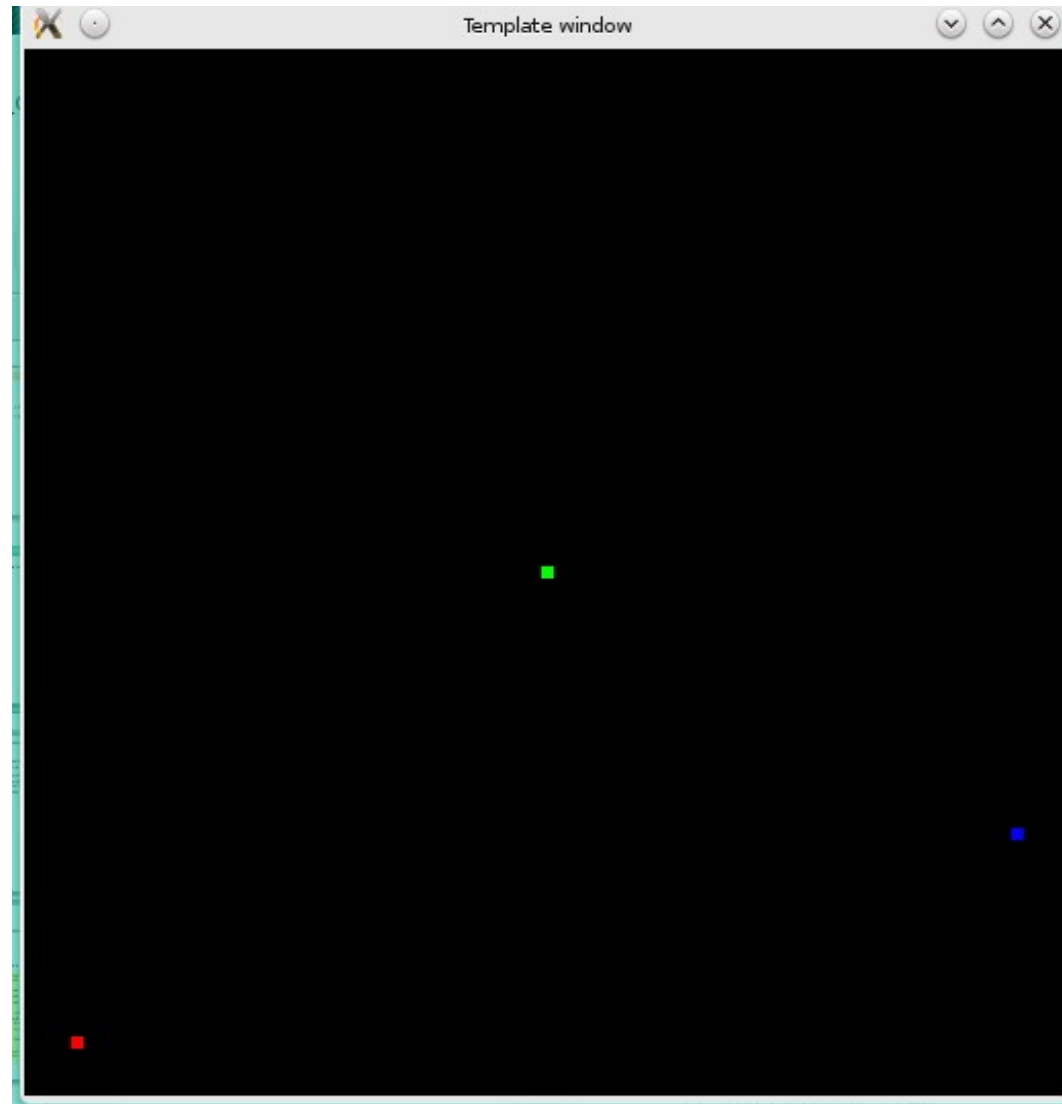


Лекция 11

- CUDA+OpenGL.
- Вычислительные шейдеры (введение).

```
glDrawArrays(GL_POINTS /*GL_TRIANGLES*/, 0, num_of_verticies);
```



```

int initBuffer(){
    glGenBuffers( 1,&bufferID);
    glBindBuffer( GL_ARRAY_BUFFER, bufferID);

    GLfloat* vertex_buffer_data=(GLfloat*)calloc(num_of_verticies*6, sizeof(GLfloat));

    for(int i=0; i<num_of_verticies;i++){
        vertex_buffer_data[i*6] = (GLfloat)(0.01f*(-99+2*(rand()%100)));
        vertex_buffer_data[i*6+1]= (GLfloat)(0.01f*(-99+2*(rand()%100)));
        vertex_buffer_data[i*6+2]= (GLfloat)0.0f;
        vertex_buffer_data[i*6+3]= (GLfloat)1.0f;
        vertex_buffer_data[i*6+4]= (GLfloat)1.0f;
        vertex_buffer_data[i*6+5]= (GLfloat)1.0f;
    }
    /* static const GLfloat vertex_buffer_data[] = {
        -0.9f, -0.9f, -0.0f, 1.0f, 0.0f, 0.0f,
        0.0f,  0.0f,  0.0f, 0.0f, 1.0f, 0.0f,
        0.9f, -0.5f,  0.0f, 0.0f, 0.0f, 1.0f,
    };

    */
    glBufferData( GL_ARRAY_BUFFER, 6*num_of_verticies*sizeof(float),
        vertex_buffer_data, GL_DYNAMIC_DRAW );
    free(vertex_buffer_data);
    return 0;
}

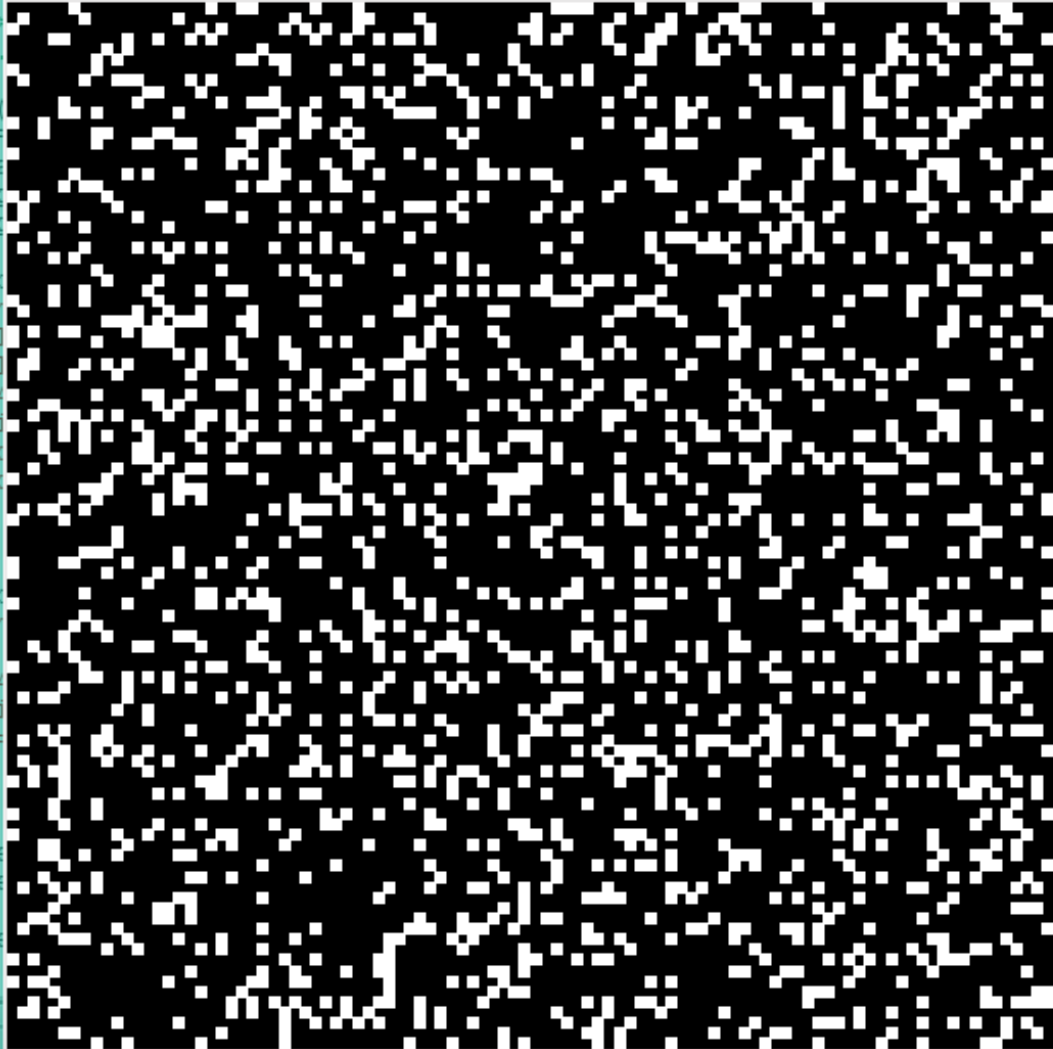
```

GPU_COURSE: util_template.cpp (2) - Kate

Tools Settings Help

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Template window



```
#include <GL/glew.h>
#include <stdio.h>
#include <stdlib.h>
#include <string>

void checkErrors(std::string desc) {
    GLenum e = glGetError();
    if (e != GL_NO_ERROR) {
        fprintf(stderr, "oper
        exit(20);
    }
}

const unsigned int window_width = 51
const unsigned int window_height = 51

GLuint bufferID;
GLuint progHandle;
GLuint genRenderProg(); |

const int num_of_verticies=2048;

int initBuffer(){

    glGenBuffers( 1,&bufferID);

    glBindBuffer( GL_ARRAY_BUFFER, bufi

    /*
    static const GLfloat vertex_buffer_
        > > > > -0.91
        > > > > 0.01
        > > > > 0.91
        > > > > };
    */
    GLfloat* vertex_buffer_data=(GLflo
        num_of_verticie

1 line: 19 of 79 Col: 25 LINE INS
002: ~/WORKSHOP/EDUCATION/SibsUTIS/COURSES/2017-2018/2017-2018/4. GPU 3-d course/workspace/Lecture11/
003: GPU 3-d course/workspace/Lecture11/
```

```
void initData();
```

```
int initBuffer(){
```

```
    glGenBuffers( 1,&bufferID);
```

```
    glBindBuffer( GL_ARRAY_BUFFER, bufferID);
```

```
    glBufferData( GL_ARRAY_BUFFER, 6*num_of_verticies*sizeof(float),  
                                                           0, GL_DYNAMIC_DRAW );
```

```
    initData();
```

```
    return 0;
```

```
}
```

```
void initData(){
    GLfloat* vertex_buffer_data=(GLfloat*)calloc(
        num_of_verticies*6, sizeof(GLfloat));

    for(int i=0; i<num_of_verticies;i++){
        vertex_buffer_data[i*6] = (GLfloat)(0.01f*(-99+2*(rand()%100)));
        vertex_buffer_data[i*6+1]= (GLfloat)(0.01f*(-99+2*(rand()%100)));
        vertex_buffer_data[i*6+2]= (GLfloat)0.0f;
        vertex_buffer_data[i*6+3]= (GLfloat)1.0f;
        vertex_buffer_data[i*6+4]= (GLfloat)0.0f;
        vertex_buffer_data[i*6+5]= (GLfloat)1.0f;
    }

    glBufferData( GL_ARRAY_BUFFER, 6*num_of_verticies*sizeof(float),
        vertex_buffer_data, GL_DYNAMIC_DRAW );

    free(vertex_buffer_data);
}
```

```
void initData();
void hInitData(GLuint, int);
void csDataInit(GLuint, int);

int initBuffer(){
    glGenBuffers( 1,&bufferID);
    glBindBuffer( GL_ARRAY_BUFFER, bufferID);

    glBufferData( GL_ARRAY_BUFFER, 6*num_of_vertices*sizeof(float),
                                                           0, GL_DYNAMIC_DRAW );

#ifdef HOST_CALC
    initData();
#endif
#ifdef CUDA_CALC
    hInitData(bufferID, num_of_vertices);
#endif
#ifdef CSH_CALC
    csDataInit(bufferID, num_of_vertices);
#endif

    return 0;
}
```

```
#include <GL/glew.h>
#include <cuda_runtime.h>
#include <cuda_gl_interop.h>
```

cuda_template.cu

```
__global__ void glnitData(float* devA);

void hlnitData(GLuint bufID, int N){
    cudaGLRegisterBufferObject(bufID);

    float *devA;
    cudaGLMapBufferObject((void**)&devA, bufID);

    dim3 threads_per_block(128);
    dim3 blocks(N/128);

    glnitData<<<blocks, threads_per_block>>>(devA);
    cudaDeviceSynchronize();

    cudaGLUnmapBufferObject(bufID);

    cudaFree(devA);
}
```



```
#include <curand_kernel.h>
```

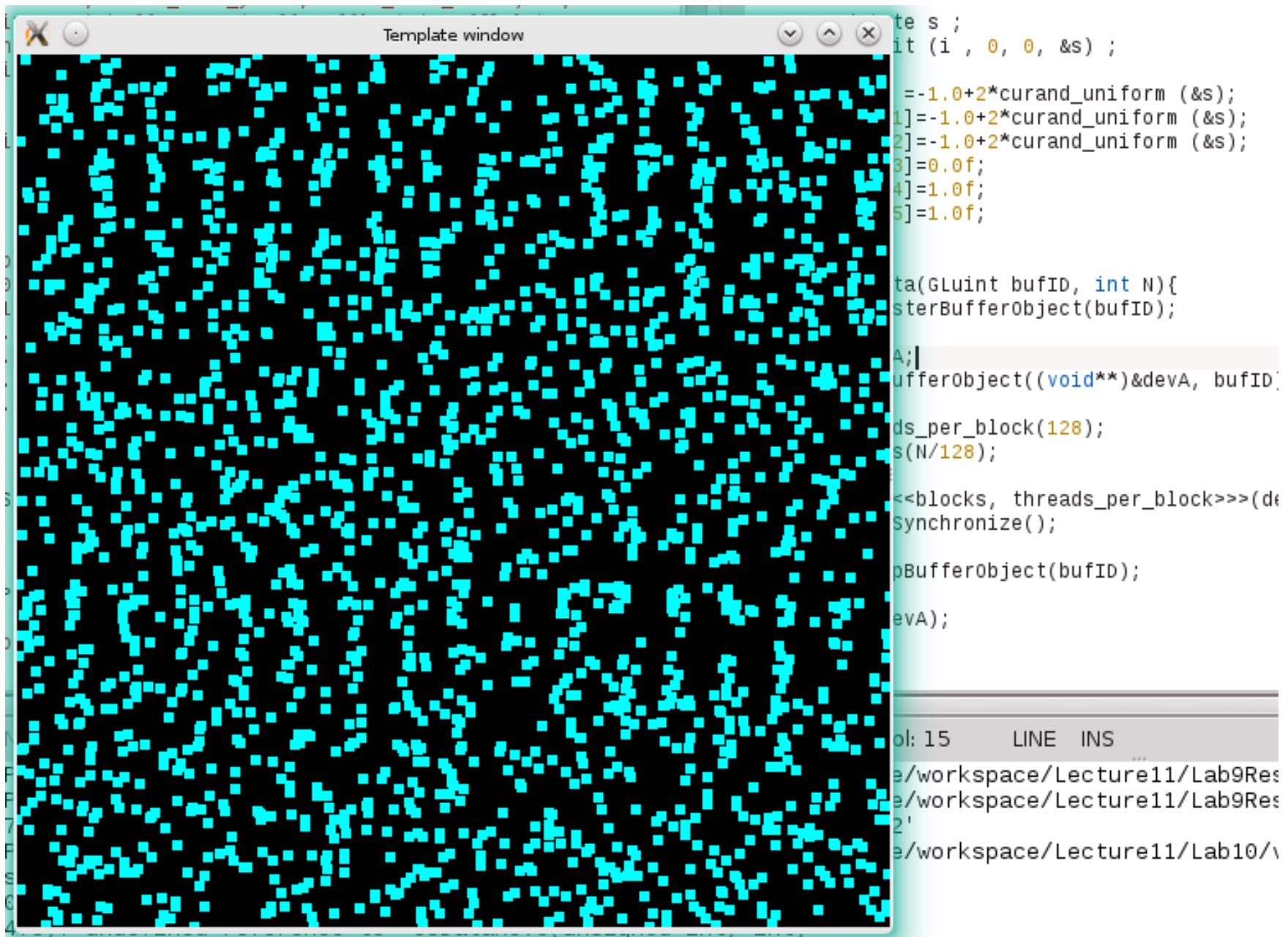
```
__global__ void gInitData(float* devA){  
    int i=threadIdx.x+blockIdx.x*blockDim.x;
```

```
    curandState s ;  
    curand_init (i , 0, 0, &s) ;
```

```
    devA[i*6] =-1.0+2*curand_uniform (&s);  
    devA[i*6+1]=-1.0+2*curand_uniform (&s);  
    devA[i*6+2]=-1.0+2*curand_uniform (&s);  
    devA[i*6+3]=0.0f;  
    devA[i*6+4]=1.0f;  
    devA[i*6+5]=1.0f;
```

```
}
```

```
~> nvcc -DCUDA_CALC -o s_tmpl main.cpp util_template.cpp  
sh_template.cpp cuda_template.cu -lGLEW -lGL -lGLU -lglfw
```



```
~> nvcc -DCUDA_CALC -o s_template main.cpp util_template.cpp  
sh_template.cpp cuda_template.cu -I/glew -I/igl -I/glu -I/glfw
```

```
#include <GL/glew.h>
#include <stdio.h>
#include <string>
#include <string.h>
#include <stdlib.h>
```

csH_template.cpp

```
void checkErrors(std::string desc);
GLuint genComputeProg();
GLuint computeShaderID;
```

```
void csDataInit(GLuint inBuf,int N){
    glBindBufferBase(GL_SHADER_STORAGE_BUFFER, 0, inBuf);

    computeShaderID=genComputeProg();
    glUseProgram(computeShaderID);

    glDispatchCompute(N/128, 1, 1);

    glMemoryBarrier( GL_SHADER_STORAGE_BARRIER_BIT );

}
```

```
GLuint genComputeProg(){
    GLuint progHandle = glCreateProgram();
    GLuint cs = glCreateShader(GL_COMPUTE_SHADER);

    const char *cpSrc[] = {
        "#version 430\n",
        "layout (local_size_x = 128, local_size_y = 1, local_size_z = 1) in;\n",
        "layout(std430, binding = 0) buffer InputBufferA{float inBuf[];};\n",
        "float lmap(in uint i){\n",
        "    uint count;\n",
        "    float x=0.78;\n",
        "    for(count=0;count<i;count++)\n",
        "        x=3.99*x*(1-x);\n",
        "    return x;\n",
        "}\n",
        "void main() {\n",
        "    uint index = gl_GlobalInvocationID.x;\n",
        "    inBuf[index*6]=-1.0+2.0*lmap(index);\n",
        "    inBuf[index*6+1]=-1.0+2.0*lmap(index*10);\n",
        "    inBuf[index*6+2]=0.0;\n",
        "    inBuf[index*6+3]=1.0;\n",
        "    inBuf[index*6+4]=1.0;\n",
        "    inBuf[index*6+5]=0.0;\n",
        "}"
    };
};
```

```
glShaderSource(cs, 2, cpSrc, NULL);

glCompileShader(cs);
int rvalue;
glGetShaderiv(cs, GL_COMPILE_STATUS, &rvalue);
if (!rvalue) {
    fprintf(stderr, "Error in compiling cs\n");
    exit(30);
}
glAttachShader(progHandle, cs);

glLinkProgram(progHandle);

glGetProgramiv(progHandle, GL_LINK_STATUS, &rvalue);
if (!rvalue) {
    fprintf(stderr, "Error in linking cs\n");
    exit(32);
}

checkErrors("Render shaders");

return progHandle;
}
```

Compute Shaders

CUDA

```
glUseProgram(computeShaderID);  
glDispatchCompute(N/128,1,1);
```

```
gDataInit<<<N/128, 128>>>(devA);
```

```
glMemoryBarrier(...);
```

```
cudaDeviceSynchronize();
```

```
gl_NumWorkGroups
```

```
gridDim
```

```
gl_WorkGroupSize
```

```
blockDim
```

```
gl_WorkGroupID
```

```
blockIdx
```

```
gl_LocalInvocationID
```

```
threadIdx
```

```
gl_GlobalInvocationID
```

```
threadIdx+ blockIdx* blockDim
```

```
int info[3];
```

```
glGetIntegeri_v(GL_MAX_COMPUTE_WORK_GROUP_COUNT, 0,  
&info[0]);
```

```
glGetIntegeri_v(GL_MAX_COMPUTE_WORK_GROUP_COUNT, 1,  
&info[1]);
```

```
glGetIntegeri_v(GL_MAX_COMPUTE_WORK_GROUP_COUNT, 2,  
&info[2]);
```

```
printf("max work group size x:%i y:%i z:%i\n", info[0], info[1], info[2]);
```

```
glGetIntegeri_v(GL_MAX_COMPUTE_WORK_GROUP_SIZE, 0, &info[0]);
```

```
glGetIntegeri_v(GL_MAX_COMPUTE_WORK_GROUP_SIZE, 1, &info[1]);
```

```
glGetIntegeri_v(GL_MAX_COMPUTE_WORK_GROUP_SIZE, 2, &info[2]);
```

```
printf("max local work group sizes x:%i y:%i z:%i\n", info[0], info[1], info[2]);
```

```

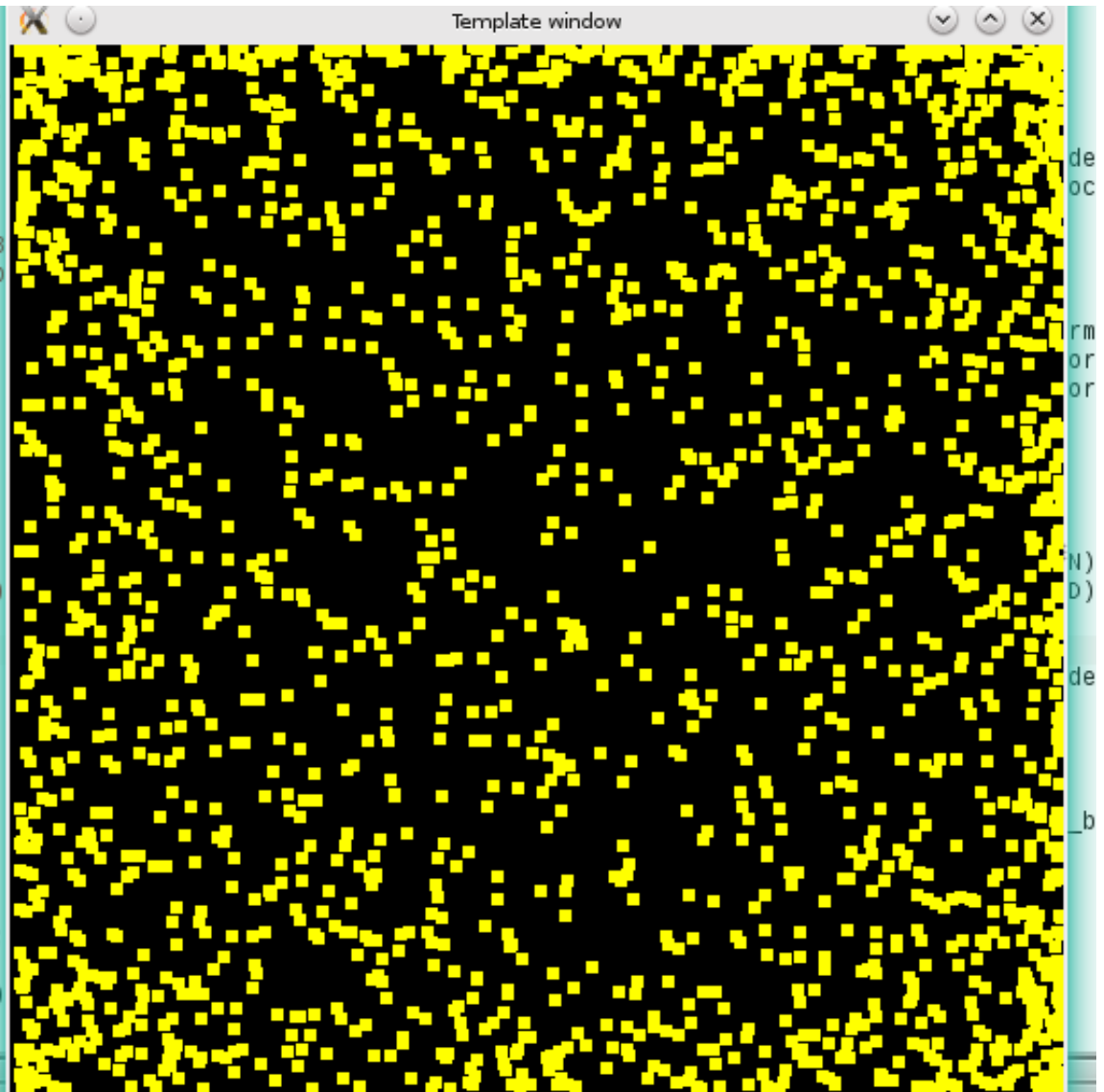
t genComputeProg(){
    GLuint progHandle = glCreateProgram();
    GLuint cs = glCreateShader(GL_COMPUTE_SHADER);

    const char *cpSrc[] = {
        "#version 430\n",
        "layout (local_size_x = 128, local_size_y\n",
        "layout(std430, binding = 0) buffer InputB\n",
        /*layout(std430, binding = 1) buffer Outp\n",
        float lmap(in uint i){\n",
        "    uint count;\n",
        "    float x=0.78;\n",
        "    for(count=0;count<i;count++)\n",
        "        x=3.99*x*(1-x);\n",
        "    return x;\n",
        "}\n",
        void main() {\n",
        "    uint index = gl_GlobalInvocationID.x;\n",
        "    inBuf[index*6]=-1.0+2.0*lmap(index);\n",
        "    inBuf[index*6+1]=-1.0+2.0*lmap(index*10)\n",
        "    inBuf[index*6+2]=0.0;\n",
        "    inBuf[index*6+3]=1.0;\n",
        "    inBuf[index*6+4]=1.0;\n",
        "    inBuf[index*6+5]=0.0;\n",
        "}"
    };

    glShaderSource(cs, 2, cpSrc, NULL);

    glCompileShader(cs);
    int rvalue;
    glGetShaderiv(cs, GL_COMPILE_STATUS, &rvalue);
    if (!rvalue) {
        fprintf(stderr, "Error in compiling cs\n");
        exit(30);
    }
}

```



```

~> g++ -DCSH_CALC -o s_tmpl main.cpp util_template.cpp
sh_template.cpp csh_template.cpp -lGLEW -lGL -lGLU -lglfw

```


Спасибо за внимание!