pool-party

Claude Heiland-Allen

2016–2018

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1 caustics.c

```
/* ==========================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
```

```
Copyright (C) 2008,2009  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------------
Caustics Shader
=============================================================================== */

#include <stdlib.h>
#include "util.h"
#include "caustics.h"
#include "caustics.vert.c"
#include "caustics.frag.c"

//=============================================================================
// initialization
struct caustics *caustics_init(struct caustics *caustics) {
  if (! caustics) { return 0; }
  if (! shader_init(&caustics->shader, caustics_vert, caustics_frag)) {
    return 0;
  }
  shader_uniform(caustics, tex);
  caustics->value.tex = 0;
  caustics->width = 0;
  caustics->height = 0;
  glGenTextures(1, &(caustics->texture));
  glBindTexture(GL_TEXTURE_2D, caustics->texture);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
  glGenVertexArrays(1, &caustics->vao);
  return caustics;
}

//=============================================================================
// reshape callback
void caustics_reshape(
  struct caustics *caustics, int w, int h
) {
  caustics->width  = roundtwo(w) * 2;
  caustics->height = roundtwo(h) * 2;
  float *zero = calloc(1, sizeof(float) * caustics->width * caustics->height);
  glBindTexture(GL_TEXTURE_2D, caustics->texture);
  glTexImage2D(GL_TEXTURE_2D, 0, GL_R32F,
    caustics->width, caustics->height,
    0, GL_RED, GL_FLOAT, zero
  );
  glBindTexture(GL_TEXTURE_2D, 0);
  free(zero);
}

//=============================================================================
// display callback
void caustics_display(
  struct caustics *caustics, GLuint fbo, GLuint texture
) {
  glBindFramebuffer(GL_FRAMEBUFFER, fbo);
  glFramebufferTexture2D(
    GL_FRAMEBUFFER, GL_COLOR_ATTACHMENT0, GL_TEXTURE_2D,
    caustics->texture, 0
  );
```

```
  glBindTexture(GL_TEXTURE_2D, texture);
  glUseProgram(caustics->shader.program);
  shader_updatei(caustics, tex);
  glViewport(0, 0, caustics->width, caustics->height);
  glClear(GL_COLOR_BUFFER_BIT);
  glEnable(GL_BLEND);
  glBlendFunc(GL_SRC_ALPHA, GL_ONE);
  glBindVertexArray(caustics->vao);
  glDrawArrays(GL_TRIANGLES, 0, 6 * caustics->width/2 * caustics->height/2);
  glBindVertexArray(0);
  glDisable(GL_BLEND);
  glBindFramebuffer(GL_FRAMEBUFFER, 0);
  glUseProgram(0);
  glBindTexture(GL_TEXTURE_2D, 0);
}

// EOF
```

2 caustics.frag

```
/* ============================================================================
pool-party -- water simulation
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----------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------------------
Caustics Shader
============================================================================ */

#version 330 core

in vec2 texCoord;
out vec4 colour;

void main(void) {
  vec2 x = dFdx(texCoord);
  vec2 y = dFdy(texCoord);
  float a = length(vec2(x.x, y.x)) * length(vec2(x.y, y.y));
  colour = vec4(vec3(1.0), a);
}

// EOF
```

3 caustics.h

```
/* ============================================================================
pool-party -- water simulation
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----------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------------------
Caustics Shader
============================================================================ */
```

```
#ifndef CAUSTICS_H
#define CAUSTICS_H 1

#include "shader.h"

//==============================================================
// data
struct caustics { struct shader shader;
  struct { GLint  tex; } uniform;
  struct { int    tex; } value;
  GLuint texture;
  GLuint vao;
  int width;
  int height;
};

//==============================================================
// protoypes
struct caustics *caustics_init(struct caustics *caustics);
void caustics_reshape(
  struct caustics *caustics, int w, int h
);
void caustics_display(
  struct caustics *caustics, GLuint fbo, GLuint texture
);

#endif
```

4 caustics.vert

```
/* ============================================================
pool-party -- water simulation
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------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009  Claude Heiland-Allen <claude@mathr.co.uk>
------------------------------------------------------------------
Caustics Shader
============================================================ */

#version 330 core

uniform sampler2D tex;

out vec2 texCoord;

void main(void) {
  int w = textureSize(tex, 0).x;
  ivec2 d = ivec2(0, 0);
  switch (gl_VertexID % 6) {
    case 0: d = ivec2(0, 0); break;
    case 1: d = ivec2(1, 0); break;
    case 2: d = ivec2(1, 1); break;
    case 3: d = ivec2(1, 1); break;
    case 4: d = ivec2(0, 1); break;
```

```
    case 5: d = ivec2(0, 0); break;
  }
  int t = gl_VertexID / 6;
  int p = t % w;
  int q = t / w;
  ivec2 tc = ivec2(p, q) + d;
  if (tc.x < 0) { tc.x += w; }
  if (tc.y < 0) { tc.y += w; }
  vec3 c = vec3(vec2(tc), 0.0);
  vec3 s = vec3(vec2(tc), 256.0);
  if (tc.x >= w) { tc.x -= w; }
  if (tc.y >= w) { tc.y -= w; }
  ivec2 tcx1 = tc + ivec2(1, 0);
  if (tcx1.x < 0) { tcx1.x += w; }
  if (tcx1.y < 0) { tcx1.y += w; }
  if (tcx1.x >= w) { tcx1.x -= w; }
  if (tcx1.y >= w) { tcx1.y -= w; }
  ivec2 tcx2 = tc - ivec2(1, 0);
  if (tcx2.x < 0) { tcx2.x += w; }
  if (tcx2.y < 0) { tcx2.y += w; }
  if (tcx2.x >= w) { tcx2.x -= w; }
  if (tcx2.y >= w) { tcx2.y -= w; }
  ivec2 tcy1 = tc + ivec2(0, 1);
  if (tcy1.x < 0) { tcy1.x += w; }
  if (tcy1.y < 0) { tcy1.y += w; }
  if (tcy1.x >= w) { tcy1.x -= w; }
  if (tcy1.y >= w) { tcy1.y -= w; }
  ivec2 tcy2 = tc - ivec2(0, 1);
  if (tcy2.x < 0) { tcy2.x += w; }
  if (tcy2.y < 0) { tcy2.y += w; }
  if (tcy2.x >= w) { tcy2.x -= w; }
  if (tcy2.y >= w) { tcy2.y -= w; }
  float h = texelFetch(tex, tc, 0).r;
  s.z += h;
  float hx1 = texelFetch(tex, tcx1, 0).r;
  float hx2 = texelFetch(tex, tcx2, 0).r;
  float hy1 = texelFetch(tex, tcy1, 0).r;
  float hy2 = texelFetch(tex, tcy2, 0).r;
  vec3 x = normalize(vec3(1.0, 0.0, 0.5 * (hx1 - hx2)));
  vec3 y = normalize(vec3(0.0, 1.0, 0.5 * (hy1 - hy2)));
  vec3 normal = normalize(cross(x, y));
  if (normal.z < 0.0) {
    normal = -normal;
  }
  vec3 incident = normalize(vec3(0.0, 0.0, -1.0));
  float eta = 1.0/1.333;
  vec3 r = refract(incident, normal, eta);
  if (r.z < 0.0) {
    float k = s.z / r.z;
    c = s - k * r;
  }
  gl_Position = vec4(vec2(c.xy) / float(w) * 2.0 - vec2(1.0), 0.0, 2.0);
  texCoord = vec2(d);
}

// EOF
```

5 cubic.c

```
/* ================================================================
pool-party -- water simulation
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----------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------
Cubic Interpolation Shader
================================================================ */

#include "util.h"
#include "cubic.h"
#include "cubic.vert.c"
#include "cubic.frag.c"

//================================================================
// shader initialization
struct cubic *cubic_init(struct cubic *cubic) {
  if (! cubic) { return 0; }
  if (! shader_init(&cubic->shader, cubic_vert, cubic_frag)) {
    return 0;
  }
  shader_uniform(cubic, tex);
  shader_uniform(cubic, size);
  shader_uniform(cubic, delta);
  cubic->value.tex = 0;
  cubic->value.size[0] = 0;
  cubic->value.size[1] = 0;
  cubic->value.delta[0] = 0;
  cubic->value.delta[1] = 0;
  cubic->width = 0;
  cubic->height = 0;
  glGenTextures(2, cubic->textures);
  glBindTexture(GL_TEXTURE_2D, cubic->textures[0]);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
  glBindTexture(GL_TEXTURE_2D, cubic->textures[1]);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_NEAREST);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_NEAREST);
  glGenVertexArrays(1, &cubic->vao);
  return cubic;
}

//================================================================
// shader reshape callback
void cubic_reshape(
  struct cubic *cubic, int w, int h
) {
  cubic->width  = roundtwo(w);
  cubic->height = roundtwo(h);
  glBindTexture(GL_TEXTURE_2D, cubic->textures[0]);
  glTexImage2D(GL_TEXTURE_2D, 0, GL_R32F,
    cubic->width, cubic->height / 4,
    0, GL_RED, GL_FLOAT, 0
```

```
  );
  glBindTexture(GL_TEXTURE_2D, cubic->textures[1]);
  glTexImage2D(GL_TEXTURE_2D, 0, GL_R32F,
    cubic->width, cubic->height,
    0, GL_RED, GL_FLOAT, 0
  );
}

//==========================================================
// shader display callback
void cubic_display(
  struct cubic *cubic, GLuint fbo, GLuint texture
) {
  const int aa = 4;
  glBindVertexArray(cubic->vao);
  glBindTexture(GL_TEXTURE_2D, texture);
  glUseProgram(cubic->shader.program);
  glBindFramebuffer(GL_FRAMEBUFFER, fbo);
  glFramebufferTexture2D(
    GL_FRAMEBUFFER, GL_COLOR_ATTACHMENT0, GL_TEXTURE_2D,
    cubic->textures[0], 0
  );
  cubic->value.size[0] = cubic->width / aa;
  cubic->value.size[1] = cubic->height / aa;
  cubic->value.delta[0] = 1;
  cubic->value.delta[1] = 0;
  shader_updatei(cubic, tex);
  shader_update2i(cubic, size);
  shader_update2i(cubic, delta);
  glViewport(0, 0, cubic->width, cubic->height / aa);
  glDrawArrays(GL_TRIANGLE_STRIP, 0, 4);
  glBindTexture(GL_TEXTURE_2D, cubic->textures[0]);
  glFramebufferTexture2D(
    GL_FRAMEBUFFER, GL_COLOR_ATTACHMENT0, GL_TEXTURE_2D,
    cubic->textures[1], 0
  );
  cubic->value.size[0] = cubic->width;
  cubic->value.size[1] = cubic->height / aa;
  cubic->value.delta[0] = 0;
  cubic->value.delta[1] = 1;
  shader_updatei(cubic, tex);
  shader_update2i(cubic, size);
  shader_update2i(cubic, delta);
  glViewport(0, 0, cubic->width, cubic->height);
  glDrawArrays(GL_TRIANGLE_STRIP, 0, 4);
  glBindFramebuffer(GL_FRAMEBUFFER, 0);
  glUseProgram(0);
  glBindVertexArray(0);
}

// EOF
```

6 cubic.frag

```
/* ==========================================================
pool-party -- water simulation
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```

```
/* ---------------------------------------------------------------------
based on:
mightymandel -- GPU-based Mandelbrot Set explorer
Copyright (C) 2012,2013,2014,2015 Claude Heiland-Allen
---------------------------------------------------------------------
Cubic Interpolation Shader
===================================================================== */

#version 330 core

uniform sampler2D tex;
uniform ivec2 size; // FIXME must be power of two
uniform ivec2 delta; // (1,0) or (0,1)

in vec2 p;

out vec4 colour;

vec4 interp(float t, mat4 a) {
  const mat4 m = mat4
    ( 0.0,2.0,0.0,0.0
    , -1.0,0.0,1.0,0.0
    , 2.0,-5.0,4.0,-1.0
    , -1.0,3.0,-3.0,1.0
    );
  vec4 f = vec4(1.0, t, t*t, t*t*t);
  return 0.5 * a * m * f;
}

void main(void) {
  ivec2 i = ivec2(floor(p));
  ivec2 i0 = (i -     delta) & ivec2(size - ivec2(1));
  ivec2 i1 = (i            ) & ivec2(size - ivec2(1));
  ivec2 i2 = (i +     delta) & ivec2(size - ivec2(1));
  ivec2 i3 = (i + 2 * delta) & ivec2(size - ivec2(1));
  vec2 f = p - vec2(i);
  colour =
    interp(dot(f, vec2(delta)), mat4(
      texelFetch(tex, i0, 0),
      texelFetch(tex, i1, 0),
      texelFetch(tex, i2, 0),
      texelFetch(tex, i3, 0)));
}

// EOF
```

7 cubic.h

```
/* =====================================================================
pool-party -- water simulation
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---------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
---------------------------------------------------------------------
Cubic Interpolation Shader
```

```
10 ============================================================================ */

#ifndef CUBIC_H
#define CUBIC_H 1

15 #include "shader.h"

//============================================================================
// data
struct cubic { struct shader shader;
20   struct { GLint  tex, size, delta; } uniform;
   struct { int tex, size[2], delta[2]; } value;
   GLuint textures[2];
   GLuint vao;
   int width;
25   int height;
};

//============================================================================
// protoypes
30 struct cubic *cubic_init(struct cubic *cubic);
void cubic_reshape(
   struct cubic *cubic, int w, int h
);
void cubic_display(
35   struct cubic *cubic, GLuint fbo, GLuint texture
);

#endif
```

8 cubic.vert

```
/* ============================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------------------
 5 based on:
mightymandel -- GPU-based Mandelbrot Set explorer
Copyright (C) 2012,2013,2014,2015 Claude Heiland-Allen
----------------------------------------------------------------------------
Cubic Interpolation Shader
10 ============================================================================ */

#version 330 core

uniform ivec2 size;
15
out vec2 p;

void main(void) {
   vec2 q = vec2(0.0);
20   switch (gl_VertexID) {
   case 0: q = vec2(0.0, 0.0); break;
   case 1: q = vec2(1.0, 0.0); break;
   case 2: q = vec2(0.0, 1.0); break;
   case 3: q = vec2(1.0, 1.0); break;
25   }
```

```
  gl_Position = vec4(2.0 * q - vec2(1.0), 0.0, 1.0);
  p = vec2(size) * q;
}

// EOF
```

9 .gitignore

```
*.o
*.frag.c
*.vert.c
pool-party
*.ogv
*.png
```

10 LICENSE.md

```
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Version 3, 29 June 2007

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```

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```
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```

11 main.c

```
/* ========================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009  Claude Heiland-Allen <claude@mathr.co.uk>
------------------------------------------------------------------------
Main Program Entry Point
======================================================================== */

#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <GL/glew.h>
#include <GLFW/glfw3.h>

#include "party.h"

void keycb(GLFWwindow* window, int key, int scancode, int action, int mods) {
  (void) window;
  (void) scancode;
  (void) action;
  (void) mods;
  party_keynormal(key, 0, 0);
}

int main(int argc, char **argv) {
  (void) argv;
  /* initialize GLFW etc */
  fprintf(stderr, "pool-party (GPL) 2016 Claude Heiland-Allen <claude@mathr.co.↙
      ↪ uk>\n");
  fprintf(stderr, "based on:\n");
  fprintf(stderr, "rdex (GPL) 2008,2009,2010 Claude Heiland-Allen <claude@mathr.↙
      ↪ co.uk>\n");
  srand(time(NULL));
  glfwInit();
  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_DECORATED, GL_FALSE);
  glfwWindowHint(GLFW_RESIZABLE, GL_FALSE);
  GLFWwindow *window = glfwCreateWindow(1920, 1080, "pool-party", 0, 0);
```

```
  glfwMakeContextCurrent(window);
  glewExperimental = GL_TRUE;
  glewInit();
  glGetError(); // discard common error from glew
  glfwSwapInterval(2);
  glfwSetInputMode(window, GLFW_CURSOR, GLFW_CURSOR_HIDDEN);
  glfwSetKeyCallback(window, keycb);
  /* activate callbacks and enter main loop */
  int rt = argc == 1;
  if (party_init(rt)) {
    party_reshape(1920, 1080);
    while (! glfwWindowShouldClose(window)) {
      glfwPollEvents();
      party_display(window);
      party_idle();
    }
    return 0; // never reached
  } else {
    return 1;
  }
}

// EOF
```

12 Makefile

```
#=============================================================================
# pool-party -- water simulation
# Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
#-----------------------------------------------------------------------------
# based on:
# rdex -- reaction-diffusion explorer
# Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
#-----------------------------------------------------------------------------
# Makefile
#=============================================================================

CC = gcc
CFLAGS = -std=c99 -Wall -Wextra -pedantic -O3 -fPIC -fopenmp `pkg-config --cflags jack`
LIBS = -lGL -lGLU -lglfw -lGLEW -lfftw3f -lm `pkg-config --libs jack` -lsndfile
OBJS = main.o party.o shader.o caustics.o cubic.o pool.o util.o waves.o screenshot.o wrapseams.o
GENC = caustics.frag.c caustics.vert.c cubic.frag.c cubic.vert.c pool.frag.c pool.vert.c wrapseams.frag.c wrapseams.vert.c

# optional feature: debuggability
CFLAGS += -ggdb

all: pool-party

clean:
	-rm -f $(OBJS) $(GENC)

# no suffix rules, they cause weird issues with the .frag.c files
.SUFFIXES:
.PHONY: all clean
```

```
# link program
pool-party: $(OBJS)
        $(CC) $(CFLAGS) -s -o pool-party $(OBJS) $(LIBS)

# C source to object file
%.o: %.c
        $(CC) $(CFLAGS) -o $@ -c $<

# shader source to C source
%.frag.c: %.frag s2c.sh
        ./s2c.sh $*_frag < $< > $@
%.vert.c: %.vert s2c.sh
        ./s2c.sh $*_vert < $< > $@

# dependencies
caustics.o: caustics.c caustics.frag.c caustics.h caustics.vert.c shader.h util.h
cubic.o: cubic.c cubic.frag.c cubic.vert.c cubic.h shader.h util.h
main.o: main.c party.h
pool.o: pool.c pool.h pool.frag.c pool.vert.c shader.h util.h
party.o: party.c party.h caustics.h cubic.h waves.h pool.h screenshot.h wrapseams.h
screenshot.o: screenshot.c screenshot.h
shader.o: shader.c shader.h
util.o: util.c util.h
waves.o: waves.c waves.h util.h
wrapseams.o: wrapseams.c wrapseams.h wrapseams.vert.c wrapseams.frag.c shader.h util.h

# EOF
```

13 party.c

```
/* ===========================================================================
pool-party -- water simulation
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---------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
---------------------------------------------------------------------------
Main Module
=========================================================================== */

#include <math.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "party.h"

//===========================================================================
// main module global mutable state
static struct party party;

void party_audiocb(float *l, float *r, int nframes) {
  float g = 0.025;
```

```
  for (int i = 0; i < nframes; ++i) {
    float h = i / (float) nframes;
    float h1 = 1 - h;
    float c[2];
    c[0] = h1 * party.center[0] + h * party.center[1];
    c[1] = h1 * party.center[2] + h * party.center[3];
    int j = party.ix / 4;
    float f = (party.ix & 3) / 4.0f;
    float f1 = 1 - f;
    l[i] = tanhf(g * hip(&party.hip[0]
      , h1 * (party.audio[0][j] * f1 + party.audio[0][(j + 1) & 255] * f)
      + h  * (party.audio[2][j] * f1 + party.audio[2][(j + 1) & 255] * f)
      + 5 * sin(0.1 * fmax(c[0], 1) * (h1 * party.audio[4][party.ix] + h * party.audio[6][party.ix])), 5));
    r[i] = tanhf(g * hip(&party.hip[1]
      , h1 * (party.audio[1][j] * f1 + party.audio[1][(j + 1) & 255] * f)
      + h  * (party.audio[3][j] * f1 + party.audio[3][(j + 1) & 255] * f)
      + 5 * sin(0.1 * fmax(c[1], 1) * (h1 * party.audio[5][party.ix] + h * party.audio[7][party.ix])), 5));
    party.ix = (party.ix + 1) & 1023;
  }
  memcpy(&party.audio[0][0], &party.audio[2][0], 256 * sizeof(float));
  memcpy(&party.audio[1][0], &party.audio[3][0], 256 * sizeof(float));
  memcpy(&party.audio[4][0], &party.audio[6][0], 1024 * sizeof(float));
  memcpy(&party.audio[5][0], &party.audio[7][0], 1024 * sizeof(float));
  party.center[0] = party.center[1];
  party.center[2] = party.center[3];
}

static volatile int party_incb = 0;
int party_processcb(jack_nframes_t nframes, void *arg) {
  (void) arg;
  jack_default_audio_sample_t *out[2];
  out[0] = jack_port_get_buffer(party.port[0], nframes);
  out[1] = jack_port_get_buffer(party.port[1], nframes);
  party_incb = 1;
  party_audiocb(out[0], out[1], nframes);
  party_incb = 0;
  return 0;
}

//============================================================
// main module initialization
int party_init(int rt) {
  memset(&party, 0, sizeof(party));
  party.rt = rt;
  if (! waves_init(&party.waves)) { return 0; }
  { int e = glGetError(); if (e) fprintf(stderr, "GL Error after waves %d\n", e); }
  if (! cubic_init(&party.cubic)) { return 0; }
  { int e = glGetError(); if (e) fprintf(stderr, "GL Error after cubic %d\n", e); }
  if (! caustics_init(&party.caustics)) { return 0; }
  { int e = glGetError(); if (e) fprintf(stderr, "GL Error after caustics %d\n", e); }
  if (! wrapseams_init(&party.wrapseams)) { return 0; }
  { int e = glGetError(); if (e) fprintf(stderr, "GL Error after wrapseams %d\n
```

```
    ↳ ", e); }
  if (! pool_init(&party.pool)) { return 0; }
  { int e = glGetError(); if (e) fprintf(stderr, "GL Error after pool %d\n", e);↙
    ↳ }
  if (! screenshot_init(&party.screenshot, rt)) { return 0; }
  { int e = glGetError(); if (e) fprintf(stderr, "GL Error after screenshot %d\n↙
    ↳ ", e); }
  glGenFramebuffers(1, &party.fbo);
  party.starttime = 0;
  party.fullscreen = 0;
  party.done = 0;

  if (rt) {
    if (! (party.client = jack_client_open("pool-party", JackNoStartServer, 0)))↙
      ↳ {
      fprintf(stderr, "jack server not running?\n");
      exit(1);
    }
    jack_set_process_callback(party.client, party_processcb, 0);
    party.port[0] = jack_port_register(party.client, "output_1", ↙
      ↳ JACK_DEFAULT_AUDIO_TYPE, JackPortIsOutput, 0);
    party.port[1] = jack_port_register(party.client, "output_2", ↙
      ↳ JACK_DEFAULT_AUDIO_TYPE, JackPortIsOutput, 0);
    if (jack_activate(party.client)) {
      fprintf (stderr, "cannot activate JACK client");
      exit(1);
    }
    if (jack_connect(party.client, "pool-party:output_1", "system:playback_1")) ↙
      ↳ {
      fprintf(stderr, "cannot connect output port\n");
    }
    if (jack_connect(party.client, "pool-party:output_2", "system:playback_2")) ↙
      ↳ {
      fprintf(stderr, "cannot connect output port\n");
    }
  } else {
      SF_INFO info = { 0, 48000, 2, SF_FORMAT_WAV | SF_FORMAT_FLOAT, 0, 0 };
      party.sndfile = sf_open("pool-party.wav", SFM_WRITE, &info);
  }
  return 1;
}

//============================================================
// main module reshape callback
void party_reshape(int w, int h) {
  (void) w;
  (void) h;
  waves_reshape(&party.waves, party_tex_size, party_tex_size);
  cubic_reshape(&party.cubic, party_tex_size, party_tex_size);
  caustics_reshape(&party.caustics, party_tex_size, party_tex_size);
  wrapseams_reshape(&party.wrapseams, party_tex_size, party_tex_size);
  pool_reshape(&party.pool, w, h);
  screenshot_reshape(&party.screenshot, w, h);
}

//============================================================
// main module display callback
```

```
125 void party_display(GLFWwindow *window) {
      waves_display(&party.waves);
      cubic_display(&party.cubic, party.fbo, party.waves.texture);
      caustics_display(&party.caustics, party.fbo, party.cubic.textures[1]);
      wrapseams_display(&party.wrapseams, party.fbo, party.caustics.texture);
130   pool_display(&party.pool, party.cubic.textures[1], party.wrapseams.texture);
      if (party.rt)
        while (party_incb)
          ;
      float c[2];
135   waves_audio(&party.waves, &party.audio[2][0], &party.audio[3][0], c);
      party.center[1] = c[0];
      party.center[3] = c[1];
      wrapseams_audio(&party.wrapseams, &party.audio[6][0], &party.audio[7][0]);
      if (! party.rt)
140   {
        float audio[2][SR/FPS];
        party_audiocb(&audio[0][0], &audio[1][0], SR/FPS);
        float frames[SR/FPS][2];
        for (int i = 0; i < SR/FPS; ++i)
145       for (int c = 0; c < 2; ++c)
            frames[i][c] = audio[c][i];
        sf_writef_float(party.sndfile, &frames[0][0], SR/FPS);
      }
      glfwSwapBuffers(window);
150   screenshot_display(&party.screenshot);
      party.frame += 1;
      if (! party.rt && party.frame >= FPS * 300) {
        sf_close(party.sndfile);
        exit(0);
155   }
    }

    //============================================================================
    // main module exit callback
160 void party_atexit(void) {
      double timeelapsed = (double) time(NULL) - (double) party.starttime;
      fprintf(stderr, "\n\n↙
          ↪ ------------------------------------------------------------------------\↙
          ↪ n");
      fprintf(stderr, "------------------------------ statistics ↙
          ↪ -------------------------------\n");
      fprintf(stderr, ↙
          ↪ "------------------------------------------------------------------------\↙
          ↪ n");
165   fprintf(stderr, "%10d seconds elapsed (+/- 1)\n", (int) timeelapsed);
      fprintf(stderr, "%10d frames rendered (%f fps)\n", party.frame, party.frame / ↙
          ↪ timeelapsed);
      fprintf(stderr, "%10d frames dropped (+/- 30)\n", (int) timeelapsed * 30 - ↙
          ↪ party.frame);
      fprintf(stderr, ↙
          ↪ "------------------------------------------------------------------------\↙
          ↪ n");
    }
170
    //============================================================================
    // main module idle callback
```

```
void party_idle() {
  if (party.starttime == 0) {
    party.starttime = time(NULL);
    party.frame = 0;
    atexit(party_atexit);
  }
  int e = glGetError();
  if (e) {
    fprintf(stderr, "GL err: %d\n", e);
  }
}

//=============================================================================
// main module keyboard callback
void party_keynormal(unsigned char key, int x, int y) {
  (void) x;
  (void) y;
  switch (key) {
  case 27: // escape
  case 'Q':
  case 'q':
                exit(0);
    break;
  default:
    break;
  }
}

// EOF
```

14 party.h

```
/* ============================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------------------
Main Module
============================================================================ */

#ifndef PARTY_H
#define PARTY_H 1

#include <math.h>
#include <time.h>
#include <GL/glew.h>
#include <GLFW/glfw3.h>

#include <jack/jack.h>
#include <sndfile.h>

#include "waves.h"
#include "cubic.h"
#include "caustics.h"
```

```
#include "wrapseams.h"
#include "pool.h"
#include "screenshot.h"

//=============================================================
// configuration
#define party_tex_size 1024

#define twopi 6.283185307179586
#define SR 48000
#define FPS 30
typedef struct { double y; } HIP;
static inline double hip(HIP *s, double x, double hz) {
  double c = fmin(fmax(1 - twopi * hz / SR, 0), 1);
  double n = 0.5 * (1 + c);
  double y = x + c * s->y;
  double o = n * (y - s->y);
  s->y = y;
  return o;
}
typedef struct { double y; } LOP;
static inline double lop(LOP *s, double x, double hz) {
  double c = fmin(fmax(twopi * hz / SR, 0), 1);
  return s->y = x * c + s->y * (1 - c);
}


//=============================================================
// main module data
struct party {
  struct waves waves;
  struct cubic cubic;
  struct caustics caustics;
  struct wrapseams wrapseams;
  struct pool pool;
  struct screenshot screenshot;
  GLuint fbo;
  time_t starttime;
  unsigned int frame;
  int done;
  int fullscreen;
  char *behaviour;
  float audio[8][1024];
  float center[4];
  int ix;
  LOP lop[2];
  HIP hip[2];
  int rt;
  jack_client_t *client;
  jack_port_t *port[2];
  SNDFILE *sndfile;
};

//=============================================================
// prototypes
int party_init(int rt);
void party_reshape(int w, int h);
```

```
void party_display(GLFWwindow *window);
void party_atexit(void);
void party_idle(void);
void party_keynormal(unsigned char key, int x, int y);

#endif
```

15 pool.c

```
/* ================================================================
pool-party -- water simulation
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----------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------
Refraction Shader
================================================================ */

#include "util.h"
#include "pool.h"
#include "pool.vert.c"
#include "pool.frag.c"

//================================================================
// initialization
struct pool *pool_init(struct pool *pool) {
  if (! pool) { return 0; }
  if (! shader_init(&pool->shader, pool_vert, pool_frag)) {
    return 0;
  }
  shader_uniform(pool, texSurface);
  shader_uniform(pool, texCaustics);
  pool->value.texSurface = 1;
  pool->value.texCaustics = 0;
  pool->width = 0;
  pool->height = 0;
  glGenVertexArrays(1, &pool->vao);
  return pool;
}

//================================================================
// reshape callback
void pool_reshape(
  struct pool *pool, int w, int h
) {
  pool->width  = w;
  pool->height = h;
}

//================================================================
// display callback
void pool_display(
  struct pool *pool, GLuint texSurface, GLuint texCaustics
) {
  glActiveTexture(GL_TEXTURE1);
```

```
  glBindTexture(GL_TEXTURE_2D, texSurface);
  glActiveTexture(GL_TEXTURE0);
  glBindTexture(GL_TEXTURE_2D, texCaustics);
  glUseProgram(pool->shader.program);
  shader_updatei(pool, texSurface);
  shader_updatei(pool, texCaustics);
  glViewport(0, 0, pool->width, pool->height);
  glClear(GL_COLOR_BUFFER_BIT);
  glBindVertexArray(pool->vao);
  glDrawArrays(GL_TRIANGLE_STRIP, 0, 4);
  glBindVertexArray(0);
  glUseProgram(0);
}

// EOF
```

16 pool.frag

```
/* ==========================================================================
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--------------------------------------------------------------------------
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Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------
Refraction Shader
========================================================================== */

#version 330 core

uniform sampler2D texSurface;
uniform sampler2D texCaustics;

const float pi = 3.141592653589793;

in vec2 p0;

out vec4 colour;

void main(void) {
  int w = textureSize(texCaustics, 0).x;

  vec2 p = p0;
  float u = 2.0 * p.x - 1.0;
  float v = 2.0 * p.y - 1.0;
  u *= 0.75;
  v *= 0.75;
  vec3 incident = normalize(vec3(2.0 * u, 2.0 * v, u * u + v * v - 1.0));

  if (incident.z > 0.0) {
    // do cloud reflection

    discard;

  } else {
    // do water refraction and reflection
```

```
40
      vec3 eye = vec3(0.0, 0.0, 0.5);
      float e = eye.z / incident.z;
      p = vec2(eye - e * incident);
      p += vec2(0.5);
45    vec2 dx = vec2(1.0 / float(w), 0.0);
      vec2 dy = vec2(0.0, 1.0 / float(w));
      float h = texture(texSurface, p).r;
      float hx1 = texture(texSurface, p + dx).r;
      float hx2 = texture(texSurface, p - dx).r;
50    float hy1 = texture(texSurface, p + dy).r;
      float hy2 = texture(texSurface, p - dy).r;
      vec3 x = normalize(vec3(1.0, 0.0, 0.5 * (hx1 - hx2)));
      vec3 y = normalize(vec3(0.0, 1.0, 0.5 * (hy1 - hy2)));
      vec3 normal = normalize(cross(x, y));
55    if (normal.z < 0.0) {
        normal = -normal;
      }

      float caustic = 0.0;
60    float eta = 1.0/1.333;
      vec3 r = refract(incident, normal, eta);
      if (dot(normal, incident) < 0.0 && r.z < 0.0) {
        vec3 s = vec3(p * float(w), h + 256.0);
        float k = s.z / r.z;
65      vec3 c = s - k * r;
        vec2 q = c.xy / float(w);
        caustic = 0.5 * log(1.0 + texture(texCaustics, q).r);
      }

70    float sky = 0.0;
      vec3 f = vec3(0.0);
      if (dot(normal, incident) < 0.0) {
        f = reflect(incident, normal);
        vec3 light = normalize(vec3(0.0, 0.0, 1.0));
75      sky = mix(0.5, 1.0, pow(max(0.0, dot(f, light)), 64.0));
      } else {
        sky = 1.0;
      }
      float a = abs(dot(f, normal));
80    float b = abs(dot(r, normal));
      float rs = (eta * a - b) / (eta * a + b);
      float rp = (eta * b - a) / (eta * b + a);
      float fresnel = 0.5 * (rs * rs + rp * rp);

85    float grey = tanh(clamp(mix(caustic, sky, fresnel), 0.0, 4.0));
      vec3 rgb = vec3(grey) + vec3(0.1, 0.1, 0.2)
        * sin(2.0 * pi * pow(vec3(grey), vec3(0.5, 0.666, 0.75)));
      colour = vec4(rgb, 1.0);
    }
90  }

// EOF
```

17 pool.h

```
/* ============================================================
```

```
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-------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------
Refraction Shader
=========================================================================== */

#ifndef POOL_H
#define POOL_H 1

#include "shader.h"

//===========================================================================
// data
struct pool { struct shader shader;
  struct { GLint  texSurface, texCaustics; } uniform;
  struct { int    texSurface, texCaustics; } value;
  GLuint vao;
  int width;
  int height;
};

//===========================================================================
// protoypes
struct pool *pool_init(struct pool *pool);
void pool_reshape(
  struct pool *pool, int w, int h
);
void pool_display(
  struct pool *pool, GLuint texSurface, GLuint texCaustics
);

#endif
```

18 pool.vert

```
/* ==========================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------
based on:
mightymandel -- GPU-based Mandelbrot Set explorer
Copyright (C) 2012,2013,2014,2015 Claude Heiland-Allen
-------------------------------------------------------------------------
Cubic Interpolation Shader
=========================================================================== */

#version 330 core

uniform ivec2 size;

out vec2 p0;

void main(void) {
```

```
  vec2 q = vec2(0.0);
  switch (gl_VertexID) {
  case 0: q = vec2(0.0, 0.0); break;
  case 1: q = vec2(1.0, 0.0); break;
  case 2: q = vec2(0.0, 1.0); break;
  case 3: q = vec2(1.0, 1.0); break;
  }
  gl_Position = vec4(2.0 * q - vec2(1.0), 0.0, 1.0);
  p0 = vec2(q.x, mix(0.5 - 9.0 / 32.0, 0.5 + 9.0 / 32.0, q.y));
}

// EOF
```

19 README.md

```
pool-party
==========

Water simulation.

    make && ./pool-party

Legal
-----

pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>

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```

20 s2c.sh

```
#!/bin/bash
echo "/* machine-generated file, do not edit */"
echo "static const char $1[] ="
sed 's|//.*||' |
sed 's|^|"|' |
sed 's|$|\\n"|'
echo ";"
```

21 screenshot.c

```
/* ==========================================================
pool-party -- water simulation
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```

```
-------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------
Screenshot Module
=========================================================================*/

#include <stdio.h>
#include <stdlib.h>
#include <GL/glew.h>
#include "screenshot.h"

//=========================================================================
// screenshot module initialization
struct screenshot *screenshot_init(struct screenshot *screenshot, int rt) {
  if (! screenshot) { return 0; }
  screenshot->width = 0;
  screenshot->height = 0;
  screenshot->buffer = 0;
  screenshot->rt = rt;
  return screenshot;
}

//=========================================================================
// screenshot module display callback
void screenshot_display(struct screenshot *screenshot) {
  if (! screenshot->rt) {
    glReadPixels(0, 0, screenshot->width, screenshot->height, GL_RED, ↙
        ↳ GL_UNSIGNED_BYTE, screenshot->buffer);
    fprintf(stdout, "P5\n%d %d 255\n", screenshot->width, screenshot->height);
    for (int y = screenshot->height - 1; y >= 0; --y) {
      fwrite(screenshot->buffer + y * screenshot->width, screenshot->width, 1, ↙
          ↳ stdout);
    }
  }
}

//=========================================================================
// screenshot module reshape callback
void screenshot_reshape(struct screenshot *screenshot, int w, int h) {
  screenshot->width = w;
  screenshot->height = h;
  if (screenshot->buffer) free(screenshot->buffer);
  screenshot->buffer = malloc(w * h);
}

// EOF
```

22 screenshot.h

```
/* =========================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
```

```
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------------
Screenshot Module
=============================================================================== */

#ifndef SCREENSHOT_H
#define SCREENSHOT_H 1

//=============================================================================
// screenshot module data
struct screenshot {
  int width;
  int height;
  char *buffer;
  int rt;
};

//=============================================================================
// prototypes
struct screenshot *screenshot_init(struct screenshot *screenshot, int rt);
void screenshot_display(struct screenshot *screenshot);
void screenshot_reshape(struct screenshot *screenshot, int w, int h);

#endif
```

23 shader.c

```
/* ============================================================================
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-------------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
-------------------------------------------------------------------------------
Generic Shader
=============================================================================== */

#include <stdio.h>
#include <stdlib.h>
#include "shader.h"

//=============================================================================
// print a shader object's debug log
void shader_debug(GLuint obj) {
//  return; // FIXME: only dump logs when shader compile/link failed
  int infologLength = 0;
  int maxLength;
  if (glIsShader(obj)) {
    glGetShaderiv(obj, GL_INFO_LOG_LENGTH, &maxLength);
  } else {
    glGetProgramiv(obj, GL_INFO_LOG_LENGTH, &maxLength);
  }
  char *infoLog = malloc(maxLength);
  if (!infoLog) {
    return;
  }
```

```
  if (glIsShader(obj)) {
    glGetShaderInfoLog(obj, maxLength, &infologLength, infoLog);
  } else {
    glGetProgramInfoLog(obj, maxLength, &infologLength, infoLog);
  }
  if (infologLength > 0) {
    fprintf(stderr, "%s\n", infoLog);
  }
  free(infoLog);
}

//=============================================================
// generic shader initialization
struct shader *shader_init(
  struct shader *shader, const char *vert, const char *frag
) {
  if (! shader) { return 0; }
  shader->linkStatus     = 0;
  shader->vertexSource   = vert;
  shader->fragmentSource = frag;
  if (shader->vertexSource || shader->fragmentSource) {
    shader->program = glCreateProgram();
    if (shader->vertexSource) {
      shader->vertex =
        glCreateShader(GL_VERTEX_SHADER);
      glShaderSource(shader->vertex,
        1, &shader->vertexSource, 0
      );
      glCompileShader(shader->vertex);
      shader_debug(shader->vertex);
      glAttachShader(shader->program, shader->vertex);
    }
    if (shader->fragmentSource) {
      shader->fragment =
        glCreateShader(GL_FRAGMENT_SHADER);
      glShaderSource(shader->fragment,
        1, &shader->fragmentSource, 0
      );
      glCompileShader(shader->fragment);
      shader_debug(shader->fragment);
      glAttachShader(shader->program, shader->fragment);
    }
    glLinkProgram(shader->program);
    shader_debug(shader->program);
    glGetProgramiv(shader->program,
      GL_LINK_STATUS, &shader->linkStatus
    );
    if (! shader->linkStatus) { return 0; }
  } else { return 0; }
  return shader;
}

// EOF
```

24 shader.h

```
/* =============================================================
```

```
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-------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
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-------------------------------------------------------------------------
Generic Shader
========================================================================= */

#ifndef SHADER_H
#define SHADER_H 1

#include <GL/glew.h>

//=========================================================================
// generic shader data
struct shader {
  GLint linkStatus;
  GLuint program;
  GLuint fragment;
  GLuint vertex;
  const char *fragmentSource;
  const char *vertexSource;
};

//=========================================================================
// generic shader uniform location access macro
#define shader_uniform(self,name) \
  (self)->uniform.name = \
    glGetUniformLocation((self)->shader.program, #name)

//=========================================================================
// generic shader uniform update access macro (integer)
#define shader_updatei(self,name) \
  glUniform1i((self)->uniform.name, (self)->value.name)

//=========================================================================
// generic shader uniform update access macro (integer vector)
#define shader_update2i(self,name) \
  glUniform2iv((self)->uniform.name, 1, (self)->value.name)

//=========================================================================
// generic shader uniform update access macro (float)
#define shader_updatef(self,name) \
  glUniform1f((self)->uniform.name, (self)->value.name)

//=========================================================================
// generic shader initialization
struct shader *shader_init(
  struct shader *shader, const char *vert, const char *frag
);

#endif
```

25 util.c

```
/* ===========================================================================
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---------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
---------------------------------------------------------------------------
Utility Functions
=========================================================================== */

#include <assert.h>
#include "util.h"

//=============================================================================
// round 'x' up to the nearest power of two (which may be 'x' itself)
unsigned int roundtwo(unsigned int x) {
  assert(x <= 1u << 31); // termination condition
  unsigned int y = 1;
  while (y < x) y <<= 1;
  return y;
}

//=============================================================================
// find log2 of the nearest power of two above 'x'
unsigned int logtwo(unsigned int x) {
  assert(x <= 1u << 31); // termination condition
  unsigned int y = 1, z = 0;
  while (y < x) { y <<= 1; z += 1; };
  return z;
}

// EOF
```

26 util.h

```
/* ===========================================================================
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---------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
---------------------------------------------------------------------------
Utility Functions
=========================================================================== */

#ifndef UTIL_H
#define UTIL_H 1

unsigned int roundtwo(unsigned int x);
unsigned int logtwo(unsigned int x);

#endif
```

27 waves.c

```
/* ========================================================================
pool-party -- water simulation
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------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
------------------------------------------------------------------------
Wave Simulation
======================================================================== */

#include <math.h>
#include <stdlib.h>
#include <string.h>
#include "util.h"
#include "waves.h"

//========================================================================
// initialization
struct waves *waves_init(struct waves *waves) {
  if (! waves) { return 0; }
  waves->width = 0;
  waves->height = 0;
  waves->hasplan = 0;
  glGenTextures(1, &waves->texture);
  glBindTexture(GL_TEXTURE_2D, waves->texture);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_LINEAR_MIPMAP_LINEAR);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_LINEAR);
  return waves;
}


double _Complex grand2(void) {
  double u, v, s = 100;
  while (s > 1) {
    u = rand() / (double) RAND_MAX;
    v = rand() / (double) RAND_MAX;
    s = u * u + v * v;
  }
  double t = sqrt(-2 * log(s) / s);
  return u * t + I * v * t;
}

//========================================================================
// reshape callback
void waves_reshape(
  struct waves *waves, int w, int h
) {
  waves->width  = roundtwo(w) / 4;
  waves->height = roundtwo(h) / 4;
  if (waves->hasplan) {
    fftwf_destroy_plan(waves->plan);
    fftwf_free(waves->inbuf);
    fftwf_free(waves->outbuf);
    free(waves->texbuf);
    free(waves->h00);
```

```
    free(waves->h0);
    free(waves->w);
    free(waves->wp);
  }
  waves->h00 = malloc(waves->width * waves->height * sizeof(waves->h00[0]));
  waves->h0 = malloc(waves->width * waves->height * sizeof(waves->h0[0]));
  waves->w = malloc(waves->width * waves->height * sizeof(waves->w[0]));
  waves->wp = malloc(waves->width * waves->height * sizeof(waves->wp[0]));
  waves->texbuf = calloc(1, waves->width * waves->height * sizeof(waves->texbuf[0]));
  waves->inbuf = fftwf_malloc(waves->width * waves->height * sizeof(waves->inbuf[0]));
  waves->outbuf = fftwf_malloc(waves->width * waves->height * sizeof(waves->outbuf[0]));
  waves->plan = fftwf_plan_dft_2d(waves->width, waves->height, waves->inbuf, waves->outbuf, FFTW_BACKWARD, FFTW_MEASURE);
  waves->hasplan = 1;
  for (int i = 0; i < waves->width; ++i) {
    for (int j = 0; j < waves->height; ++j) {
      int ix = i * waves->height + j;
      int ii = i >= waves->width / 2 ? i - waves->width : i;
      int jj = j >= waves->height / 2 ? j - waves->height : j;
      float a = 256;
      float g = 3;
      float d = 10;
      float wx = 64;
      float wy = 0;
      float w2 = wx * wx + wy * wy;
      float k2 = ii * ii + jj * jj;
      float dot = fmax(0, (ii * wx + jj * wy) / (sqrtf(k2) * sqrtf(w2)));
      float l = w2 / g;
      float l2 = l * l;
      waves->h00[ix] = grand2();
      waves->h0[ix] = k2 == 0 ? 0 : 1.0 / sqrtf(2) * sqrtf(expf(-k2 * 0.000001 * l2) * a * expf(-1 / (k2 * l2)) / (k2 * k2) * dot * dot);
      waves->w[ix] = sqrtf(g * sqrtf(k2) * tanhf(d * sqrtf(k2)));
      waves->wp[ix] = 6.283185307179586 * (rand() / (double) RAND_MAX);
    }
  }
  glBindTexture(GL_TEXTURE_2D, waves->texture);
  glTexImage2D(GL_TEXTURE_2D, 0, GL_R32F, waves->width, waves->height, 0, GL_RED, GL_FLOAT, waves->texbuf);
}

//==========================================================================
// wind callback
void waves_adjust(
  struct waves *waves, double wx, double wy
) {
  #pragma omp parallel for
  for (int i = 0; i < waves->width; ++i) {
    for (int j = 0; j < waves->height; ++j) {
      int ix = i * waves->height + j;
      int ii = i >= waves->width / 2 ? i - waves->width : i;
      int jj = j >= waves->height / 2 ? j - waves->height : j;
      float a = 256;
      float g = 3;
```

```
      float w2 = wx * wx + wy * wy;
      float k2 = ii * ii + jj * jj;
      float dot = fmaxf(0, (ii * wx + jj * wy) / (sqrtf(k2) * sqrtf(w2)));
      float l = w2 / g;
      float l2 = l * l;
      waves->h0[ix] = k2 == 0 ? 0 : 1.0 / sqrtf(2) * sqrtf(expf(-k2 * 0.000001 * l2) * a * expf(-1 / (k2 * l2)) / (k2 * k2) * dot * dot);
    }
  }
}

//==========================================================
// display callback
void waves_display(
  struct waves *waves
) {
  double t = waves->frame / 30.0;
  waves_adjust(waves, -pow(0.5, 1.333 * (1 - cos(6.283185307179586 * t / 300))) * 48, 0);
  #pragma omp parallel for
  for (int i = 0; i < waves->width; ++i) {
    for (int j = 0; j < waves->height; ++j) {
      int k = i * waves->height + j;
      int nk = ((waves->width - i) % waves->width) * waves->height + ((waves->height - j) % waves->height);
      waves->inbuf[k] = waves->h00[k] * waves->h0[k] * cexpf(I * (waves->w[k] * t + waves->wp[k]))
            + conjf(waves->h00[nk]) * waves->h0[nk] * cexpf(-I * (waves->w[k] * t + waves->wp[k]));
    }
  }
  fftwf_execute(waves->plan);
  for (int k = 0; k < waves->width * waves->height; ++k) {
    waves->texbuf[k] = crealf(waves->outbuf[k]);
  }
  glBindTexture(GL_TEXTURE_2D, waves->texture);
  glTexSubImage2D(GL_TEXTURE_2D, 0, 0, 0, waves->width, waves->height, GL_RED, GL_FLOAT, waves->texbuf);
  glGenerateMipmap(GL_TEXTURE_2D);
  waves->frame++;
}

//==========================================================
// audio callback
void waves_audio(struct waves *waves, float *left, float *right, float *center) {
  memcpy(left, &waves->texbuf[15 * waves->height / 32 * waves->width], waves->width * sizeof(float));
  memcpy(right, &waves->texbuf[17 * waves->height / 32 * waves->width], waves->width * sizeof(float));
  center[0] = waves->texbuf[waves->height / 2 * waves->width + 15 * waves->width / 32];
  center[1] = waves->texbuf[waves->height / 2 * waves->width + 17 * waves->width / 32];
}
```

```
// EOF
```

28 waves.h

```
/* ==========================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------
Wave Simulation
========================================================================== */

#ifndef WAVES_H
#define WAVES_H 1

#include <GL/glew.h>
#include <complex.h>
#include <fftw3.h>

//============================================================================
// data
struct waves {
  int hasplan;
  fftwf_plan plan;
  float _Complex *inbuf;
  float _Complex *outbuf;
  float _Complex *h00;
  float *h0;
  float *w;
  float *wp;
  float *texbuf;
  GLuint texture;
  int width;
  int height;

  int frame;
};

//============================================================================
// protoypes
struct waves *waves_init(struct waves *waves);
void waves_reshape(
  struct waves *waves, int w, int h
);
void waves_display(
  struct waves *waves
);
void waves_audio(struct waves *waves, float *left, float *right, float *center);
void waves_adjust(struct waves *waves, double wx, double wy);

#endif
```

29 wrapseams.c

```
/* ================================================================================
pool-party -- water simulation
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--------------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------------
Wrap Seams Shader
================================================================================ */

#include <stdlib.h>
#include <string.h>
#include "util.h"
#include "wrapseams.h"
#include "wrapseams.vert.c"
#include "wrapseams.frag.c"

//==============================================================================
// initialization
struct wrapseams *wrapseams_init(struct wrapseams *wrapseams) {
  if (! wrapseams) { return 0; }
  if (! shader_init(&wrapseams->shader, wrapseams_vert, wrapseams_frag)) {
    return 0;
  }
  shader_uniform(wrapseams, tex);
  wrapseams->value.tex = 0;
  wrapseams->width = 0;
  wrapseams->height = 0;
  glGenTextures(1, &(wrapseams->texture));
  glBindTexture(GL_TEXTURE_2D, wrapseams->texture);
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER, GL_LINEAR_MIPMAP_LINEAR)↙
    ↳ ;
  glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER, GL_LINEAR);
  glGenVertexArrays(1, &wrapseams->vao);
  return wrapseams;
}

//==============================================================================
// reshape callback
void wrapseams_reshape(
  struct wrapseams *wrapseams, int w, int h
) {
  if (wrapseams->audio[0]) free(wrapseams->audio[0]);
  if (wrapseams->audio[1]) free(wrapseams->audio[1]);
  wrapseams->width  = roundtwo(w);
  wrapseams->height = roundtwo(h);
  float *zero = calloc(1, sizeof(float) * wrapseams->width * wrapseams->height);
  glBindTexture(GL_TEXTURE_2D, wrapseams->texture);
  glTexImage2D(GL_TEXTURE_2D, 0, GL_R32F,
    wrapseams->width, wrapseams->height,
    0, GL_RED, GL_FLOAT, zero
  );
  glGenerateMipmap(GL_TEXTURE_2D);
  glBindTexture(GL_TEXTURE_2D, 0);
  free(zero);
  wrapseams->audio[0] = calloc(1, wrapseams->height * sizeof(float));
```

```
  wrapseams->audio[1] = calloc(1, wrapseams->height * sizeof(float));
}

//============================================================
// display callback
void wrapseams_display(
  struct wrapseams *wrapseams, GLuint fbo, GLuint texture
) {
  glBindFramebuffer(GL_FRAMEBUFFER, fbo);
  glFramebufferTexture2D(
    GL_FRAMEBUFFER, GL_COLOR_ATTACHMENT0, GL_TEXTURE_2D,
    wrapseams->texture, 0
  );
  glBindTexture(GL_TEXTURE_2D, texture);
  glUseProgram(wrapseams->shader.program);
  shader_updatei(wrapseams, tex);
  glViewport(0, 0, wrapseams->width, wrapseams->height);
  glBindVertexArray(wrapseams->vao);
  glDrawArrays(GL_TRIANGLES, 0, 6);
  glBindVertexArray(0);
  glBindFramebuffer(GL_FRAMEBUFFER, 0);
  glUseProgram(0);
  glBindTexture(GL_TEXTURE_2D, wrapseams->texture);
  glGenerateMipmap(GL_TEXTURE_2D);
  glBindTexture(GL_TEXTURE_2D, 0);
  glBindFramebuffer(GL_FRAMEBUFFER, fbo);
  glFramebufferTexture2D(
    GL_FRAMEBUFFER, GL_COLOR_ATTACHMENT0, GL_TEXTURE_2D,
    wrapseams->texture, 0
  );
  glReadPixels(31 * wrapseams->width / 64, 0, 1, wrapseams->height, GL_RED, ↙
      ↳ GL_FLOAT, wrapseams->audio[0]);
  glReadPixels(33 * wrapseams->width / 64, 0, 1, wrapseams->height, GL_RED, ↙
      ↳ GL_FLOAT, wrapseams->audio[1]);
  glBindFramebuffer(GL_FRAMEBUFFER, 0);
}

//============================================================
// audio callback
void wrapseams_audio(struct wrapseams *wrapseams, float *left, float *right) {
  memcpy(left,  wrapseams->audio[0], wrapseams->height * sizeof(float));
  memcpy(right, wrapseams->audio[1], wrapseams->height * sizeof(float));
}

// EOF
```

30 wrapseams.frag

```
/* ============================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009,2010  Claude Heiland-Allen <claude@mathr.co.uk>
------------------------------------------------------------
Wrap Seams Shader
```

```
10 ============================================================================ */

#version 330 core

uniform sampler2D tex;
15 in vec2 texCoord;
out vec4 colour;

void main(void) {
  colour = vec4
20   ( texture(tex, texCoord).r
    + texture(tex, texCoord + vec2(0.5, 0.0)).r
    + texture(tex, texCoord + vec2(0.0, 0.5)).r
    + texture(tex, texCoord + vec2(0.5, 0.5)).r
    );
25 }

// EOF
```

31 wrapseams.h

```
/* ============================================================================
pool-party -- water simulation
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----------------------------------------------------------------------------
 5 based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008  Claude Heiland-Allen <claude@mathr.co.uk>
----------------------------------------------------------------------------
Wrap Seams Shader
10 ============================================================================ */

#ifndef WRAPSEAMS_H
#define WRAPSEAMS_H 1

15 #include "shader.h"

//============================================================================
// data
struct wrapseams { struct shader shader;
20   struct { GLint  tex; } uniform;
   struct { int    tex; } value;
   GLuint texture;
   GLuint vao;
   int width;
25   int height;
   float *audio[2];
};

//============================================================================
30 // protoypes
struct wrapseams *wrapseams_init(struct wrapseams *wrapseams);
void wrapseams_reshape(
  struct wrapseams *wrapseams, int w, int h
);
35 void wrapseams_display(
  struct wrapseams *wrapseams, GLuint fbo, GLuint texture
```

```
);
void wrapseams_audio(struct wrapseams *wrapseams, float *left, float *right);

#endif
```

32 wrapseams.vert

```
/* ================================================================================
pool-party -- water simulation
Copyright (C) 2016  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------------
based on:
rdex -- reaction-diffusion explorer
Copyright (C) 2008,2009  Claude Heiland-Allen <claude@mathr.co.uk>
--------------------------------------------------------------------------------
Wrap Seams Shader
================================================================================ */

#version 330 core

out vec2 texCoord;

void main(void) {
  ivec2 d = ivec2(0, 0);
  switch (gl_VertexID % 6) {
    case 0: d = ivec2(0, 0); break;
    case 1: d = ivec2(1, 0); break;
    case 2: d = ivec2(1, 1); break;
    case 3: d = ivec2(1, 1); break;
    case 4: d = ivec2(0, 1); break;
    case 5: d = ivec2(0, 0); break;
  }
  gl_Position = vec4(2.0 * vec2(d) - 1.0, 0.0, 1.0);
  texCoord = 0.5 * vec2(d) + vec2(0.25);
}

// EOF
```