Intro to Graphics Spring 2017 – Lab 4

Due Date: February 8th

Lab Objective

- Introduce yourself to the GLSL GPU programming language.
- Experiment by rendering a 2D signed distance function on the GPU.

Lab Setup

- Go to https://www.shadertoy.com/view/MtySDK
- Edit the code in the window.
- Press the button at the bottom left (or alt-enter) of the code window to run your code.

Optional: Check out popular Shadertoys: https://www.shadertoy.com/results?sort=popular

Optional: Consider making a Shadertoy account if you want to save and share your Shadertoys.

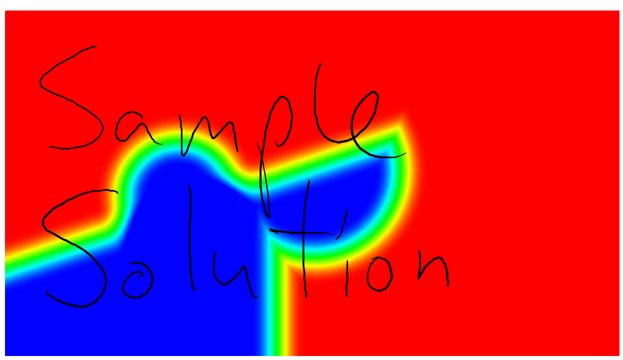
Submission Guidelines

Implement the missing code in the provided Shadertoy program.

Submit your code as a text file to Connex, and include a screenshot.

Expected Result

You should have something like the following image (depending on how you design your scene):



Lab Instructions

You must complete the following tasks:

1. Implement sdSphere, which computes the signed distance to a sphere's surface.
2. Implement sdPlane, which computes the signed distance to a plane's surface.
3. Change the scene using CSG operators (csgUnion/csgIntersect/csgBlend/csgDifference) and signed distance functions (sdSphere/sdPlane).

About GLSL

GLSL is a language designed for 3D math. The vec2/vec3/vec4 types we've seen before in C++ are built into the GLSL language. You can use `length(v)`, `dot(u,v)`, `cross(u,v)`, directly in your code.

To access the elements of a vec2/vec3/vec4, you can use the `.x .y .z` suffix as always.

You can also access multiple components simultaneously.

For example:

> `vec3(1,2,3).xz` returns `vec2(1,3)`
>
> `vec3(1,2,3).zzz` returns `vec3(3,3,3)`

There are also built-in matrix types like mat2/mat3/mat4, but you don't need them today.

Other than that, the language is very close to C. One main difference is that there are no pointers.

Signed Distance to a Sphere

For a sphere with radius r and center c, the signed distance of point p from the surface of the sphere is:

$$sdSphere(r, c, p) = \|p - c\| - r$$

Notice how this is a signed distance:

- $sdSphere$ is > 0 when the point is outside the sphere.
- $sdSphere = 0$ when the point is exactly on the surface of the sphere.
- $sdSphere < 0$ when the point is inside the sphere.

Signed Distance to a Plane

For a plane with normal n, and given an arbitrary point on the plane c, the signed distance of point p from the surface of the plane is given as follows:

$$sdPlane(r, c, p) = (n \circ p) - (n \circ c)$$

Notice how in 3D, this expands to the form you see in linear algebra courses: $ax + by + cz + d$

The sign of $sdPlane$ follows the same rules as $sdSphere$ above.

Constructive Solid Geometry (CSG) Operators

Implicit surfaces make it easy to combine shapes using a technique called constructive solid geometry. In this exercise, you will see four basic CSG operators: union, intersect, blend, and difference.

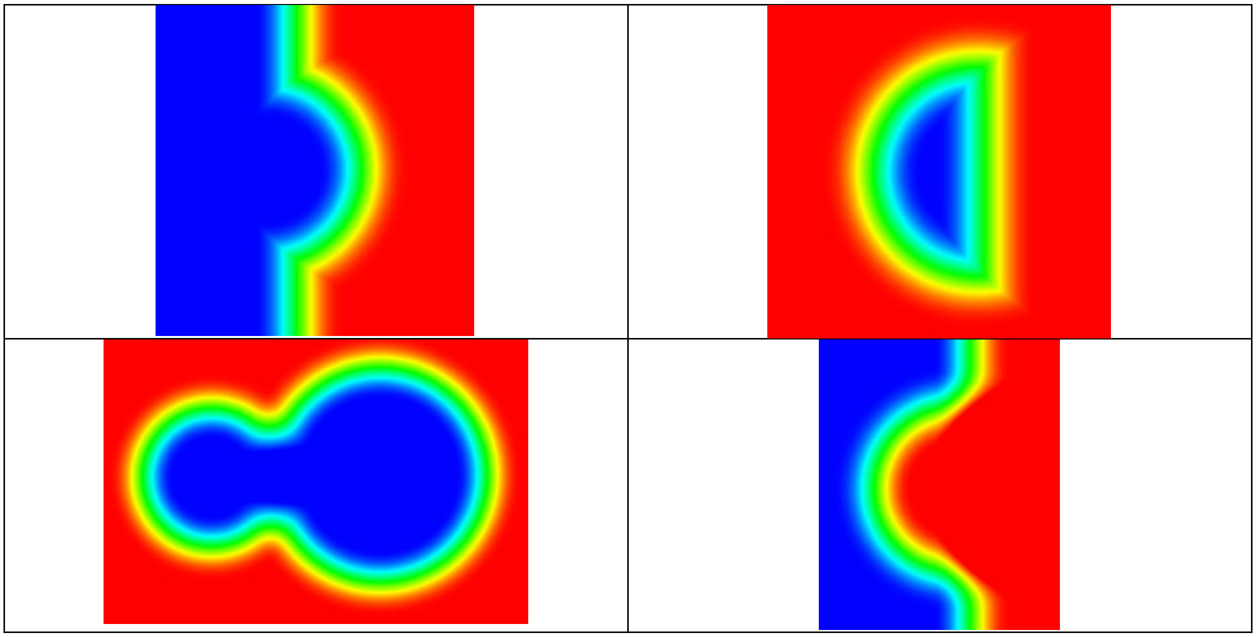


Table 1: (top-left) union, (top-right) intersect, (bottom-left) blend, (bottom-right) difference.

There is some provided code that demonstrates how to use signed distance functions and constructive solid geometry functions together. Follow these examples and use the CSG operators to create your own scene that demonstrates SDFs and CSG operators.