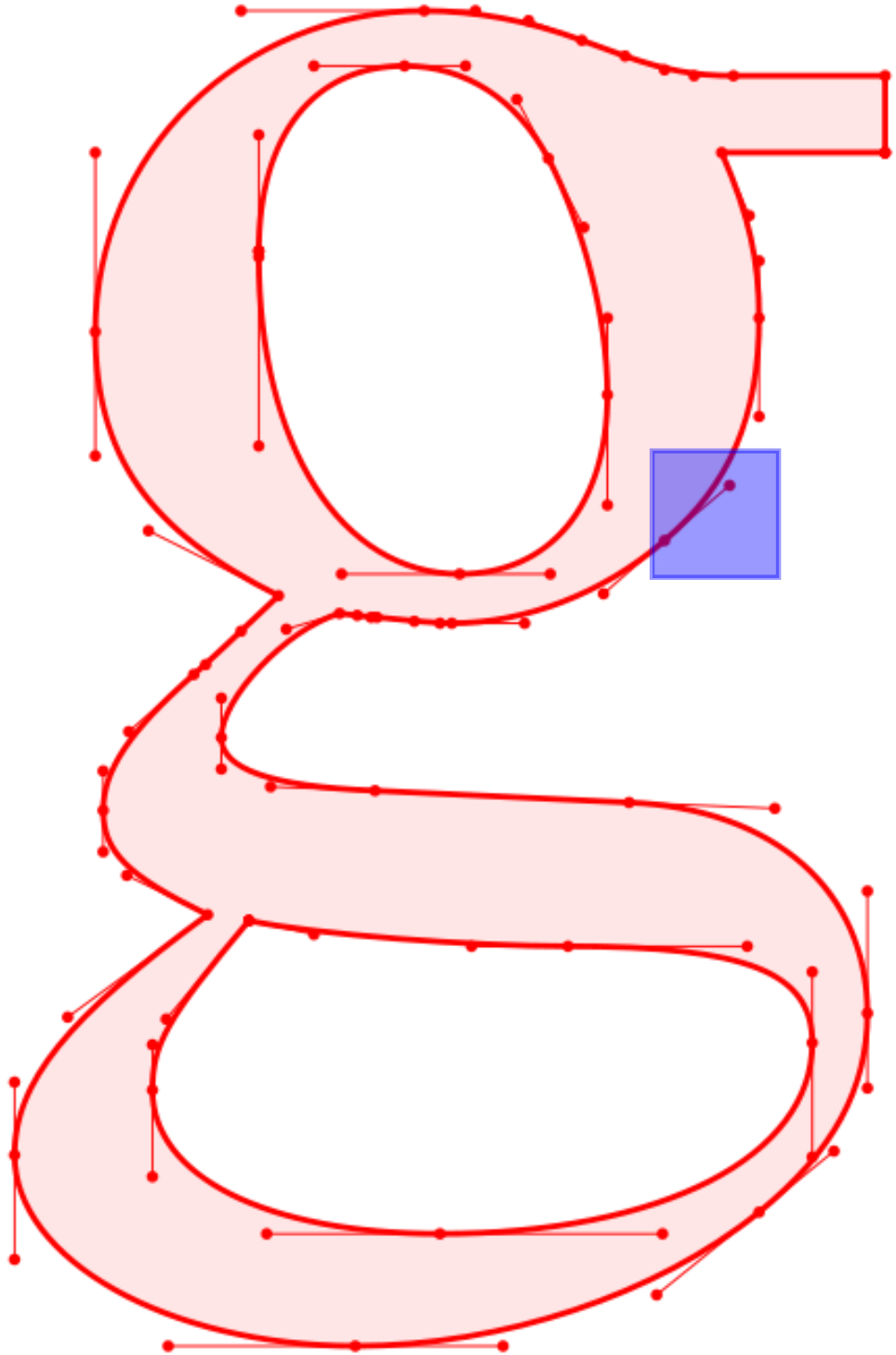
What would you do if you ~~knew you could not fail~~ have a high-resolution display?

~~200+ppi (160 even)~~

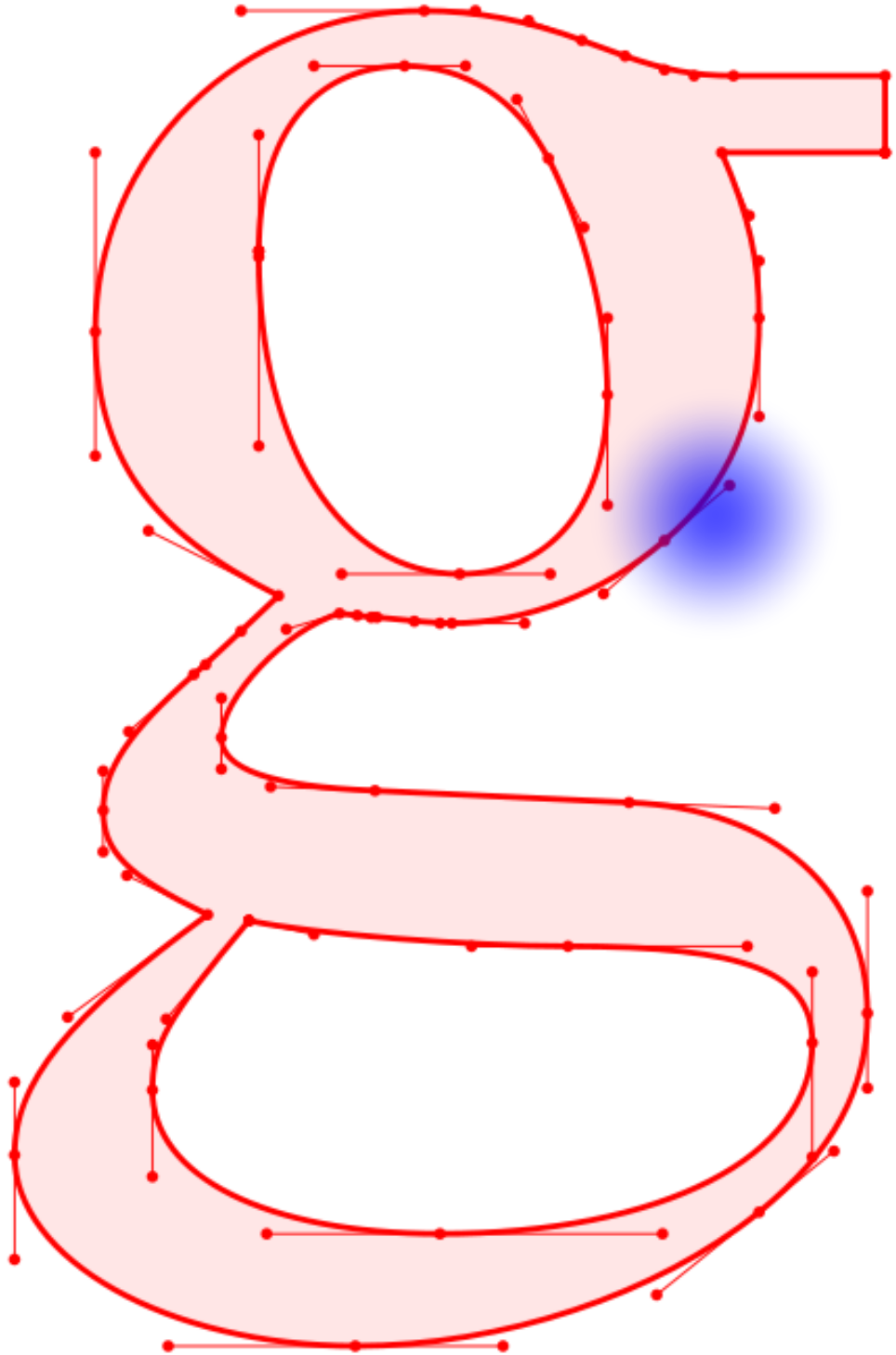
300+ppi (450 even)



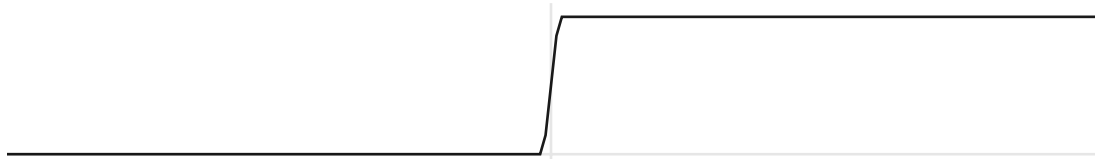
Coverage-based Anti-Aliasing

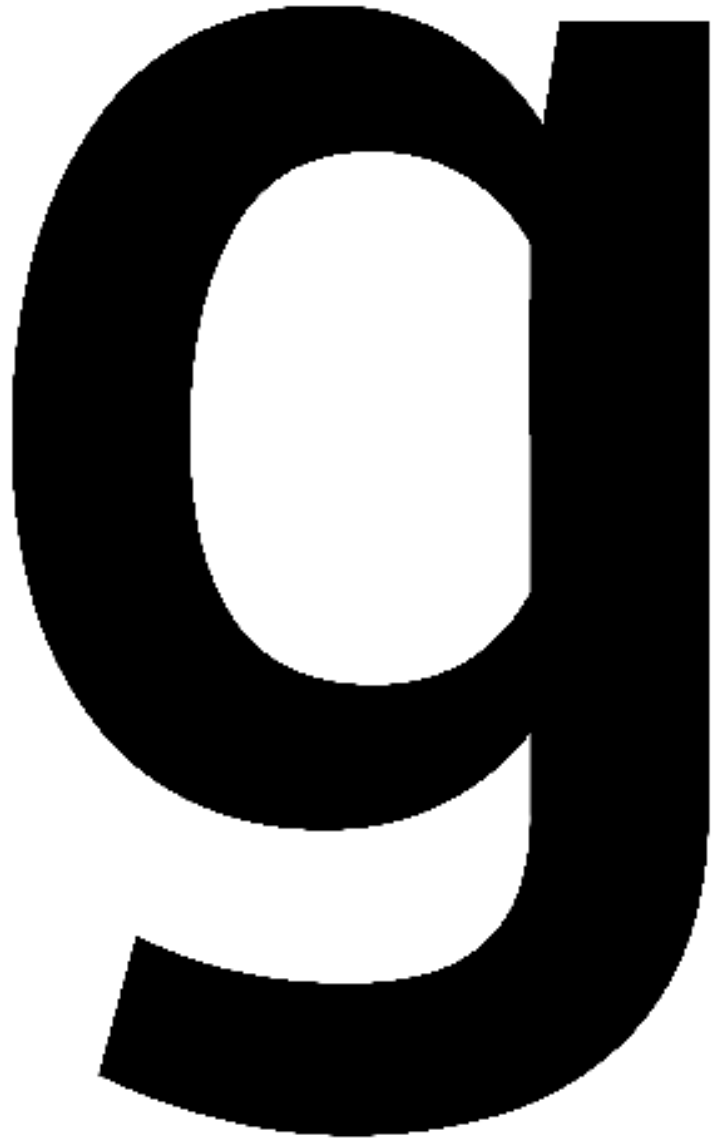


SDF-based Anti-Aliasing

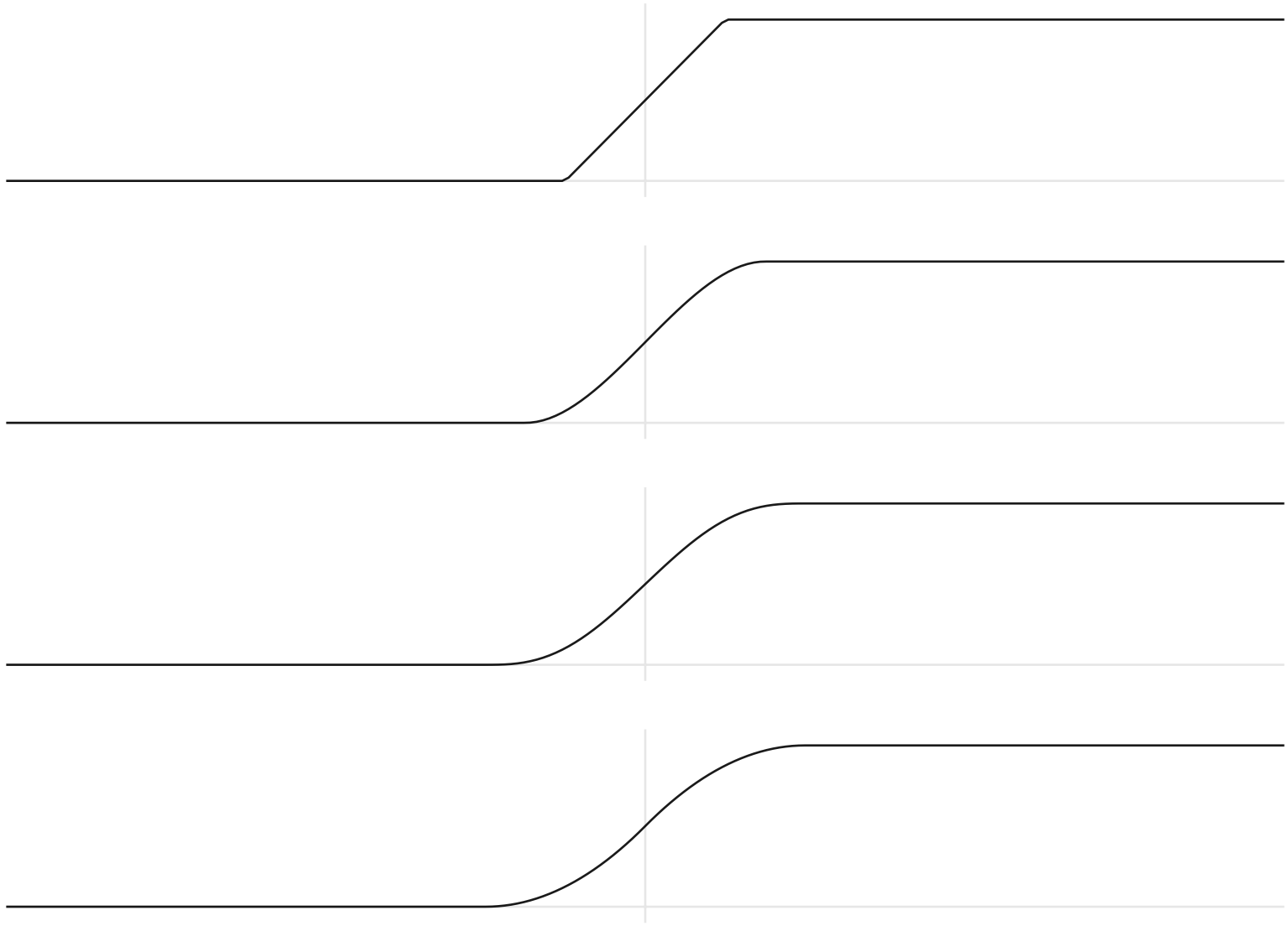



g



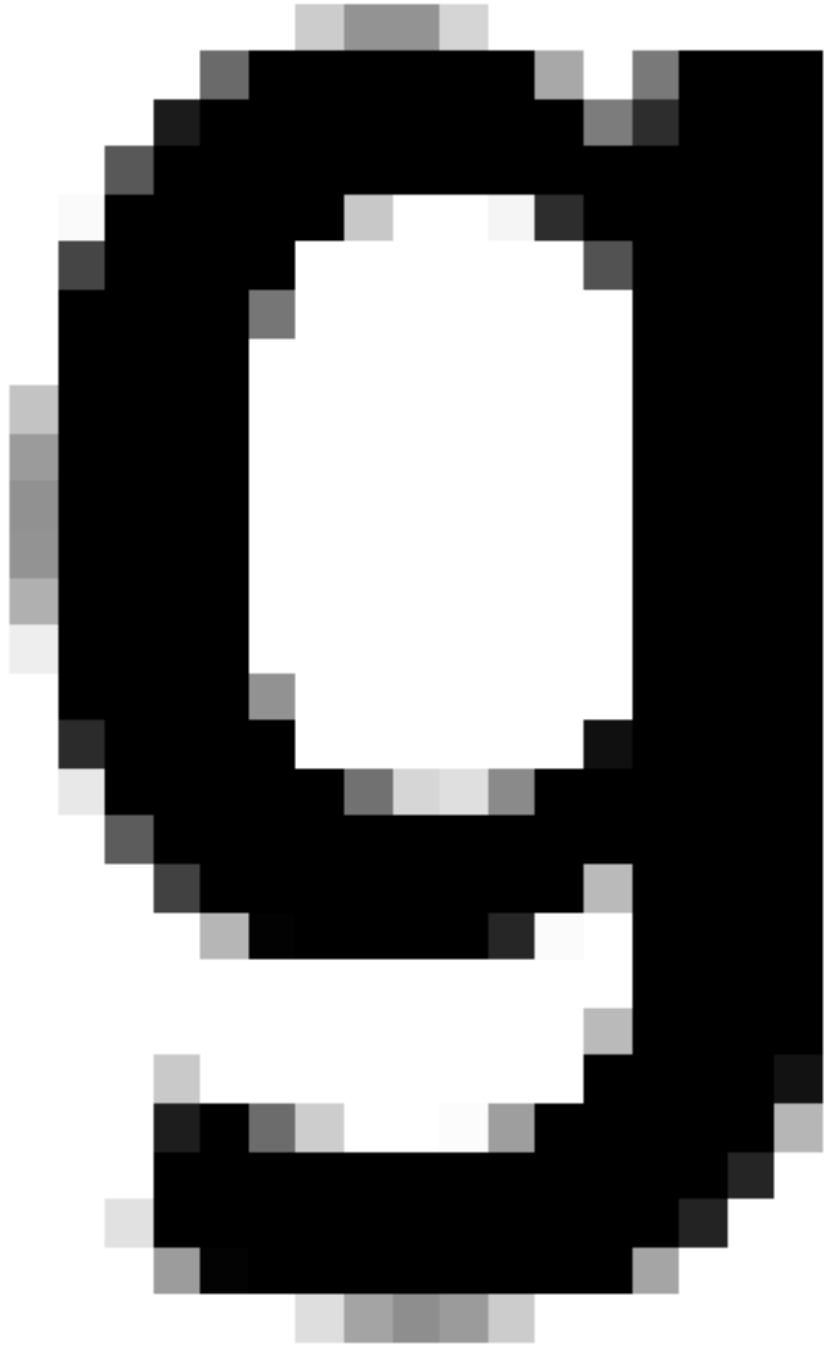


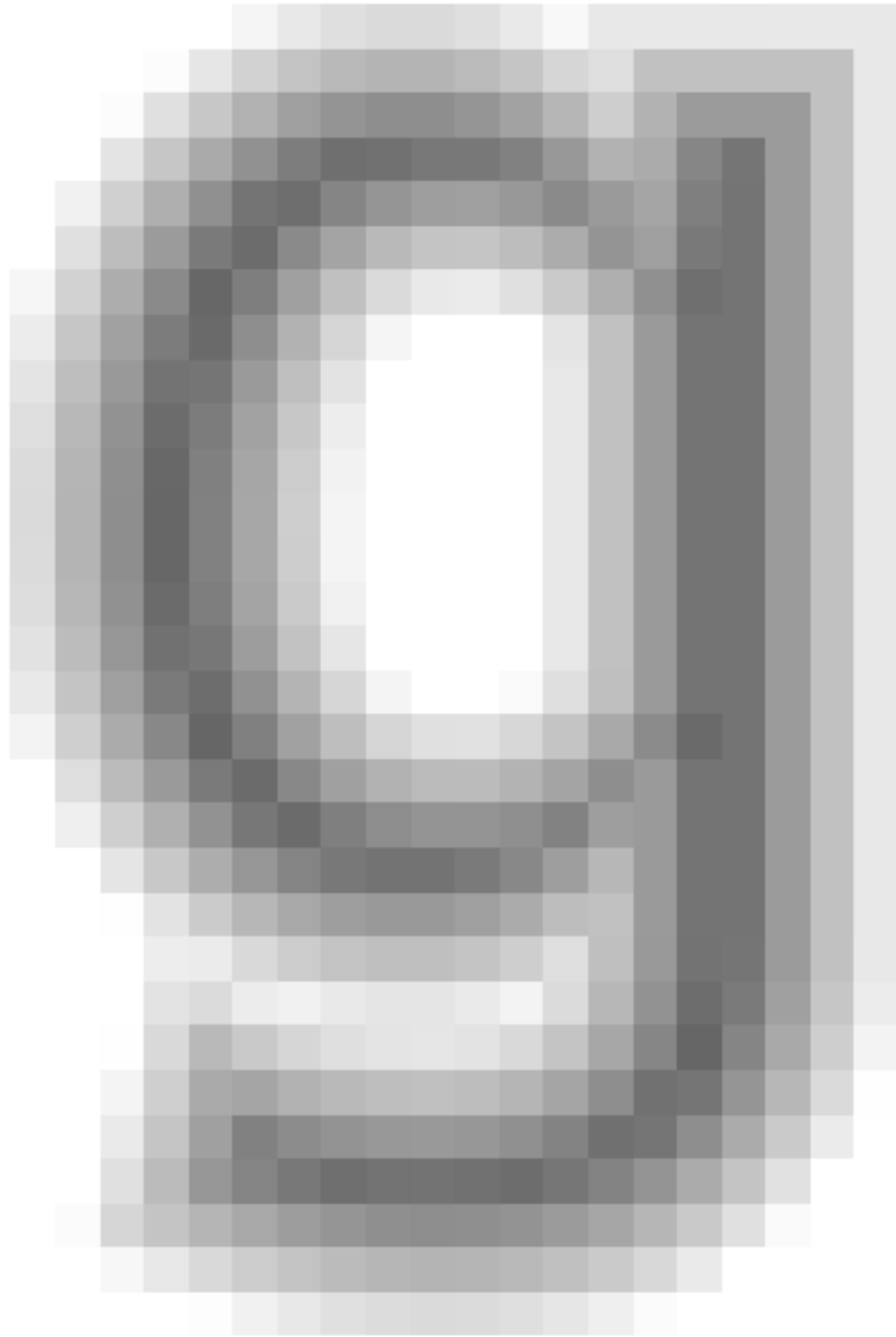
g



SDF is *linear* over uniform-scaling and translation

Represent SDF on GPU



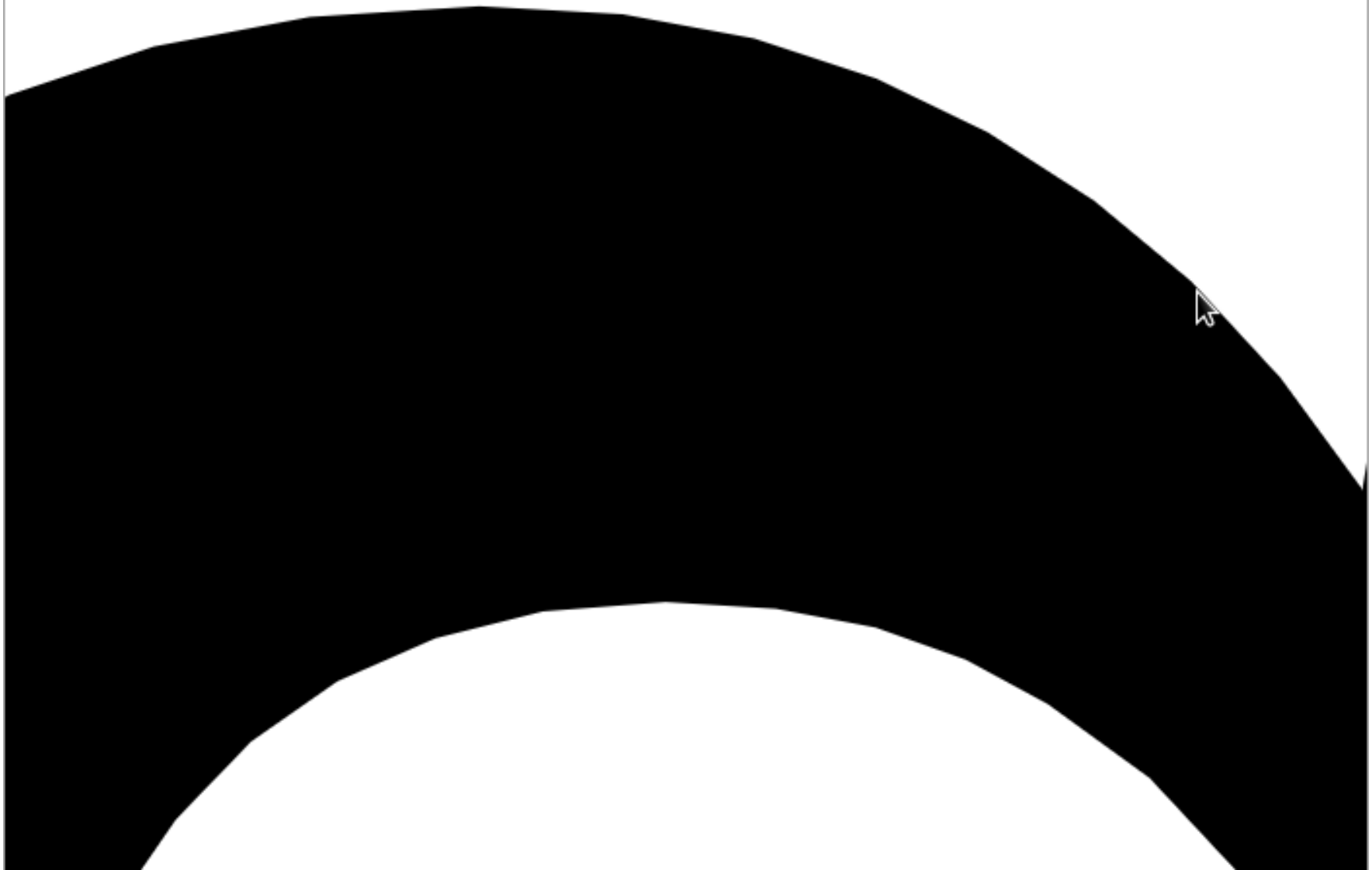


Vector all the glyphs!

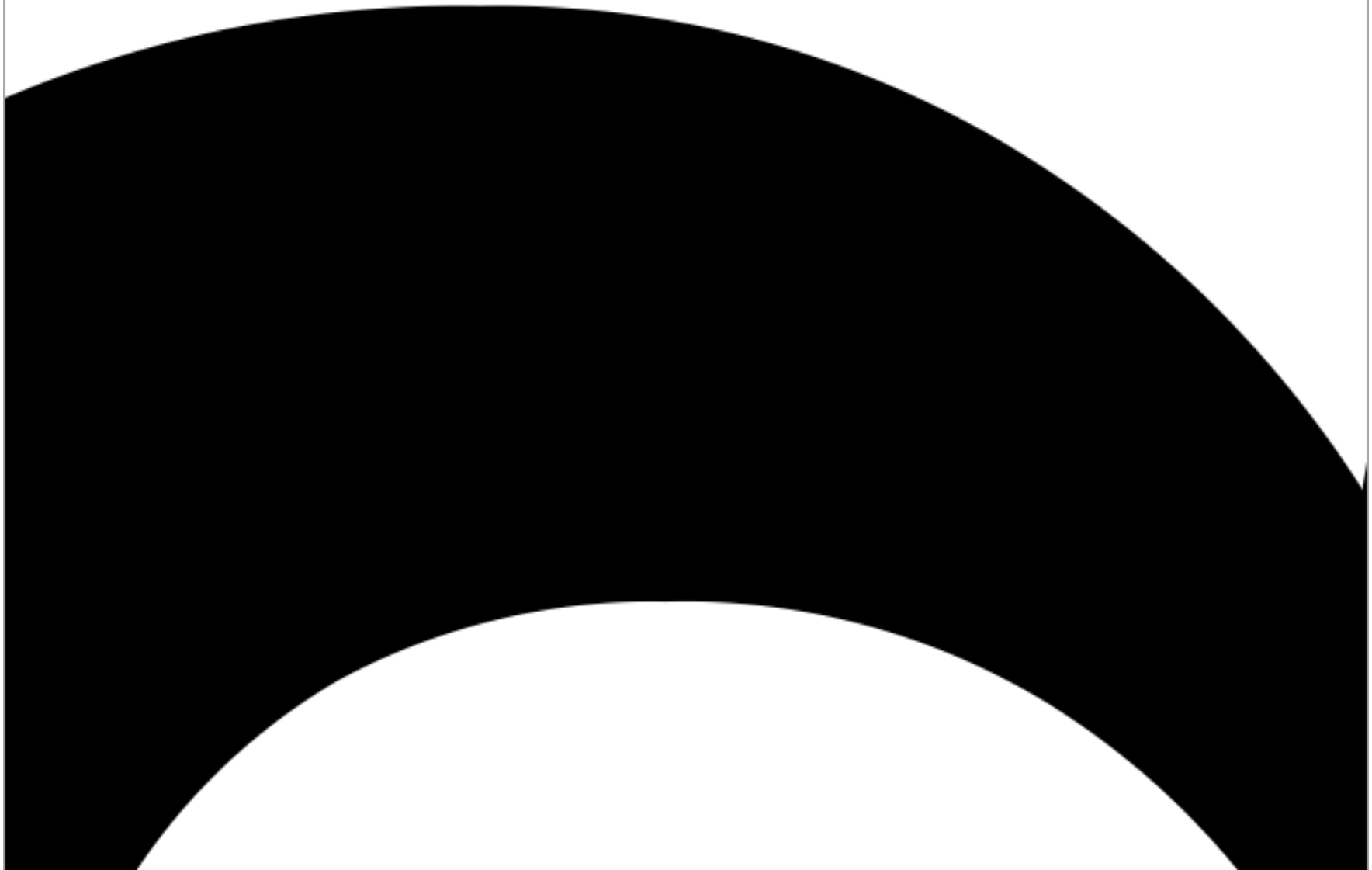
Distance to Bézier


Ouch!

Convert to line segments

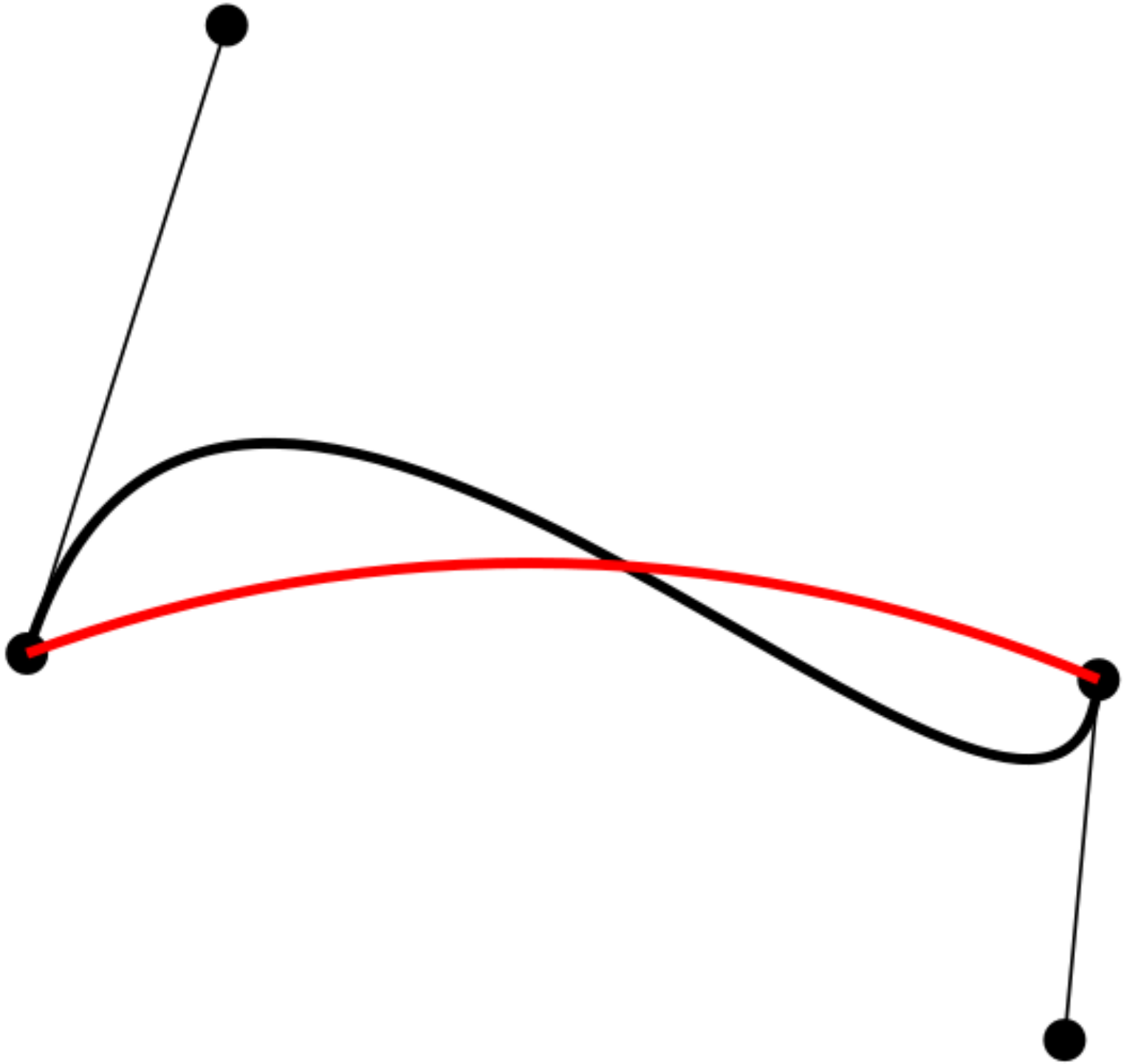


Convert to circular arc splines

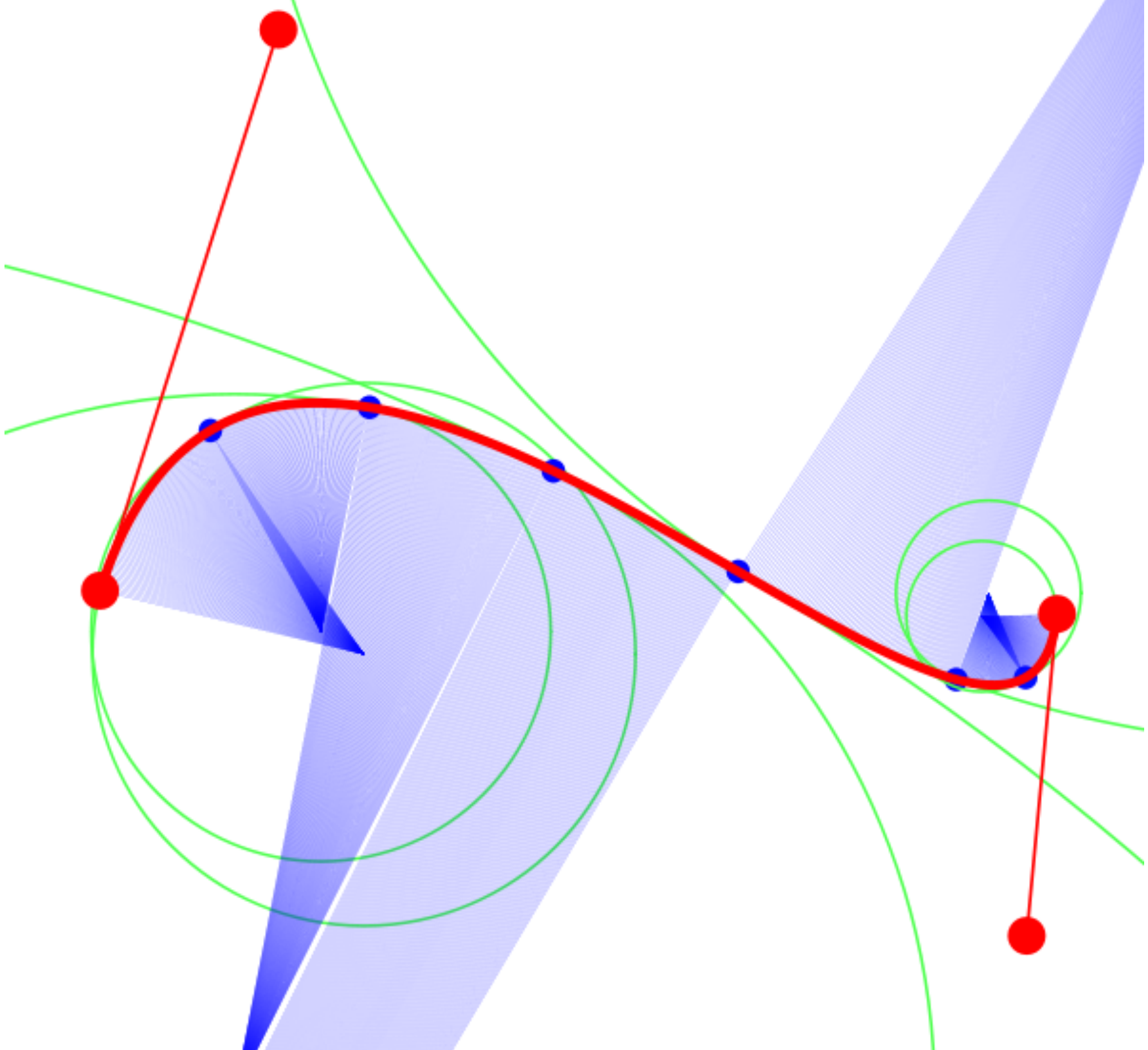


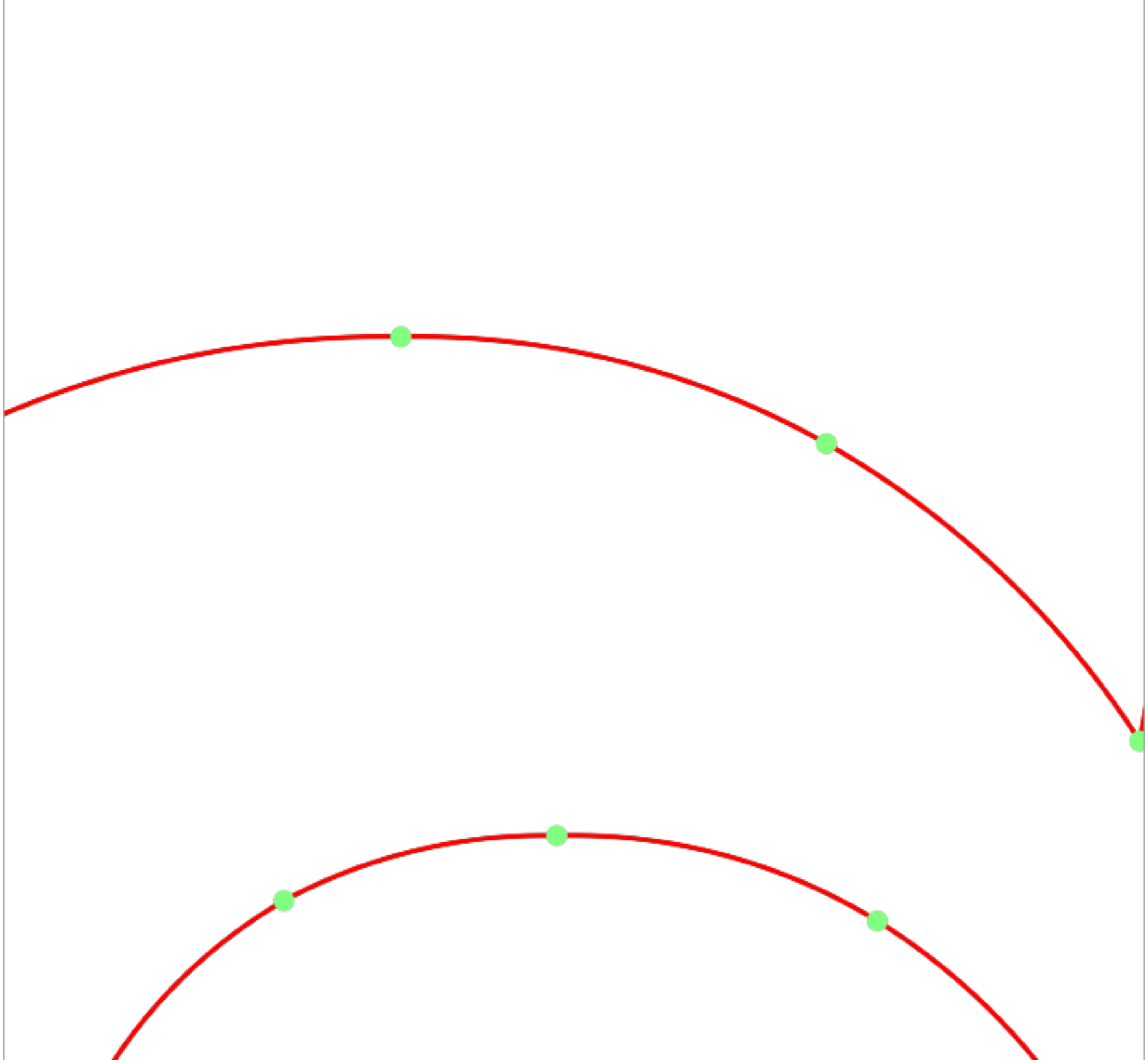
Arc-spline approximation

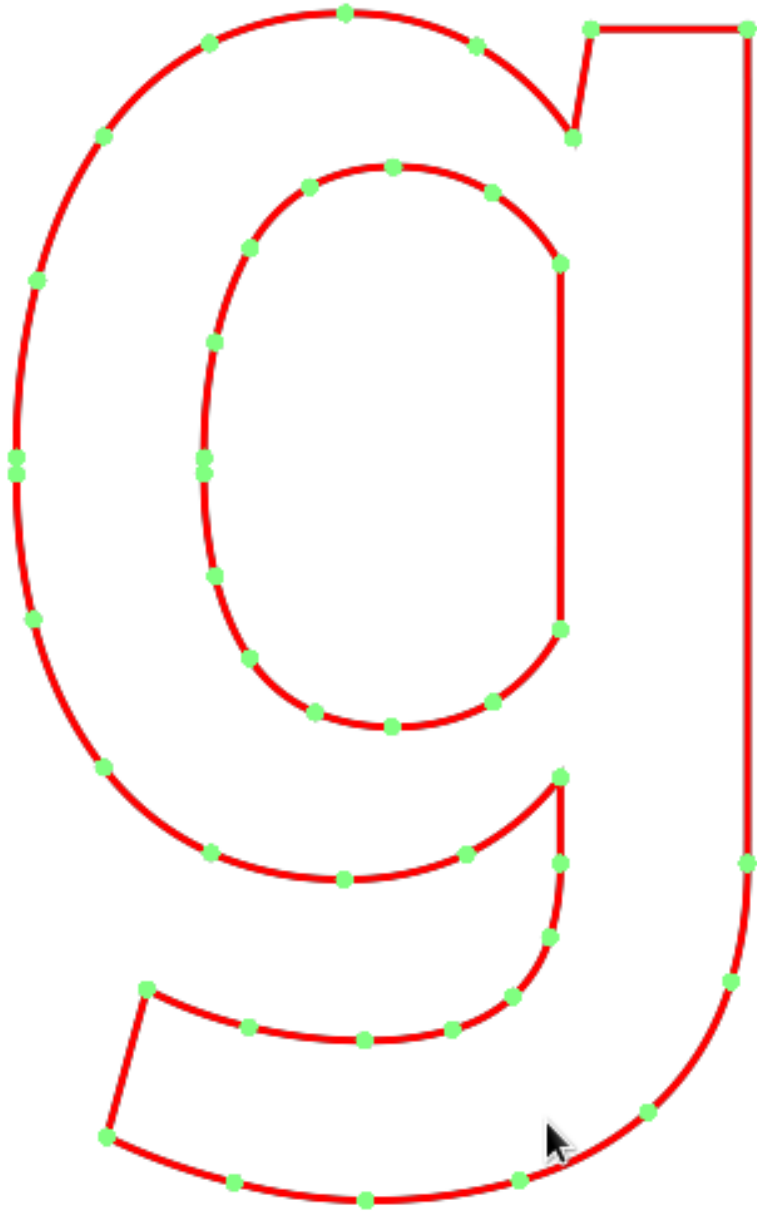
Error function



Physics simulation

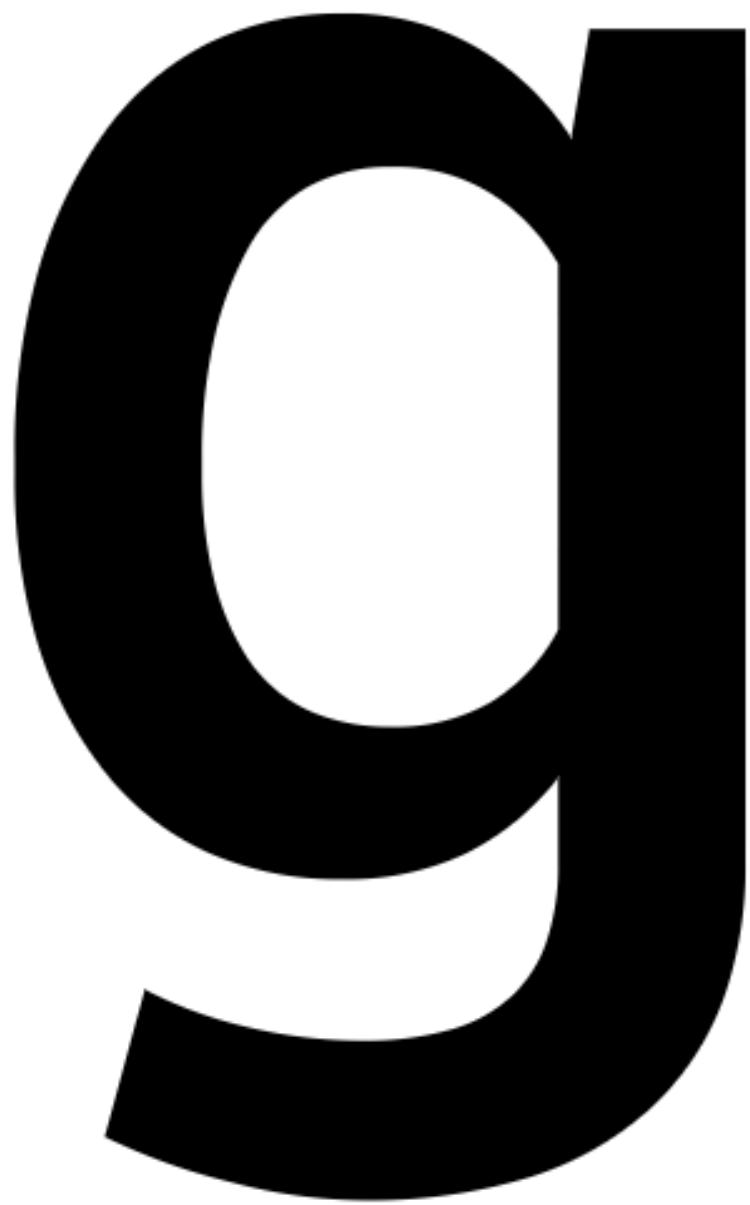






GPU time!

- Stuff it all in a texture
- Ship it!


g

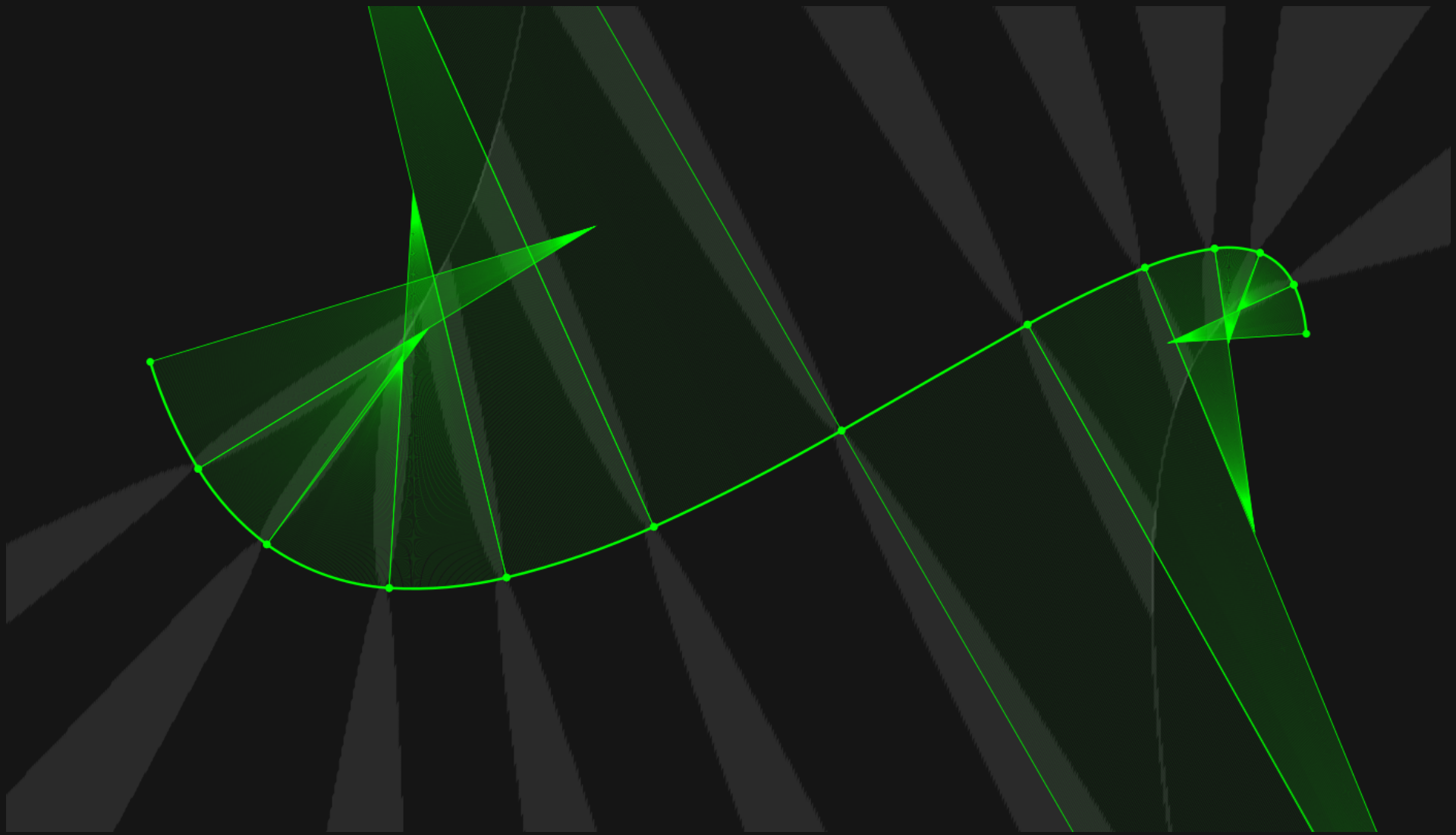
***You're* insane!**

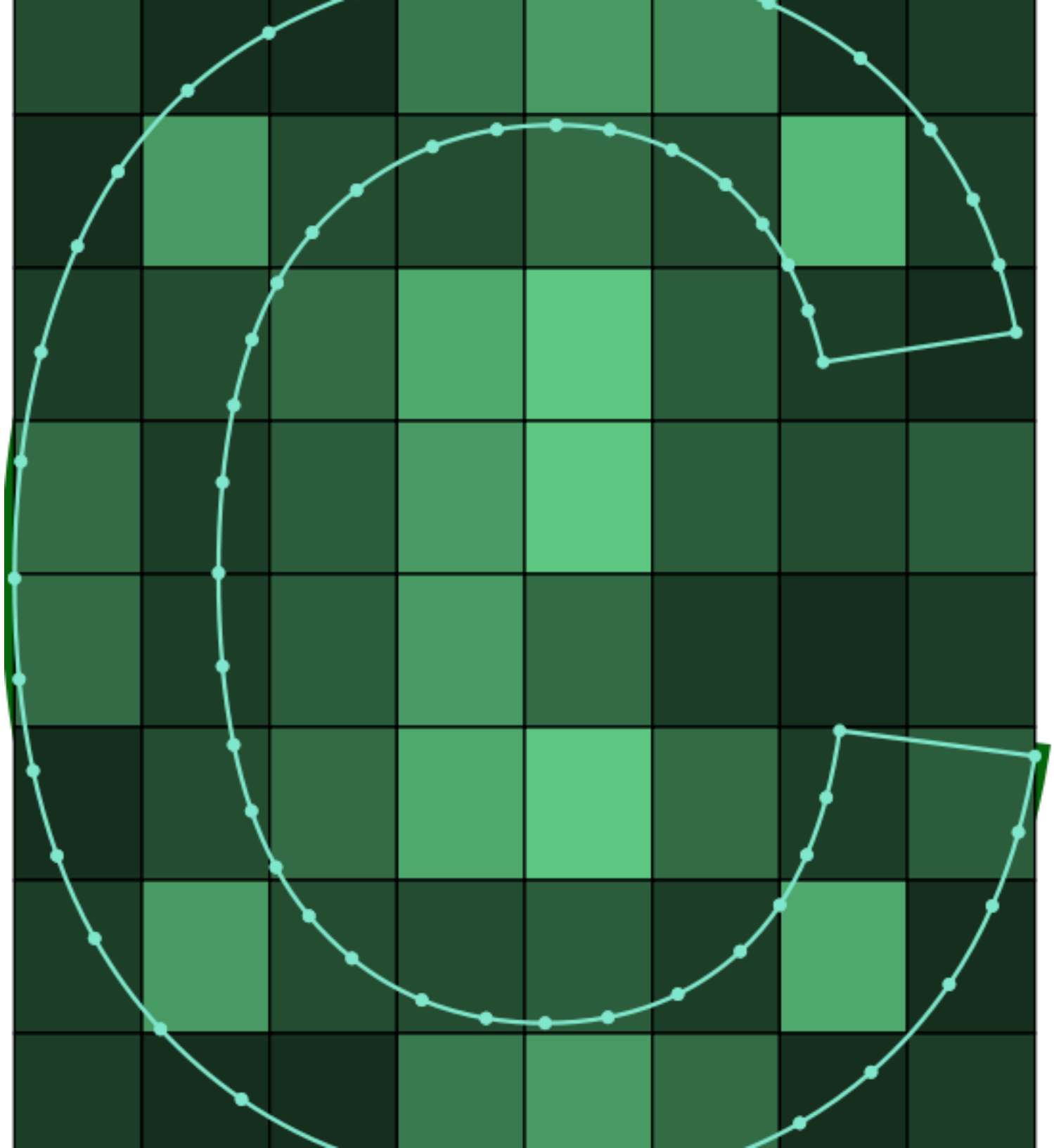
Corner cases

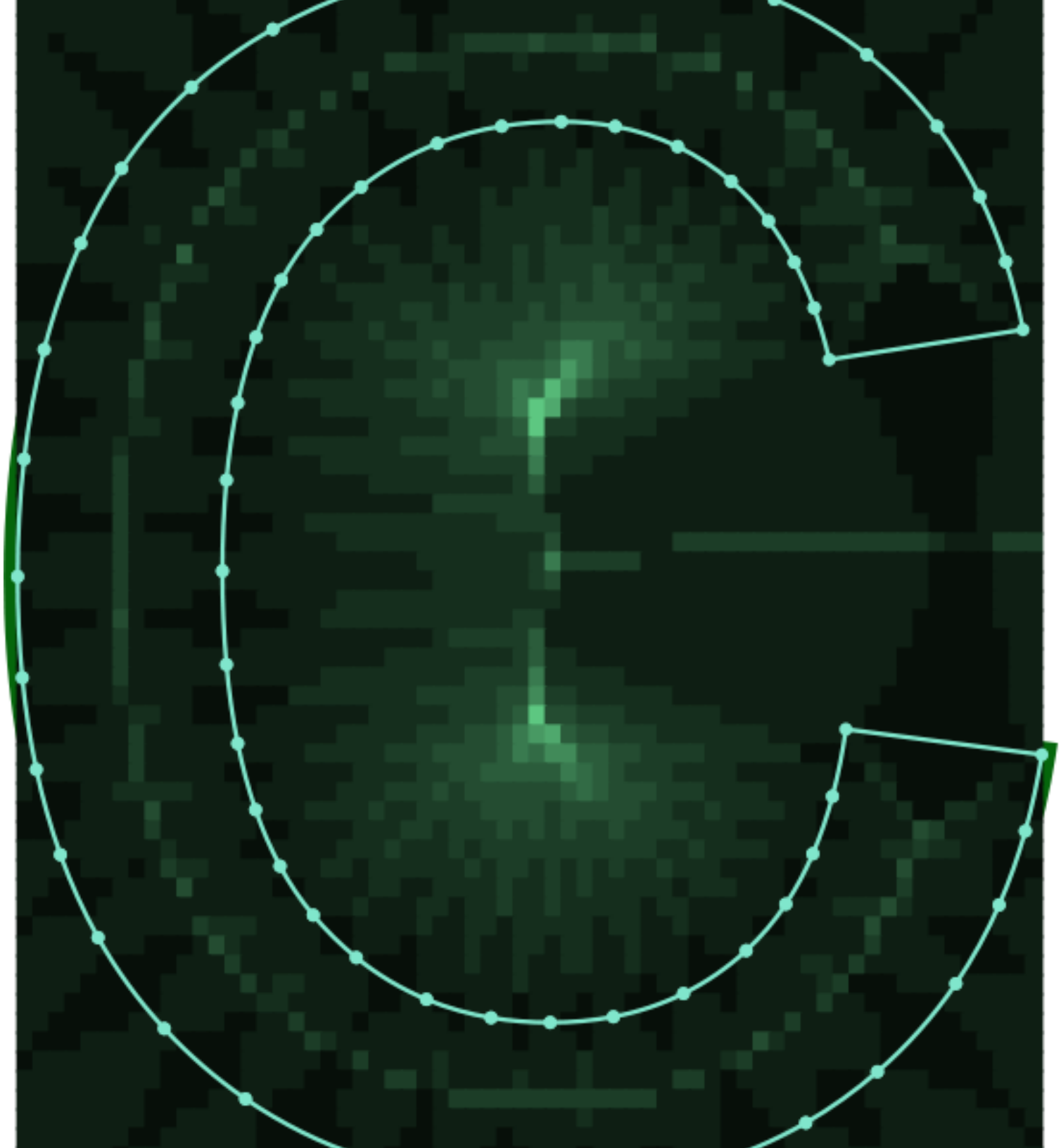
- Overlapping contours
- Tangent arcs
- Float preceision

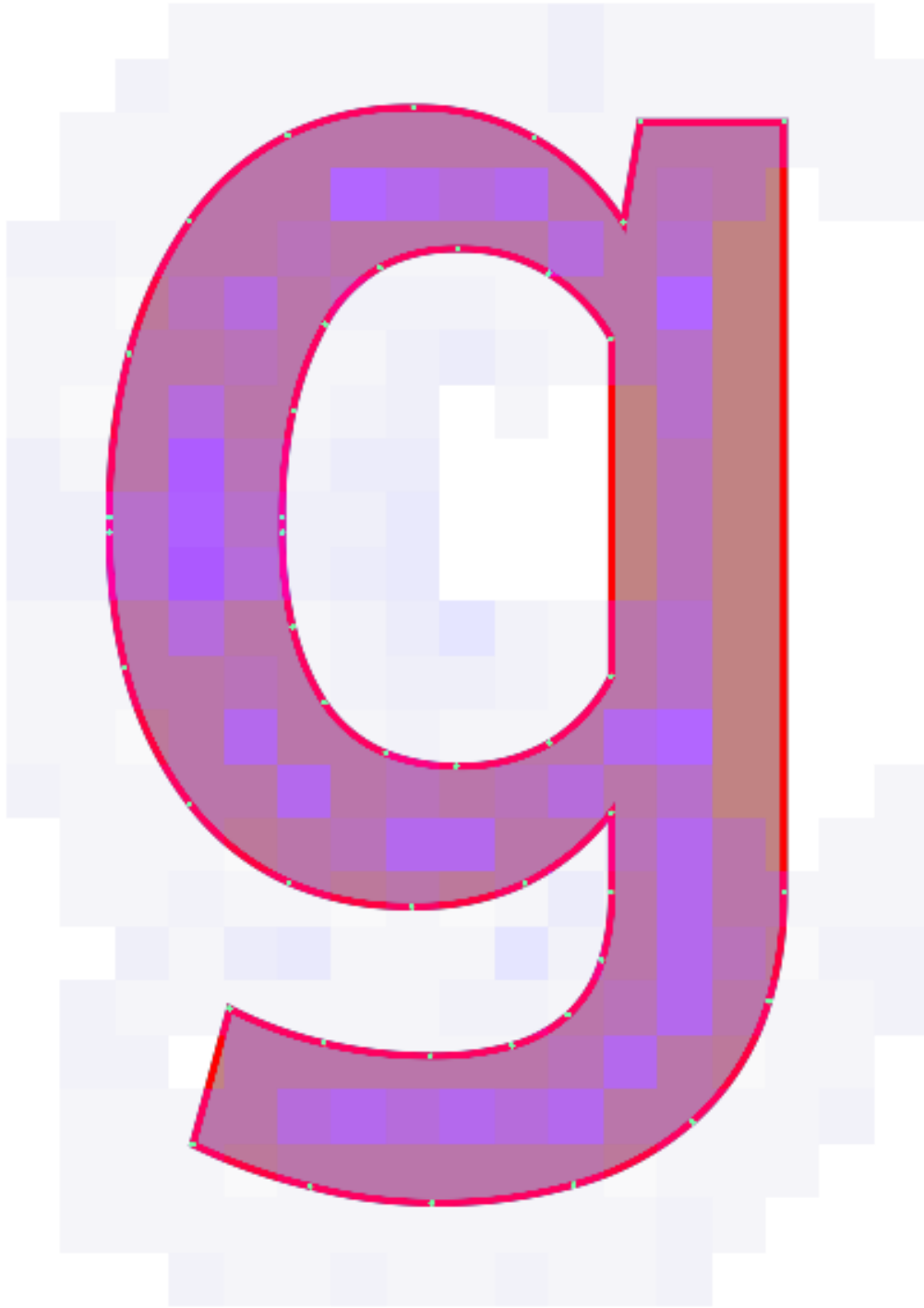
Random access

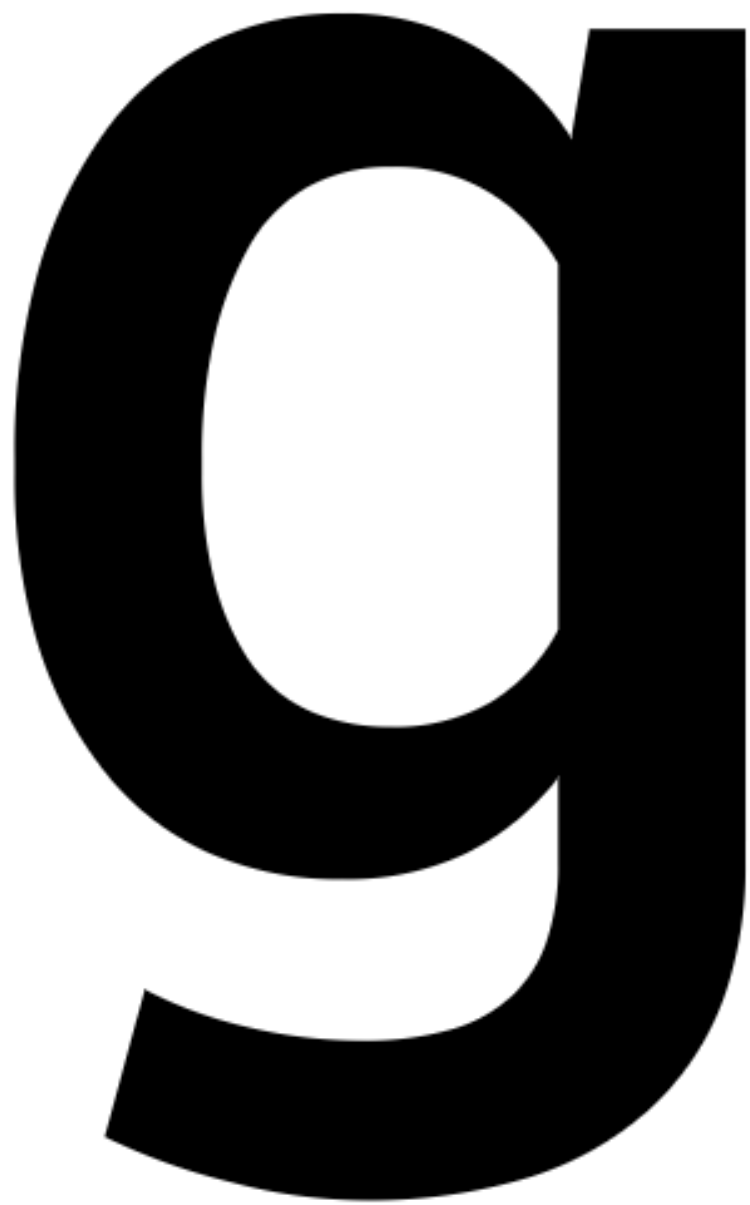
- Coarse grid
- Various optimizations










g

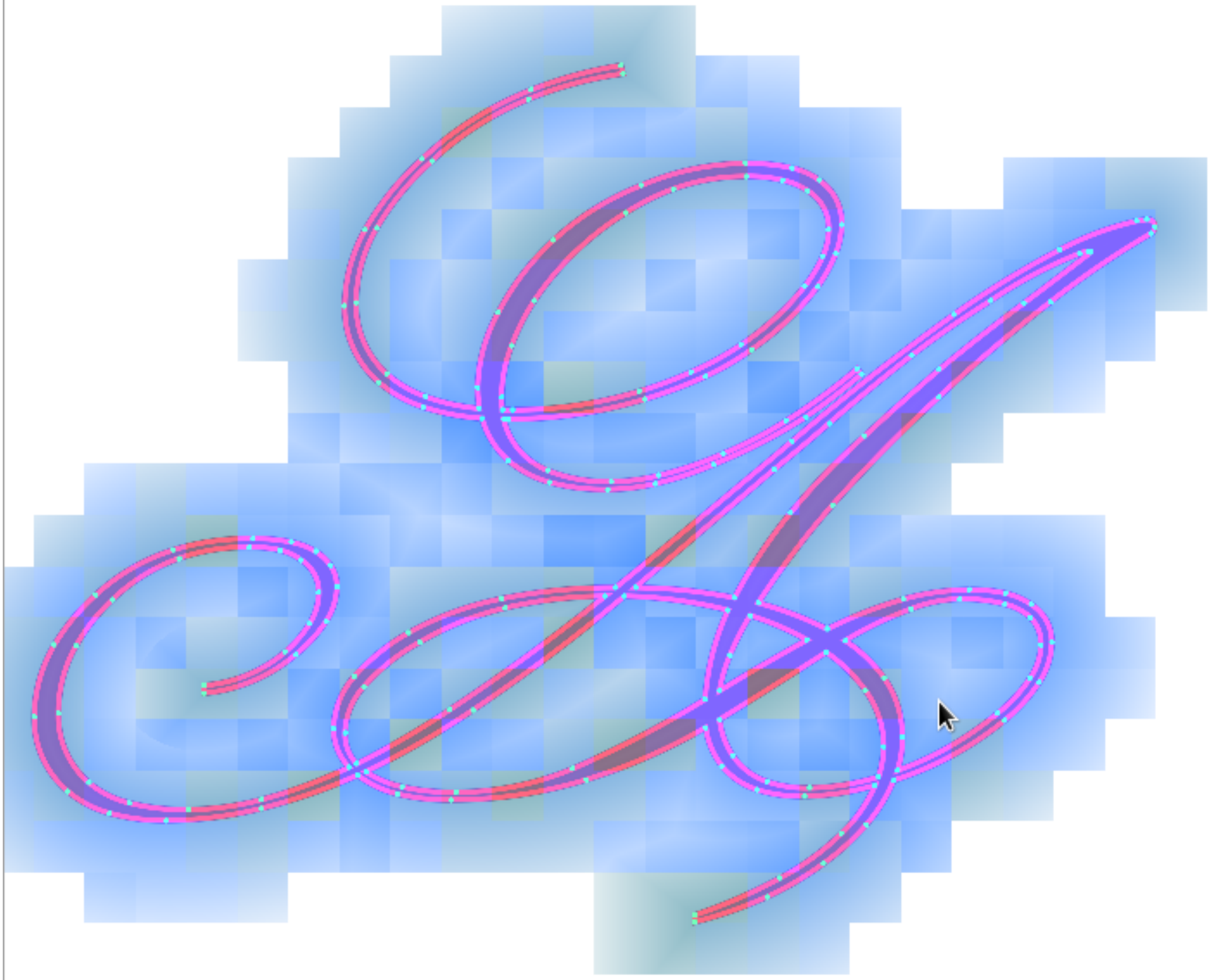
It's **insane!**

Demo time!

Limitations

Memory footprint

Speed+memory
font-dependent




A
A
A
a
a

Advantages

Memory footprint

Subpixel positioning

Pinch-to-zoom

Challenges

- Shader size / complexity
- Pixel cost
- Conditionals
- Dependent texture lookups
- Variable loop iterations
- Interpolation accuracy

```
varying vec3 lightDir,normal;
uniform sampler2D tex,l3d;

void main()
{
  vec3 ct,cf,c;
  vec4 texel;
  float intensity,at,af,a;

  intensity = max(dot(lightDir,normalize(normal)),0.0);

  cf = intensity * (gl_FrontMaterial.diffuse).rgb +
                   gl_FrontMaterial.ambient.rgb;
  af = gl_FrontMaterial.diffuse.a;

  texel = texture2D(tex,gl_TexCoord[0].st);

  ct = texel.rgb;
  at = texel.a;

  c = cf * ct;
  a = af * at;

  float coef = smoothstep(1.0,0.2,intensity);
  c += coef *  vec3(texture2D(l3d,gl_TexCoord[0].st));

  gl_FragColor = vec4(c, a);
}
```


L3D
L3D

```
#ifndef GLYPHY_TEXTURE1D_FUNC
#define GLYPHY_TEXTURE1D_FUNC glyphy_texture1D_func
#endif
#ifndef GLYPHY_TEXTURE1D_EXTRA_DECLS
#define GLYPHY_TEXTURE1D_EXTRA_DECLS
#endif
#ifndef GLYPHY_TEXTURE1D_EXTRA_ARGS
#define GLYPHY_TEXTURE1D_EXTRA_ARGS
#endif

#ifndef GLYPHY_SDF_TEXTURE1D_FUNC
#define GLYPHY_SDF_TEXTURE1D_FUNC GLYPHY_TEXTURE1D_FUNC
#endif
#ifndef GLYPHY_SDF_TEXTURE1D_EXTRA_DECLS
#define GLYPHY_SDF_TEXTURE1D_EXTRA_DECLS GLYPHY_TEXTURE1D_EXTRA_DECLS
#endif
#ifndef GLYPHY_SDF_TEXTURE1D_EXTRA_ARGS
#define GLYPHY_SDF_TEXTURE1D_EXTRA_ARGS GLYPHY_TEXTURE1D_EXTRA_ARGS
#endif
#ifndef GLYPHY_SDF_TEXTURE1D
#define GLYPHY_SDF_TEXTURE1D(offset) GLYPHY_RGBA(GLYPHY_SDF_TEXTURE1D_FUNC (offset GLYPHY_TEXTURE1D_EXTRA_ARGS))
#endif

#ifndef GLYPHY_MAX_NUM_ENDPOINTS
#define GLYPHY_MAX_NUM_ENDPOINTS 32
#endif
```

```
glyphy_arc_list_t
glyphy_arc_list (const vec2 p, const ivec2 nominal_size GLYPHY_SDF_TEXTURE1D_EXTRA_DECLS)
{
  int cell_offset = glyphy_arc_list_offset (p, nominal_size);
  vec4 arc_list_data = GLYPHY_SDF_TEXTURE1D (cell_offset);
  return glyphy_arc_list_decode (arc_list_data, nominal_size);
}
```

```
float
glyphy_sdf (const vec2 p, const ivec2 nominal_size GLYPHY_SDF_TEXTURE1D_EXTRA_DECLS)
{
  glyphy_arc_list_t arc_list = glyphy_arc_list (p, nominal_size  GLYPHY_SDF_TEXTURE1D_EXTRA_ARGS);

  /* Short-circuits */
  if (arc_list.num_endpoints == 0) {
    /* far-away cell */
    return GLYPHY_INFINITY * float(arc_list.side);
  } if (arc_list.num_endpoints == -1) {
    /* single-line */
    float angle = arc_list.line_angle;
    vec2 n = vec2 (cos (angle), sin (angle));
    return dot (p - (vec2(nominal_size) * .5), n) - arc_list.line_distance;
  }
```

```
float side = float(arc_list.side);
float min_dist = GLYPHY_INFINITY;
glyphy_arc_t closest_arc;

glyphy_arc_endpoint_t endpoint_prev, endpoint;
endpoint_prev = glyphy_arc_endpoint_decode (GLYPHY_SDF_TEXTURE1D (arc_list.offset), nominal_size)
```

```
for (int i = 1; i < GLYPHY_MAX_NUM_ENDPOINTS; i++)
{
  if (i >= arc_list.num_endpoints) {
    break;
  }
  endpoint = glyphy_arc_endpoint_decode (GLYPHY_SDF_TEXTURE1D (arc_list.offset + i), nominal_size);
  glyphy_arc_t a = glyphy_arc_t (endpoint_prev.p, endpoint.p, endpoint.d);
  endpoint_prev = endpoint;
  if (glyphy_isinf (a.d)) continue;
```

```
if (glyphy_arc_wedge_contains (a, p))
{
  float sdist = glyphy_arc_wedge_signed_dist (a, p);
  float udist = abs (sdist) * (1. - GLYPHY_EPSILON);
  if (udist <= min_dist) {
    min_dist = udist;
    side = sdist <= 0. ? -1. : +1.;
  }
}
```

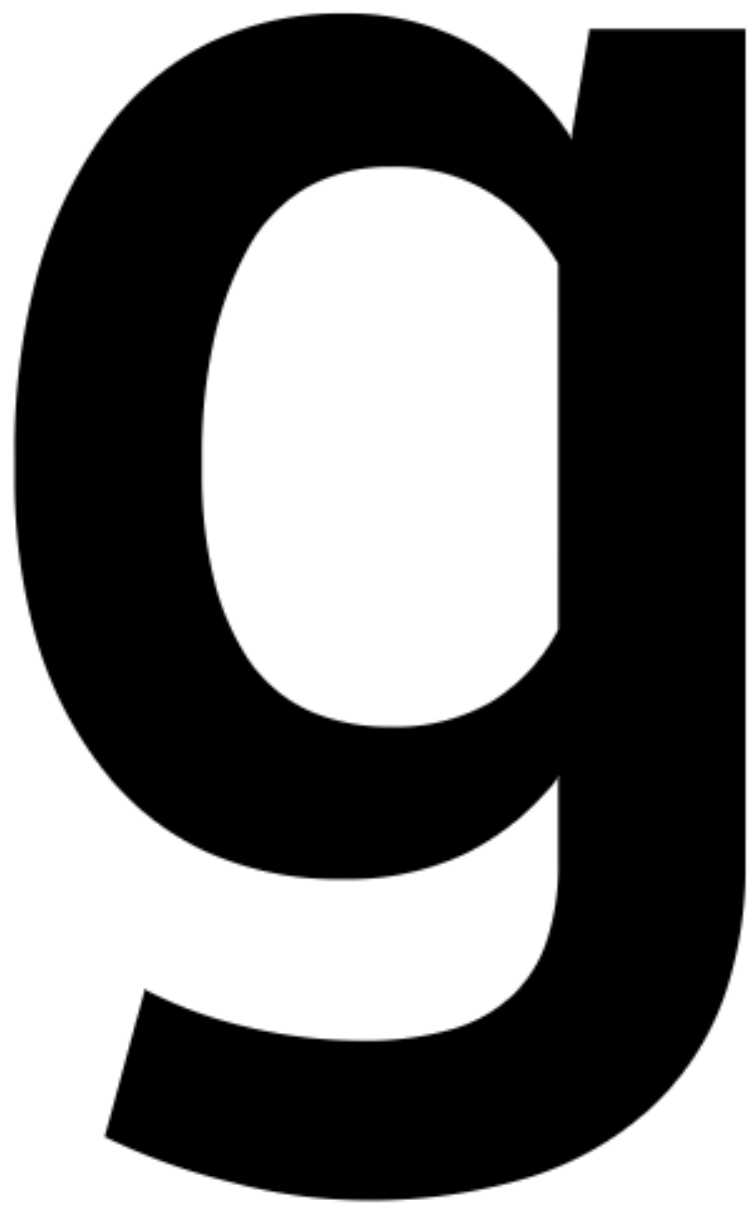
```
  else
  {
    float udist = min (distance (p, a.p0), distance (p, a.p1));
    if (udist < min_dist) {
      min_dist = udist;
      side = 0.; /* unsure */
      closest_arc = a;
    } else if (side == 0. && udist == min_dist) {
      /* If this new distance is the same as the current minimum,
       * compare extended distances.  Take the sign from the arc
       * with larger extended distance. */
      float old_ext_dist = glyphy_arc_extended_dist (closest_arc, p);
      float new_ext_dist = glyphy_arc_extended_dist (a, p);

      float ext_dist = abs (new_ext_dist) <= abs (old_ext_dist) ?
                       old_ext_dist : new_ext_dist;

      side = sign (ext_dist);
    }
  }
}
```

```
  if (side == 0.) {
    // Technically speaking this should not happen, but it does.  So try to fix it.
    float ext_dist = glyphy_arc_extended_dist (closest_arc, p);
    side = sign (ext_dist);
  }

  return min_dist * side;
}
```


g

Drivers

Case study

Mesa software renderer

"Infinite loop detected in fragment program"

Case study

Nvidia+Mac

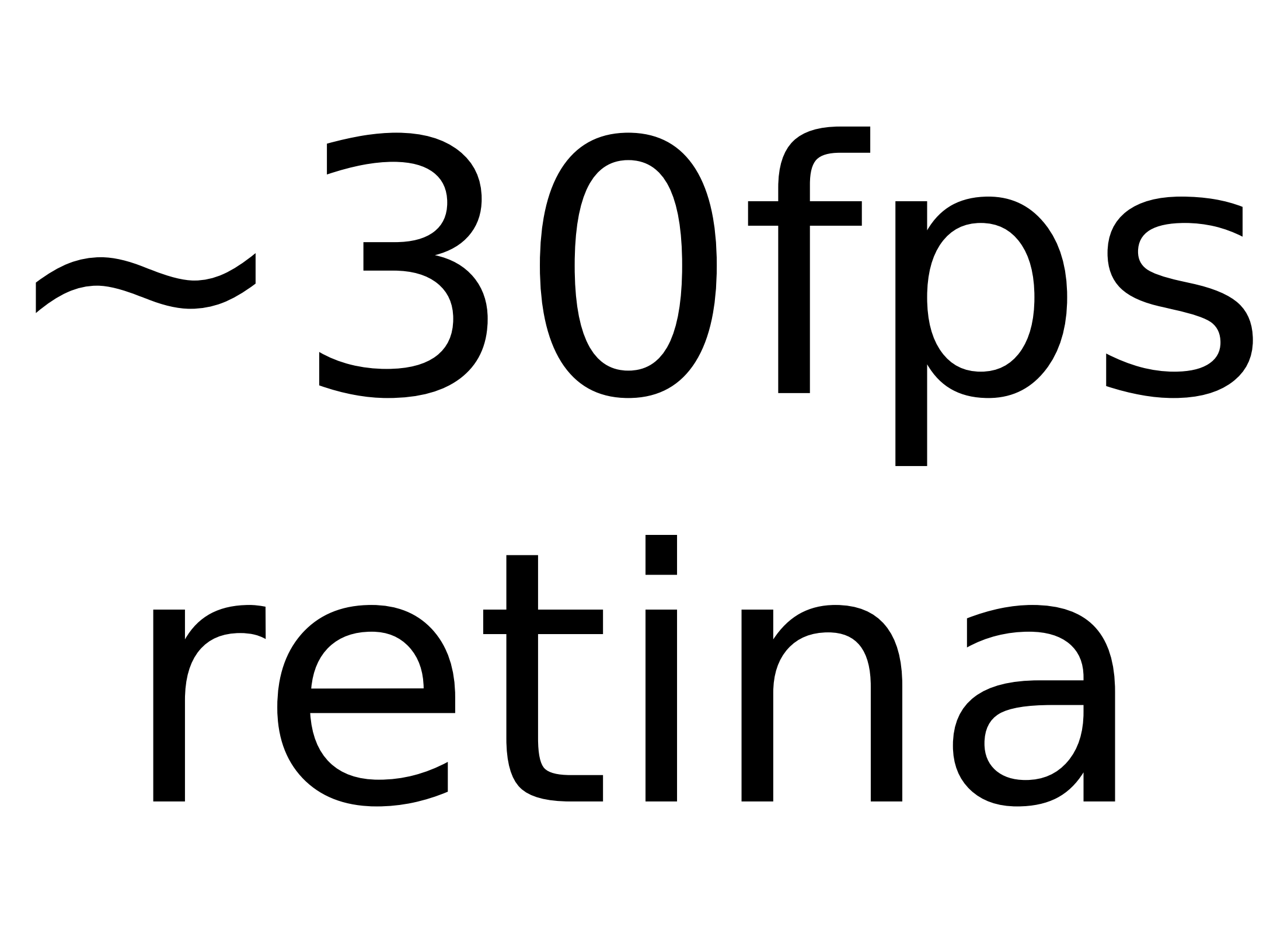
```
diff --git a/src/glyphy-common.glsl b/src/glyphy-common.glsl
index 2021d74..95f857b 100644
--- a/src/glyphy-common.glsl
+++ b/src/glyphy-common.glsl
@@ -16,17 +16,6 @@

-#define GLYPHY_PASTE_ARGS(prefix, name) prefix ## name
-#define GLYPHY_PASTE(prefix, name) GLYPHY_PASTE_ARGS (prefix, name)
-
-#ifndef GLYPHY_PREFIX
-#define GLYPHY_PREFIX glyphy_
-#endif
-
-#ifndef glyphy
-#define glyphy(name) name
-#endif
-

@@ -36,13 +25,13 @@

-struct glyphy(arc_t) {
+struct glyphy_arc_t {
    vec2  p0;
```

150+fps
Macbook Air 2011


~30fps
retina

Case study

AMD+Mac

```
diff --git a/src/glyphy-common.glsl b/src/glyphy-common.glsl
index 5e969c2..c9349b7 100644
--- a/src/glyphy-common.glsl
+++ b/src/glyphy-common.glsl
@@ -151,25 +151,30 @@ glyphy_arc_wedge_contains (const glyphy_arc_t a, const vec2 p)

+float
+glyphy_arc_wedge_signed_dist_shallow (const glyphy_arc_t a, const vec2 p)
+{
+  vec2 v = normalize (a.p1 - a.p0);
+  float line_d = dot (p - a.p0, glyphy_perpendicular (v));
+  ...
+  return line_d + r;
+}
+
 float
 glyphy_arc_wedge_signed_dist (const glyphy_arc_t a, const vec2 p)
 {
-  if (abs (a.d) <= .01)
-  {
-    vec2 v = normalize (a.p1 - a.p0);
-    float line_d = dot (p - a.p0, glyphy_perpendicular (v));
-    ...
-    return line_d + r;
-  }
+  if (abs (a.d) <= .01)
+    return glyphy_arc_wedge_signed_dist_shallow (a, p);
   vec2 c = glyphy_arc_center (a);
   return sign (a.d) * (distance (a.p0, c) - distance (p, c));
 }
```

Case study

Intel+Linux

commit 137c5ece7d22bcbb017e52f00273b42a191f496d
Author: Eric Anholt <eric@anholt.net>
Date: Wed Apr 11 13:24:22 2012 -0700

    i965: Convert live interval computation to using live variable analysis.

    Our previous live interval analysis just said that anything in a loop
    was live for the whole loop. If you had to spill a reg in a loop,
    then we would consider the unspilled value live across the loop too,
    so you never made progress by spilling. Eventually it would consider
    everything in the loop unspillable and fail out.

    With the new analysis, things completely deffed and used inside the
    loop won't be marked live across the loop, so even if you
    spill/unspill something that used to be live across the loop, you
    reduce register pressure. But you usually don't even have to spill
    any more, since our intervals are smaller than before.

    This fixes assertion failure trying to compile the shader for the
    "glyphy" text rasterier and piglit glsl-fs-unroll-explosion.

    Improves Unigine Tropics performance 1.3% +/- 0.2% (n=5), by allowing
    more shaders to be compiled in 16-wide mode.

60+fps
i965 Thinkpad

Case study

iPod 3G

"Demo runs SLOW on my iPod 3G. ~3 FPS"

Case study
Android 4.3+LGE

```
 int
 test()
 {
-    float f = 1.0;
-    return int(f);
+    float f = 1.0;
+    int i = int(f);
+    return i;
 }
```

Case study
Android 4.4+LGE

```
diff --git a/src/glyphy-sdf.glsl b/src/glyphy-sdf.glsl
index a46c0d4..6cc827c 100644
--- a/src/glyphy-sdf.glsl
+++ b/src/glyphy-sdf.glsl
@@ -36,7 +36,7 @@
 #endif
 #ifndef GLYPHY_SDF_TEXTURE1D
-#define GLYPHY_SDF_TEXTURE1D(offset) GLYPHY_RGBA (GLYPHY_SDF_TEXTURE1D_FUNC (...))
+#define GLYPHY_SDF_TEXTURE1D(offset) GLYPHY_RGBA(GLYPHY_SDF_TEXTURE1D_FUNC (...))
 #endif
```

25fps
Nexus 4/5

Code: libglyphy

- ~400 lines *.h
- ~2500 lines *.cc *.hh
- ~370 lines *.glsl
- No dependencies

Code: glyphy-demo

- ~2800 lines *.cc *.h
- ~150 lines *.glsl
- FreeType, GLUT

More work

- Subpixel-rendering
- Anisotropic-antialiasing

Gallery!