inflector-gadget

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Contents

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```

2 double_frag.glsl

```
#version 400 core

#define MAXCOUNT 256

const double er = 1.0e10;

uniform bool centering;
uniform bool julia;
uniform int count;
uniform dvec3 inflection[MAXCOUNT];

uniform dvec2 center;
uniform dvec2 radius;
uniform dvec2 aspect;

uniform dvec3 dragging;

in vec2 texcoord;

out vec4 colour;

dvec2 cMul(dvec2 a, dvec2 b)
{
  return dvec2(a.x * b.x - a.y * b.y, a.x * b.y + a.y * b.x);
}

dvec2 cSqr(dvec2 a)
{
```

```
  return cMul(a, a);
}

dvec4 cMul(dvec4 a, dvec4 b)
{
  return dvec4(cMul(a.xy, b.xy), cMul(a.xy, b.zw) + cMul(a.zw, b.xy));
}

dvec4 cSqr(dvec4 a)
{
  return cMul(a, a);
}

void main()
{
  dvec2 texcoord_ = center + cMul(radius, aspect * dvec2(texcoord));
  double px = double(length(dvec4(radius, radius) * dvec4(dFdx(vec2(aspect) * ↙
      ↳ texcoord), dFdy(vec2(aspect) * texcoord))));
  dvec4 c = dvec4(texcoord_, px, 0.0);
  if (0 < count)
  {
    double r = inflection[0].z;
    dvec4 f = dvec4(inflection[0].xy, 0.0, 0.0);
    dvec4 d = c;
    if (! centering)
    {
      d -= f;
    }
    c = cSqr(d / r) * r + f;
  }
  for (int i = 1; i < count && i < MAXCOUNT; ++i)
  {
    double r = inflection[i].z;
    dvec4 f = dvec4(inflection[i].xy, 0.0, 0.0);
    dvec4 d = c - f;
    c = cSqr(d / r) * r + f;
  }
  int n = 0;
  dvec4 z = julia && count != 0 ? c : dvec4(0.0, 0.0, 0.0, 0.0);
       c = julia && count != 0 ? dvec4(inflection[count - 1].xy, 0.0, 0.0) : c;
  for (n = 0; n < 1024; ++n)
  {
    if (dot(z.xy, z.xy) >= er)
      break;
    z = cSqr(z) + c;
  }
  if (dot(z.xy, z.xy) < er)
  {
    colour = vec4(1.0, 0.0, 0.0, 1.0);
    return;
  }
  float r = float(length(z.xy));
  float dr = float(length(z.zw));
  float de = 2.0 * r * log(r) / dr;
  float g = tanh(clamp(de, 0.0, 4.0));
  if (isnan(de) || isinf(de) || isnan(dr) || isinf(dr) || isnan(r) || isinf(r) ↙
      ↳ || isnan(g) || isinf(g))
```

```
    g = 1.0;
  vec4 grey = vec4(vec3(g), 1.0);
  vec4 blue = vec4(0.5, 0.5, 1.0, 1.0);
  colour = length(texcoord_ - dragging.xy) < dragging.z ? blue * grey : grey;
}
```

3 double_vert.glsl

```
#version 400 core

layout (location = 0) in vec2 point;

out vec2 texcoord;

void main()
{
  texcoord = point;
  gl_Position = vec4(point, 0.0, 1.0);
}
```

4 float_frag.glsl

```
#version 330 core

#define MAXCOUNT 256

const float er = 1.0e10;

uniform bool centering;
uniform bool julia;
uniform int count;
uniform vec3 inflection[MAXCOUNT];

uniform vec2 center;
uniform vec2 radius;
uniform vec2 aspect;

uniform vec3 dragging;

in vec2 texcoord;

out vec4 colour;

vec2 cMul(vec2 a, vec2 b)
{
  return vec2(a.x * b.x - a.y * b.y, a.x * b.y + a.y * b.x);
}

vec2 cSqr(vec2 a)
{
  return cMul(a, a);
}

vec4 cMul(vec4 a, vec4 b)
{
  return vec4(cMul(a.xy, b.xy), cMul(a.xy, b.zw) + cMul(a.zw, b.xy));
}
```

```
vec4 cSqr(vec4 a)
{
  return cMul(a, a);
}

void main()
{
  vec2 texcoord_ = center + cMul(radius, aspect * vec2(texcoord));
  float px = float(length(vec4(radius, radius) * vec4(dFdx(vec2(aspect) * ↙
      ↳ texcoord), dFdy(vec2(aspect) * texcoord))));
  vec4 c = vec4(texcoord_, px, 0.0);
  if (0 < count)
  {
    float r = inflection[0].z;
    vec4 f = vec4(inflection[0].xy, 0.0, 0.0);
    vec4 d = c;
    if (! centering)
    {
      d -= f;
    }
    c = cSqr(d / r) * r + f;
  }
  for (int i = 1; i < count && i < MAXCOUNT; ++i)
  {
    float r = inflection[i].z;
    vec4 f = vec4(inflection[i].xy, 0.0, 0.0);
    vec4 d = c - f;
    c = cSqr(d / r) * r + f;
  }
  int n = 0;
  vec4 z = julia && count != 0 ? c : vec4(0.0, 0.0, 0.0, 0.0);
       c = julia && count != 0 ? vec4(inflection[count - 1].xy, 0.0, 0.0) : c;
  for (n = 0; n < 1024; ++n)
  {
    if (dot(z.xy, z.xy) >= er)
      break;
    z = cSqr(z) + c;
  }
  if (dot(z.xy, z.xy) < er)
  {
    colour = vec4(1.0, 0.0, 0.0, 1.0);
    return;
  }
  float r = float(length(z.xy));
  float dr = float(length(z.zw));
  float de = 2.0 * r * log(r) / dr;
  float g = tanh(clamp(de, 0.0, 4.0));
  if (isnan(de) || isinf(de) || isnan(dr) || isinf(dr) || isnan(r) || isinf(r) ↙
      ↳ || isnan(g) || isinf(g))
    g = 1.0;
  vec4 grey = vec4(vec3(g), 1.0);
  vec4 blue = vec4(0.5, 0.5, 1.0, 1.0);
  colour = length(texcoord_ - dragging.xy) < dragging.z ? blue * grey : grey;
}
```

5 float_vert.glsl

```
#version 330 core

layout (location = 0) in vec2 point;

out vec2 texcoord;

void main()
{
  texcoord = point;
  gl_Position = vec4(point, 0.0, 1.0);
}
```

6 .gitignore

```
inflector-gadget
inflector-gadget.32.exe
inflector-gadget.64.exe
*.glsl.c
*.ppm
*.gif
```

7 main.cc

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>
#include <vector>
#include <GL/glew.h>
#include <GLFW/glfw3.h>
#include <glm/glm.hpp>
using namespace glm;

#include "float_vert.glsl.c"
#include "float_frag.glsl.c"
#include "double_vert.glsl.c"
#include "double_frag.glsl.c"

#define MAXCOUNT 256

static inline dvec2 cMul(dvec2 a, dvec2 b)
{
  return dvec2(a.x * b.x - a.y * b.y, a.x * b.y + a.y * b.x);
}

static void debug_program(GLuint program) {
  GLint status = 0;
  glGetProgramiv(program, GL_LINK_STATUS, &status);
  GLint length = 0;
  glGetProgramiv(program, GL_INFO_LOG_LENGTH, &length);
  char *info = 0;
  if (length) {
    info = (char *) malloc(length + 1);
    info[0] = 0;
```

```
    glGetProgramInfoLog(program, length, 0, info);
    info[length] = 0;
  }
  if ((info && info[0]) || ! status) {
    fprintf(stderr, "program link info:\n%s", info ? info : "(no info log)");
  }
  if (info) {
    free(info);
  }
}

static void debug_shader(GLuint shader, GLenum type, const char *source) {
  GLint status = 0;
  glGetShaderiv(shader, GL_COMPILE_STATUS, &status);
  GLint length = 0;
  glGetShaderiv(shader, GL_INFO_LOG_LENGTH, &length);
  char *info = 0;
  if (length) {
    info = (char *) malloc(length + 1);
    info[0] = 0;
    glGetShaderInfoLog(shader, length, 0, info);
    info[length] = 0;
  }
  if ((info && info[0]) || ! status) {
    const char *type_str = "unknown";
    switch (type) {
      case GL_VERTEX_SHADER: type_str = "vertex"; break;
      case GL_FRAGMENT_SHADER: type_str = "fragment"; break;
      case GL_COMPUTE_SHADER: type_str = "compute"; break;
    }
    fprintf(stderr, "%s shader compile info:\n%s\nshader source:\n%s", type_str,↙
        ↳ info ? info : "(no info log)", source ? source : "(no source)");
  }
  if (info) {
    free(info);
  }
}

static GLuint vertex_fragment_shader(const char *vert, const char *frag) {
  GLuint program = glCreateProgram();
  {
    GLuint shader = glCreateShader(GL_VERTEX_SHADER);
    glShaderSource(shader, 1, &vert, 0);
    glCompileShader(shader);
    debug_shader(shader, GL_VERTEX_SHADER, vert);
    glAttachShader(program, shader);
    glDeleteShader(shader);
  }
  {
    GLuint shader = glCreateShader(GL_FRAGMENT_SHADER);
    glShaderSource(shader, 1, &frag, 0);
    glCompileShader(shader);
    debug_shader(shader, GL_FRAGMENT_SHADER, frag);
    glAttachShader(program, shader);
    glDeleteShader(shader);
  }
  glLinkProgram(program);
```

```
  debug_program(program);
  return program;
}

static struct {
  // uniform state
  bool centering;
  dvec2 center;
  dvec2 radius;
  dvec2 aspect;
  bool julia;
  int  count;
  dvec3 inflection[MAXCOUNT];
  vec3 finflection[MAXCOUNT];
  // single precision program
  GLuint fprogram;
  // uniform location
  GLint fu_centering;
  GLint fu_center;
  GLint fu_radius;
  GLint fu_aspect;
  GLint fu_julia;
  GLint fu_count;
  GLint fu_inflection;
  GLint fu_dragging;
  // double precision program
  GLuint dprogram;
  // uniform location
  GLint du_centering;
  GLint du_center;
  GLint du_radius;
  GLint du_aspect;
  GLint du_julia;
  GLint du_count;
  GLint du_inflection;
  GLint du_dragging;
  // other stuff
  int width;
  int height;
  int max_count;
  // precision
  bool have_double;
  bool use_double;
  // image saving
  unsigned char *ppm;
  int time;
  int frame;
  // key frames
  std::vector<std::vector<dvec3>> keyframes;
  int index;
  // animation
  double aindex;
  double aspeed;
  int aframes;
  bool playing;
  bool recording;
  // mouse dragging
```

```
145     bool dragging;
        bool wasdragging;
        dvec2 start_position;
        dvec2 end_position;
      } S;
150
      static void update_shader()
      {
        if (S.count > S.max_count)
          S.max_count = S.count;
155     if (S.use_double)
        {
          glUseProgram(S.dprogram);
          glUniform1i (S.du_centering, S.centering);
          glUniform2dv(S.du_center, 1, &S.center[0]);
160       glUniform2dv(S.du_radius, 1, &S.radius[0]);
          glUniform2dv(S.du_aspect, 1, &S.aspect[0]);
          glUniform3d (S.du_dragging, S.start_position[0], S.start_position[1], S.↙
              ↪ dragging ? length(S.start_position - S.end_position) : -1);
          glUniform1i (S.du_julia, S.julia);
          glUniform1i (S.du_count, S.count);
165       if (S.count > 0)
            glUniform3dv(S.du_inflection, S.count, &S.inflection[MAXCOUNT - S.count↙
                ↪ ][0]);
        }
        else
        {
170       vec2 center = S.center;
          vec2 radius = S.radius;
          vec2 aspect = S.aspect;
          glUseProgram(S.fprogram);
          glUniform1i (S.fu_centering, S.centering);
175       glUniform2fv(S.fu_center, 1, &center[0]);
          glUniform2fv(S.fu_radius, 1, &radius[0]);
          glUniform2fv(S.fu_aspect, 1, &aspect[0]);
          glUniform3f (S.fu_dragging, S.start_position[0], S.start_position[1], S.↙
              ↪ dragging ? length(S.start_position - S.end_position) : -1);
          glUniform1i (S.fu_julia, S.julia);
180       glUniform1i (S.fu_count, S.count);
          if (S.count > 0)
          {
            for (int i = 0; i < S.count; ++i)
              S.finflection[MAXCOUNT - S.count + i] = S.inflection[MAXCOUNT - S.count ↙
                  ↪ + i];
185         glUniform3fv(S.fu_inflection, S.count, &S.finflection[MAXCOUNT - S.count↙
                ↪ ][0]);
          }
        }
      }

190   static void activate_keyframe()
      {
        if (S.playing)
          return;
        if (0 <= S.index && S.index < int(S.keyframes.size()))
195     {
          const std::vector<dvec3> &keyframe = S.keyframes[S.index];
```

```
      S.count = keyframe.size();
      for (int i = 0; i < S.count; ++i)
        S.inflection[MAXCOUNT - 1 - i] = keyframe[i];
  }
}

static void add_keyframe()
{
  if (S.playing)
    return;
  std::vector<dvec3> keyframe(S.count);
  for (int i = 0; i < S.count; ++i)
    keyframe[i] = S.inflection[MAXCOUNT - 1 - i];
  if (S.keyframes.size() > 0)
    S.index++;
  else
    S.index = 0;
  S.keyframes.insert(S.keyframes.begin() + S.index, keyframe);
}

static void delete_keyframe()
{
  if (S.playing)
    return;
  if (0 <= S.index && S.index < int(S.keyframes.size()))
  {
    S.keyframes.erase(S.keyframes.begin() + S.index);
    if (S.index >= int(S.keyframes.size()))
    {
      S.index = 0;
    }
  }
  activate_keyframe();
}

static void next_keyframe()
{
  S.index++;
  if (S.index >= int(S.keyframes.size()))
    S.index = 0;
  activate_keyframe();
}

static void previous_keyframe()
{
  S.index--;
  if (S.index < 0)
  {
    if (S.keyframes.size() > 0)
      S.index = S.keyframes.size() - 1;
    else
      S.index = 0;
  }
  activate_keyframe();
}

static void faster_animation(bool much)
```

```
{
  S.aspeed *= much ? 2.0 : 1.0905077326652577; // 2**(1/8)
  if (isinf(S.aspeed))
    S.aspeed = 1.0 / 64;
}

static void slower_animation(bool much)
{
  S.aspeed /= much ? 2.0 : 1.0905077326652577; // 2**(1/8)
  if (S.aspeed == 0)
    S.aspeed = 1.0 / 64;
}

static void update_animation()
{
  if (S.keyframes.size() > 0)
  {
    S.aindex = fmod(S.aindex + S.aspeed, S.keyframes.size());
    int ix1 = int(floor(S.aindex)) % S.keyframes.size();
    int ix0 = (ix1 - 1 + S.keyframes.size()) % S.keyframes.size();
    int ix2 = (ix1 + 1) % S.keyframes.size();
    int ix3 = (ix2 + 1) % S.keyframes.size();
    double t = S.aindex - floor(S.aindex);
    double c0 = t * t * (2 - t) - t;
    double c1 = t * t * (3 * t - 5) + 2;
    double c2 = t * t * (4 - 3 * t) + t;
    double c3 = t * t * (t - 1);
    const std::vector<dvec3> &f0 = S.keyframes[ix0];
    const std::vector<dvec3> &f1 = S.keyframes[ix1];
    const std::vector<dvec3> &f2 = S.keyframes[ix2];
    const std::vector<dvec3> &f3 = S.keyframes[ix3];
    int s0 = f0.size();
    int s1 = f1.size();
    int s2 = f2.size();
    int s3 = f3.size();
    int s = std::min(std::min(std::min(s0, s1), s2), s3);
    S.count = s;
    for (int i = 0; i < s; ++i)
      S.inflection[MAXCOUNT - 1 - i] = 0.5 * (c0 * f0[i] + c1 * f1[i] + c2 * f2[↙
          ↳ i] + c3 * f3[i]);
  }
}

static void add_point(dvec2 point, double radius)
{
  if (S.count >= MAXCOUNT)
    return;
  S.count++;
  S.inflection[MAXCOUNT - S.count] = dvec3(point[0], point[1], radius);
}

static void undo_add_point()
{
  if (S.count <= 0)
    return;
  S.count--;
}
```

```
310
    static void redo_add_point()
    {
      if (S.count >= S.max_count)
        return;
315   S.count++;
    }

    static void save_screenshot()
    {
320   char filename[100];
      snprintf(filename, 100, "inflector-gadget_%08x_%06d.ppm", S.time, S.frame++);
      fprintf(stderr, "saving image '%s'\n", filename);
      FILE *f = fopen(filename, "wb");
      glReadPixels(0, 0, S.width, S.height, GL_RGB, GL_UNSIGNED_BYTE, S.ppm);
325   fprintf(f, "P6\n%d %d\n255\n", S.width, S.height);
      for (int y = S.height - 1; y >= 0; --y)
      {
        fwrite(S.ppm + y * S.width * 3, S.width * 3, 1, f);
      }
330   fflush(f);
      fclose(f);
    }

    static void keycb(GLFWwindow *window, int key, int scancode, int action, int ↙
      ↳ mods)
335 {
      (void) scancode;
      if (action == GLFW_PRESS)
        switch (key)
        {
340       case GLFW_KEY_Q:
          case GLFW_KEY_ESCAPE:
            glfwSetWindowShouldClose(window, GL_TRUE);
            break;
          case GLFW_KEY_HOME:
345         S.center = dvec2(0.0, 0.0);
            S.radius = dvec2(2.0, 0.0);
            break;
          case GLFW_KEY_UP:
            S.radius *= (mods & GLFW_MOD_SHIFT) ? 0.1 : 0.5;
350         break;
          case GLFW_KEY_DOWN:
            S.radius *= (mods & GLFW_MOD_SHIFT) ? 10.0 : 2.0;
            break;
          case GLFW_KEY_J:
355         S.julia = true;
            break;
          case GLFW_KEY_M:
            S.julia = false;
            break;
360       case GLFW_KEY_C:
            S.centering = ! S.centering;
            break;
          case GLFW_KEY_0:
            S.count = 0;
365         break;
```

```
      case GLFW_KEY_MINUS:
        undo_add_point();
        break;
      case GLFW_KEY_EQUAL:
        redo_add_point();
        break;
      case GLFW_KEY_D:
        if (S.have_double)
          S.use_double = true;
        else
          fprintf(stderr, "double precision not available (needs OpenGL 4)\n");
        break;
      case GLFW_KEY_F:
        S.use_double = false;
        break;
      case GLFW_KEY_S:
        save_screenshot();
        break;
      case GLFW_KEY_SPACE:
        add_keyframe();
        break;
      case GLFW_KEY_DELETE:
        delete_keyframe();
        break;
      case GLFW_KEY_LEFT:
        previous_keyframe();
        break;
      case GLFW_KEY_RIGHT:
        next_keyframe();
        break;
      case GLFW_KEY_ENTER:
      case GLFW_KEY_KP_ENTER:
        S.playing = ! S.playing;
        if (! S.playing)
          activate_keyframe();
        break;
      case GLFW_KEY_RIGHT_BRACKET:
        faster_animation(mods & GLFW_MOD_SHIFT);
        break;
      case GLFW_KEY_LEFT_BRACKET:
        slower_animation(mods & GLFW_MOD_SHIFT);
        break;
      case GLFW_KEY_V:
        if (mods & GLFW_MOD_SHIFT)
        {
          S.time = time(0);
          S.frame = 0;
          S.aframes = round(S.keyframes.size() / S.aspeed);
          S.aspeed = double(S.keyframes.size()) / double(S.aframes);
          if (isnan(S.aspeed) || isinf(S.aspeed))
            S.aspeed = 1.0 / 64;
          S.playing = true;
          S.recording = true;
        }
        break;
      case GLFW_KEY_H:
        fprintf(stderr,
```

```
            "keyboard controls for navigation:\n"
            "\tESC, Q\tquit\n"
            "\tH\tshow this help\n"
            "\tHOME\treset view\n"
            "\tUP\tzoom in (faster with SHIFT)\n"
            "\tDOWN\tzoom out (faster with SHIFT)\n"
            "\tJ\tJulia mode\n"
            "\tM\tMandelbrot mode\n"
            "\tC\ttoggle centering mode\n"
            "\tD\tuse double precision (requires OpenGL 4)\n"
            "\tF\tuse single precision (default)\n"
            "\t0\treset inflections\n"
            "\t-\tundo add inflection disc\n"
            "\t=\tredo add inflection disc\n"
            "\tS\tsave screenshot (in PPM format)\n"
            "keyboard controls for animation:\n"
            "\tSPACE\tadd keyframe\n"
            "\tDELETE\tdelete keyframe\n"
            "\tLEFT\tactivate previous keyframe\n"
            "\tRIGHT\tactivate next keyframe\n"
            "\tENTER\tplay animation (press again to stop)\n"
            "\t[\tplay slower (more with SHIFT)\n"
            "\t]\tplay faster (more with SHIFT)\n"
            "\tV\t(with SHIFT) save image sequence (in PPM format)\n"
            "mouse controls:\n"
            "\tWHEEL\tzoom about mouse cursor position\n"
            "\tLEFT\tdrag and release to add inflection disc at cursor position\n"
            "\tRIGHT\tundo add inflection disc\n"
            "\tMIDDLE\trecenter window about mouse cursor position\n"
        );
        break;
    }
}

static dvec2 mouse_position(GLFWwindow *window)
{
  double w = S.width;
  double h = S.height;
  double x = 0, y = 0;
  glfwGetCursorPos(window, &x, &y);
  double dx = 2 * ((x + 0.5) / w - 0.5);
  double dy = 2 * (0.5 - (y + 0.5) / h);
  dvec2 p = dvec2(dx, dy);
  dvec2 t = S.center + cMul(S.radius, S.aspect * p);
  if (S.centering && S.count > 0)
    t += dvec2(S.inflection[MAXCOUNT - S.count]);
  return t;
}

static void scrollcb(GLFWwindow* window, double xoffset, double yoffset)
{
  (void) xoffset;
  double g = pow(0.9, yoffset);
  dvec2 center = S.center;
  if (S.centering && S.count > 0)
    center += dvec2(S.inflection[MAXCOUNT - S.count]);
  center = mix(mouse_position(window), center, g);
```

```
480     if (S.centering && S.count > 0)
          center -= dvec2(S.inflection[MAXCOUNT - S.count]);
        S.center = center;
        S.radius *= g;
      }
485
      static void buttoncb(GLFWwindow *window, int button, int action, int mods)
      {
        (void) mods;
        if (action == GLFW_PRESS)
490       switch (button)
          {
            case GLFW_MOUSE_BUTTON_LEFT:
              S.start_position = mouse_position(window);
              if (S.centering && S.count > 0)
495             S.start_position -= dvec2(S.inflection[MAXCOUNT - S.count]);
              S.end_position = S.start_position;
              S.dragging = true;
              break;
            case GLFW_MOUSE_BUTTON_RIGHT:
500           S.wasdragging = S.dragging;
              S.dragging = false;
              break;
          }
        else if (action == GLFW_RELEASE)
505       switch (button)
          {
            case GLFW_MOUSE_BUTTON_LEFT:
              if (S.dragging)
              {
510             S.dragging = false;
                S.end_position = mouse_position(window);
                if (S.centering && S.count > 0)
                  S.end_position -= dvec2(S.inflection[MAXCOUNT - S.count]);
                double r = length(S.start_position - S.end_position);
515             if (S.centering && S.count > 0)
                  S.start_position += dvec2(S.inflection[MAXCOUNT - S.count]);
                if (r > 0)
                  add_point(S.start_position, r);
              }
520           break;
            case GLFW_MOUSE_BUTTON_RIGHT:
              if (! S.wasdragging)
                undo_add_point();
              break;
525         case GLFW_MOUSE_BUTTON_MIDDLE:
              dvec2 center = mouse_position(window);
              if (S.centering && S.count > 0)
                center -= dvec2(S.inflection[MAXCOUNT - S.count]);
              S.center = center;
530           break;
          }
      }

      static void motioncb(GLFWwindow *window, double x, double y)
535   {
        (void) x;
```

```
  (void) y;
  if (S.dragging)
  {
    S.end_position = mouse_position(window);
    if (S.centering && S.count > 0)
      S.end_position -= dvec2(S.inflection[MAXCOUNT - S.count]);
  }
}

extern int main(int argc, char **argv)
{
  (void) argc;
  (void) argv;

  fprintf(stderr, "inflector-gadget 0.4 (GPL) 2017-12-14 Claude Heiland-Allen\n");

  S.width = 1280;
  S.height = 720;
  S.max_count = 0;
  S.ppm = (unsigned char *) malloc(S.width * S.height * 3);
  S.time = time(0);
  S.frame = 0;
  S.index = 0;
  S.aindex = 0;
  S.aspeed = 1.0 / 64;
  S.playing = false;
  S.use_double = false;

  glfwInit();
  glfwWindowHint(GLFW_CLIENT_API, GLFW_OPENGL_API);
  glfwWindowHint(GLFW_CONTEXT_VERSION_MAJOR, 4);
  glfwWindowHint(GLFW_CONTEXT_VERSION_MINOR, 0);
  glfwWindowHint(GLFW_OPENGL_PROFILE, GLFW_OPENGL_CORE_PROFILE);
  glfwWindowHint(GLFW_OPENGL_FORWARD_COMPAT, GL_TRUE);
  glfwWindowHint(GLFW_RESIZABLE, GL_FALSE);
  GLFWwindow *window = glfwCreateWindow(S.width, S.height, "inflector-gadget", 0, 0);
  if (! window)
  {
    fprintf(stderr, "could not initialize OpenGL 4.0\n");
    glfwWindowHint(GLFW_CLIENT_API, GLFW_OPENGL_API);
    glfwWindowHint(GLFW_CONTEXT_VERSION_MAJOR, 3);
    glfwWindowHint(GLFW_CONTEXT_VERSION_MINOR, 3);
    glfwWindowHint(GLFW_OPENGL_PROFILE, GLFW_OPENGL_CORE_PROFILE);
    glfwWindowHint(GLFW_OPENGL_FORWARD_COMPAT, GL_TRUE);
    glfwWindowHint(GLFW_RESIZABLE, GL_FALSE);
    window = glfwCreateWindow(S.width, S.height, "inflector-gadget", 0, 0);
    if (! window)
    {
      fprintf(stderr, "could not initialize OpenGL 3.3, giving up\n");
      return 1;
    }
    else
    {
      fprintf(stderr, "initialized OpenGL 3.3\n");
      S.have_double = false;
```

```
    }
  }
  else
595 {
    fprintf(stderr, "initialized OpenGL 4.0\n");
    S.have_double = true;
  }
  glfwMakeContextCurrent(window);
600 glewExperimental = GL_TRUE;
  glewInit();
  glGetError(); // discard common error from glew
  glfwSwapInterval(1);
  glfwSetMouseButtonCallback(window, buttoncb);
605 glfwSetScrollCallback(window, scrollcb);
  glfwSetKeyCallback(window, keycb);
  glfwSetCursorPosCallback(window, motioncb);

  S.centering = true;
610 S.center = dvec2(0.0, 0.0);
  S.radius = dvec2(2.0, 0.0);
  S.aspect = dvec2(S.width * 1.0 / S.height, 1.0);
  S.julia  = true;
  S.count = 0;
615 memset(&S.inflection[0], 0, MAXCOUNT * sizeof(dvec3));

  S.fprogram = vertex_fragment_shader(float_vert, float_frag);
  S.fu_centering  = glGetUniformLocation(S.fprogram, "centering");
  S.fu_center     = glGetUniformLocation(S.fprogram, "center");
620 S.fu_radius     = glGetUniformLocation(S.fprogram, "radius");
  S.fu_aspect     = glGetUniformLocation(S.fprogram, "aspect");
  S.fu_dragging   = glGetUniformLocation(S.fprogram, "dragging");
  S.fu_julia      = glGetUniformLocation(S.fprogram, "julia");
  S.fu_count      = glGetUniformLocation(S.fprogram, "count");
625 S.fu_inflection = glGetUniformLocation(S.fprogram, "inflection");

  if (S.have_double)
  {
    S.dprogram = vertex_fragment_shader(double_vert, double_frag);
630 S.du_centering  = glGetUniformLocation(S.dprogram, "centering");
    S.du_center     = glGetUniformLocation(S.dprogram, "center");
    S.du_radius     = glGetUniformLocation(S.dprogram, "radius");
    S.du_aspect     = glGetUniformLocation(S.dprogram, "aspect");
    S.du_dragging   = glGetUniformLocation(S.dprogram, "dragging");
635 S.du_julia      = glGetUniformLocation(S.dprogram, "julia");
    S.du_count      = glGetUniformLocation(S.dprogram, "count");
    S.du_inflection = glGetUniformLocation(S.dprogram, "inflection");
  }

640 GLuint vao = 0;
  glGenVertexArrays(1, &vao);
  glBindVertexArray(vao);

  float vdata[8] =
645 { -1.0, -1.0
  ,  1.0, -1.0
  , -1.0,  1.0
  ,  1.0,  1.0
```

```
    };
  GLuint vbo = 0;
  glGenBuffers(1, &vbo);
  glBindBuffer(GL_ARRAY_BUFFER, vbo);
  glBufferData(GL_ARRAY_BUFFER, 8 * sizeof(float), &vdata[0], GL_STATIC_DRAW);
  glVertexAttribPointer(0, 2, GL_FLOAT, GL_FALSE, 0, 0);
  glEnableVertexAttribArray(0);

  while (1) {
    if (S.playing)
    {
      update_animation();
      update_shader();
      glDrawArrays(GL_TRIANGLE_STRIP, 0, 4);
      glfwSwapBuffers(window);
      if (S.recording)
      {
        save_screenshot();
        if (S.frame >= S.aframes)
        {
          S.recording = false;
          S.playing = false;
          S.time = time(0);
          S.frame = 0;
          activate_keyframe();
        }
      }
      glfwPollEvents();
    }
    else
    {
      update_shader();
      glDrawArrays(GL_TRIANGLE_STRIP, 0, 4);
      glfwSwapBuffers(window);
      glfwWaitEvents();
    }
    if (glfwWindowShouldClose(window))
      break;
  }
  free(S.ppm);

  glfwDestroyWindow(window);
  glfwTerminate();
  return 0;
}
```

8 Makefile

```
SYSTEM ?= linux

include Makefile.$(SYSTEM)

SHADERS := $(patsubst %.glsl,%.glsl.c,$(wildcard *.glsl))

all: inflector-gadget$(EXEEXT)

clean:
```

```
10          @echo "CLEAN" ; rm -f inflector-gadget$(EXEEXT) $(SHADERS)

    .SUFFIXES:
    .PHONY: all clean
    .SECONDARY: $(SHADERS)
15
    inflector-gadget$(EXEEXT): main.cc $(SHADERS)
            $(COMPILE) $(COMPILE_FLAGS) -o inflector-gadget$(EXEEXT) main.cc $(↙
                ↳ LINK_FLAGS)

    %.glsl.c: %.glsl s2c.sh
20          bash s2c.sh $* < $< > $@
```

9 Makefile.linux

```
include Makefile.unix
```

10 Makefile.macosx

```
include Makefile.unix
```

11 Makefile.unix

```
COMPILE := g++
COMPILE_FLAGS := \
        -std=c++11 \
        -Wall \
5       -pedantic \
        -Wextra \
        -Os \
        $(shell pkg-config --cflags $(GLFW) glfw3)
LINK_FLAGS := \
10      $(shell pkg-config --libs $(GLFW) glfw3) \
        -lGLEW \
        -lGL \
        -lm
EXEEXT :=
```

12 Makefile.win32

```
WINPREFIX ?= $(HOME)/win32
COMPILE := i686-w64-mingw32-g++
EXEEXT := .32.exe

5   include Makefile.windows
```

13 Makefile.win64

```
WINPREFIX ?= $(HOME)/win64
COMPILE := x86_64-w64-mingw32-g++
EXEEXT := .64.exe

5   include Makefile.windows
```

14 Makefile.windows

```
COMPILE_FLAGS := \
        -std=c++11 \
        -Wall \
        -pedantic \
        -Wextra \
        -Os \
        -pipe \
        -DGLEW_STATIC \
        -I$(WINPREFIX)/include
LINK_FLAGS := \
        -L$(WINPREFIX)/bin \
        -L$(WINPREFIX)/lib \
        -lglfw3 \
        -lgdi32 \
        -lglew32s $(WINPREFIX)/bin/glew32.dll \
        -lopengl32 \
        -lm \
        -static \
        -static-libgcc \
        -static-libstdc++
```

15 README.md

```
inflector-gadget
================

Inflection mapping gadget for complex quadratic polynomials.

keyboard controls for navigation
--------------------------------

        ESC, Q  quit
        H       show this help
        HOME    reset view
        UP      zoom in (faster with SHIFT)
        DOWN    zoom out (faster with SHIFT)
        J       Julia mode
        M       Mandelbrot mode
        C       toggle centering mode
        D       use double precision (requires OpenGL 4)
        F       use single precision (default)
        0       reset inflections
        -       undo add inflection disc
        =       redo add inflection disc
        S       save screenshot (in PPM format)

keyboard controls for animation
-------------------------------

        SPACE   add keyframe
        DELETE  delete keyframe
        LEFT    activate previous keyframe
        RIGHT   activate next keyframe
        ENTER   play animation (press again to stop)
        [       play slower (more with SHIFT)
```

```
        ]       play faster (more with SHIFT)
        V       (with SHIFT) save image sequence (in PPM format)

mouse controls
--------------

        WHEEL   zoom about mouse cursor position
        LEFT    drag and release to add inflection disc at cursor position
        RIGHT   undo add inflection disc
        MIDDLE  recenter window about mouse cursor position

legal
-----

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```

16 release.sh

```
#!/bin/bash
V=${1}
S=inflector-gadget-${V}
W=${S}-win
mkdir -p ${S} ${W}
make SYSTEM=win32 clean all
make SYSTEM=win64 clean all
strip inflector-gadget.32.exe
strip inflector-gadget.64.exe
cp -avi inflector-gadget.32.exe ${W}
cp -avi inflector-gadget.64.exe ${W}
cp -avi *.md ${W}
cp -avi *.md *.glsl *.cc Makefile* *.sh ${S}
tar --create --verbose --owner=0 --group=0 --bzip --file ${S}.tar.bz2 ${S}/*
zip -r ${W}.zip ${W}/*
gpg -b ${S}.tar.bz2
gpg -b ${W}.zip
```

17 s2c.sh

```
#!/bin/bash
echo "const char *$1 ="
# strip multiline /* .. */ comments, followed by // .. EOL comments, very hacky
tr '\n' '@' |
sed 's|/\*[^*]*\*/|\n|g' |
sed 's|//[^@]*|\n|g' |
```

```
    tr '@' '\n' |
    sed 's/^ *//g' |
    tr -s '\n ' |
10  sed 's/ = /=/g' |
    sed 's|\\|\\\\|g' |
    sed 's|"|\\"|g' |
    sed 's|^\(\#.*\)$|\\n\1\\n|' |
    sed 's|^|"|' |
15  sed 's|$|"|'
    echo '"\n"'
    echo ";"
```