

# Complex Procedural Terrains

Procedural generation is often used to offer more variety without manually creating more content. There are many algorithms for generating terrain, however most of these are limited to creating mountains and valleys. The method described in the first chapter of "GPU Gems 3" uses the marching cubes algorithm and can create complex features such as caves or bridges, which is why it was modified and implemented for the Computer Graphics project.

## Density function

The landscape generation is based on a single density function. This function uses several noise volumes (3D textures), that are filled randomly and interpolated.

## Dividing the terrain

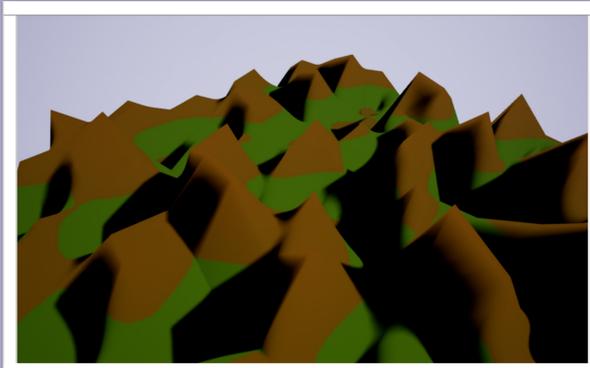
The terrain is built from two layers of blocks. For each block the marching cubes algorithm is run, resulting in a mesh that fits inside the given block.

## Marching cubes

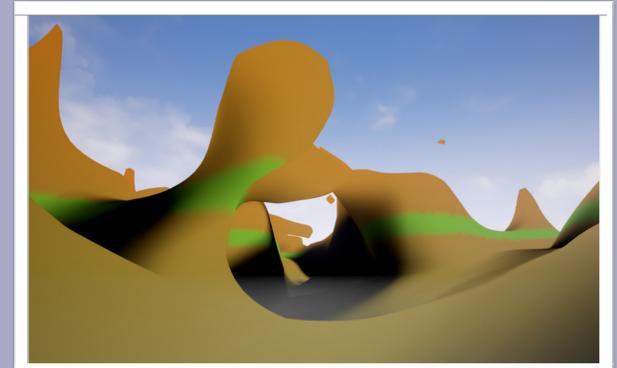
The marching cubes algorithm creates a polygonal mesh from a three-dimensional scalar field. Inside the block corner values are calculated for smaller cubes called voxels. The size and amount of the voxels determines the speed of generation as well as how detailed the resulting landscape can be.

## Cubes

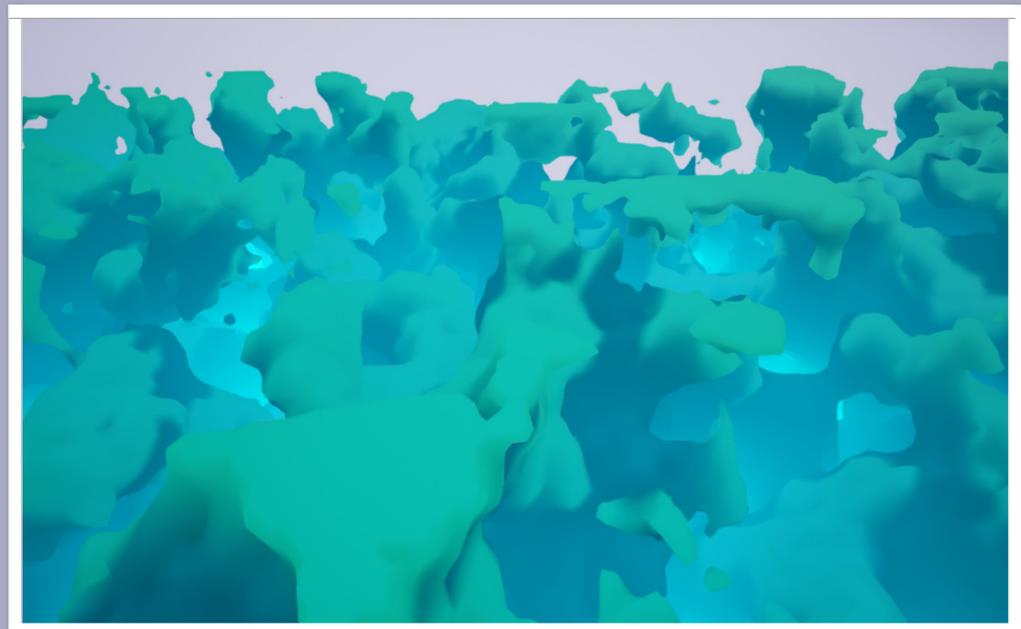
Each corner of a cube is given a value by the density function. A positive value means the corner is inside the ground and negative value the opposite. Each voxel is given a case number based on the sign of its corners. This is then used to find the triangles contained by the cube from a lookup table. Each voxel can contain up to 5 triangles. Vertices that form these triangles are on the edges of the cube. Their location is found by calculating the point on the edge where the density is zero. These triangles and vertices will form the surface of the terrain.



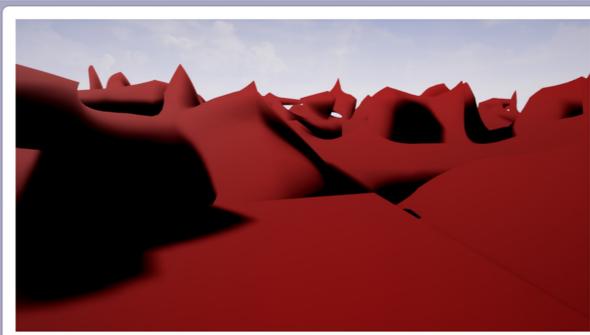
Simple terrain



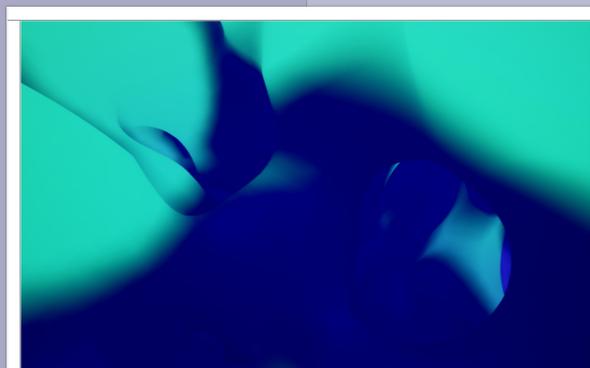
Bridge formation



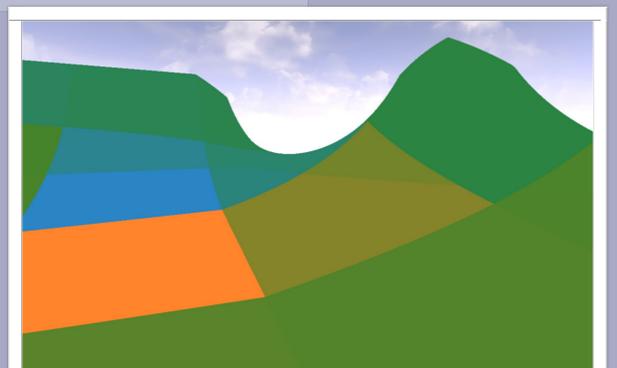
Detailed complex Terrain



Part of the landscape remained the same in both generations due to the chosen density function



View inside a cave



Example where each block is different color

<https://courses.cs.ut.ee/2016/cg/fall/Main/Project-ProceduralTerrains>