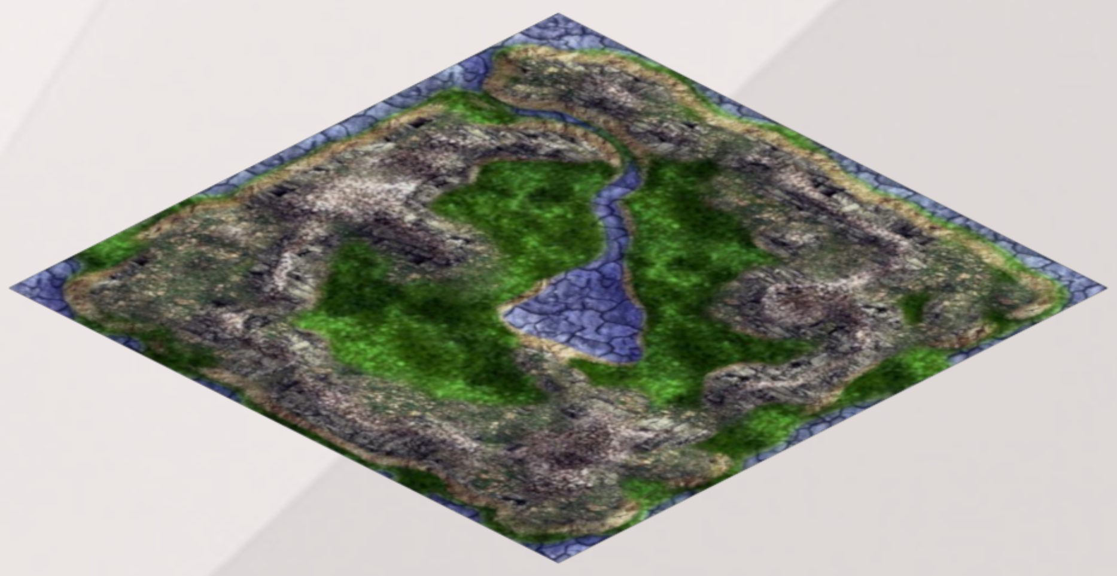
DTU Compute
Department of Applied Mathematics and Computer Science

Per-Pixel vs. Per-Vertex Real-Time Displacement Mapping

Riccardo Loggini

Introduction

Displacement Mapping is a technique that provides geometric details to parametric surfaces.
The displacement values are stored in grey scale textures called height maps.
We can distinguish two main ways to implement such features which are the Per-Pixel and the Per-Vertex approach.



Macrostructure Surface

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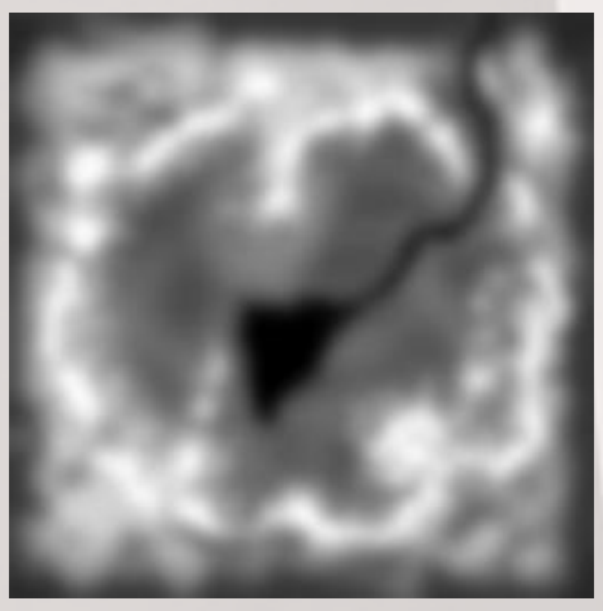

Height Map

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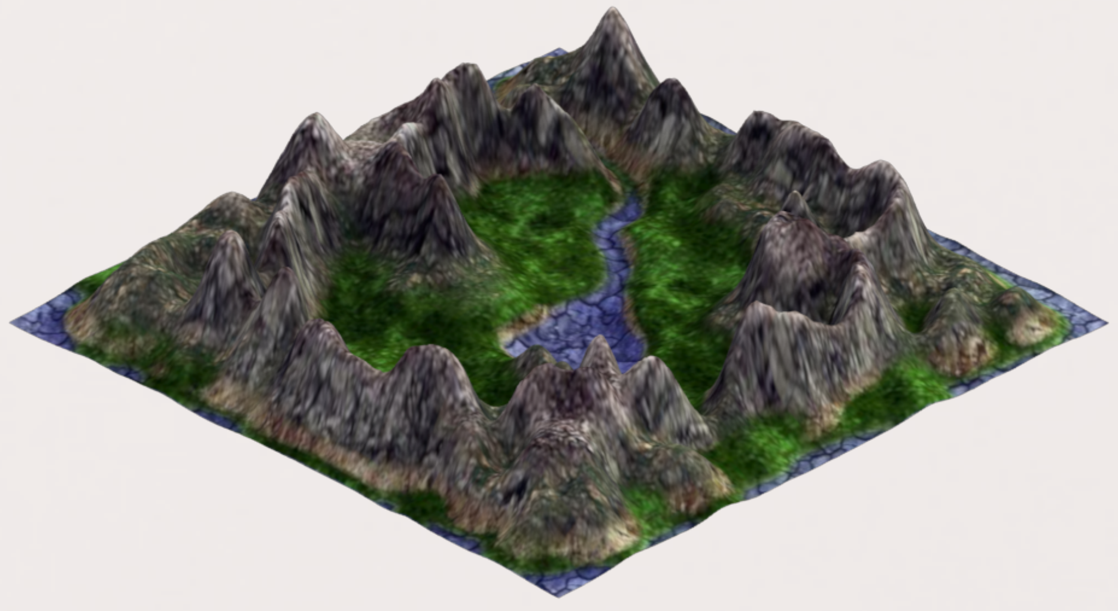
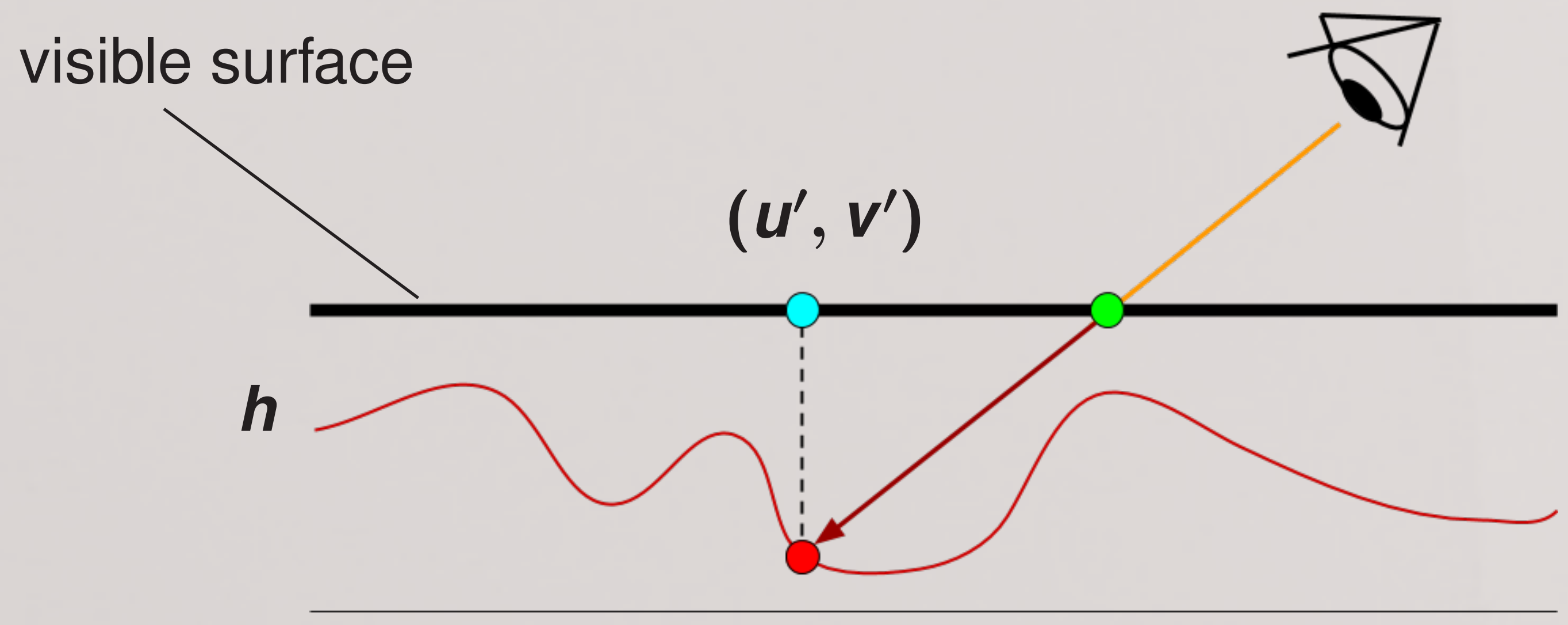


Mesostructure Surface

Per-Pixel Approach

Per-Pixel displacement mapping on the GPU can be conceptually seen as an optical illusion: the sense of depth is given by displacing the mesh texture coordinates that the viewer is looking at.
This approach translates to a ray tracing problem.

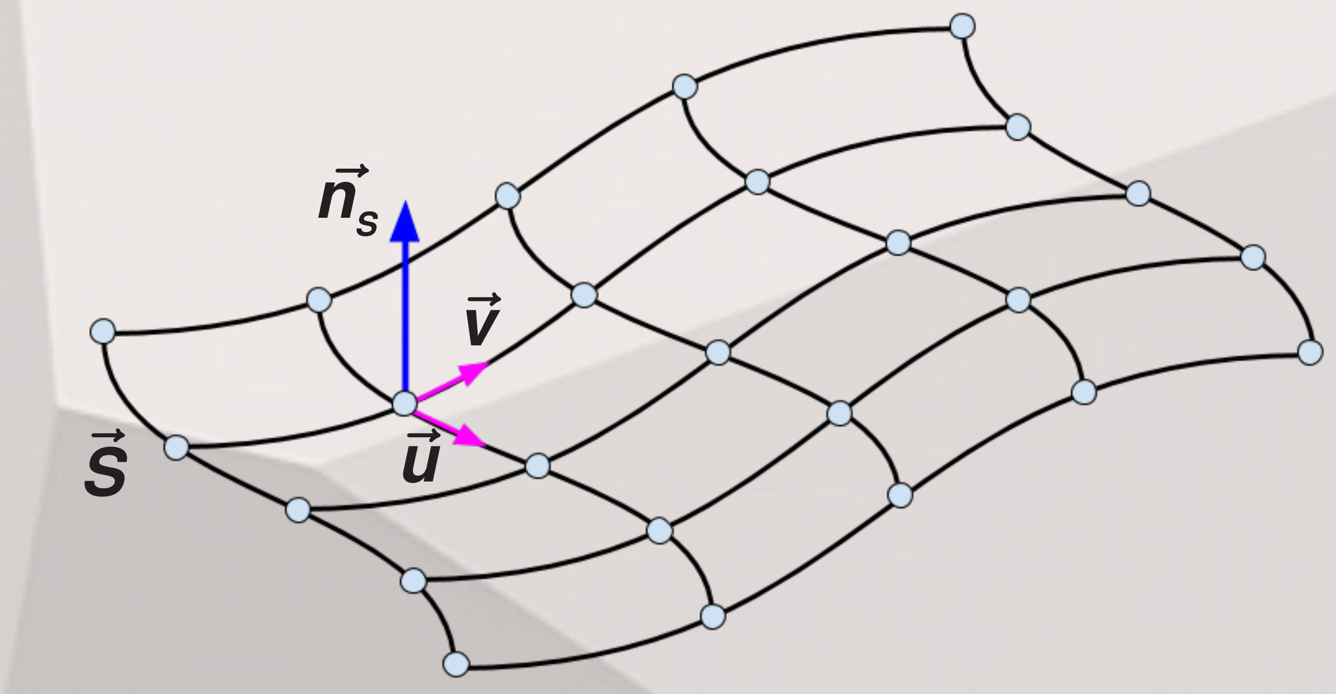


The execution is made by the fragment shader. Most of the algorithms of this family use ray marching to find the intersection point with the height map $h(u,v)$. One of them is Parallax Occlusion Mapping that was used to generate the left mesh in Preliminary Results below.

- Best for planar surfaces like walls or floors
- Best overall solution before Unified Shader Model
- Best for high frequency small displacement

Per-Vertex Approach

Per-Vertex displacement mapping on the GPU increase the internal mesh geometry by a tessellation process and then uses the vertices as control points to displace the surface $\boldsymbol{S}$ along its normal direction $\vec{n}_s$ based on the height map $\boldsymbol{h}$ values.

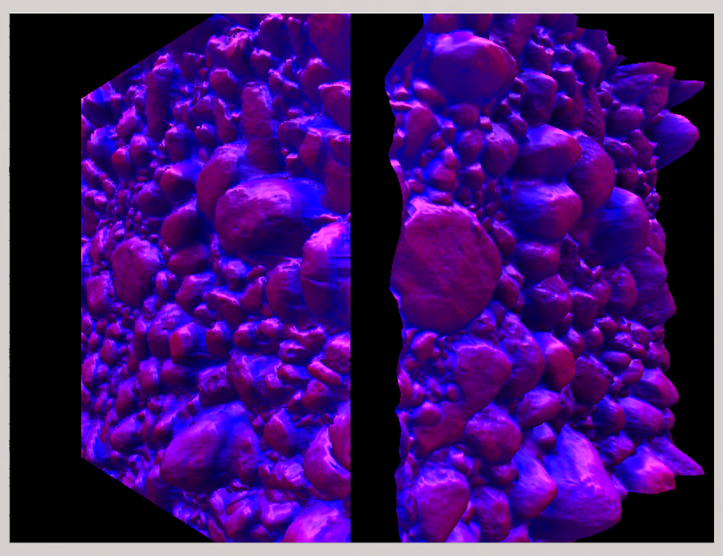


$$\vec{S'}(u,v) = \vec{S}(u,v) + h(u,v) * \vec{n}_s(u,v)$$

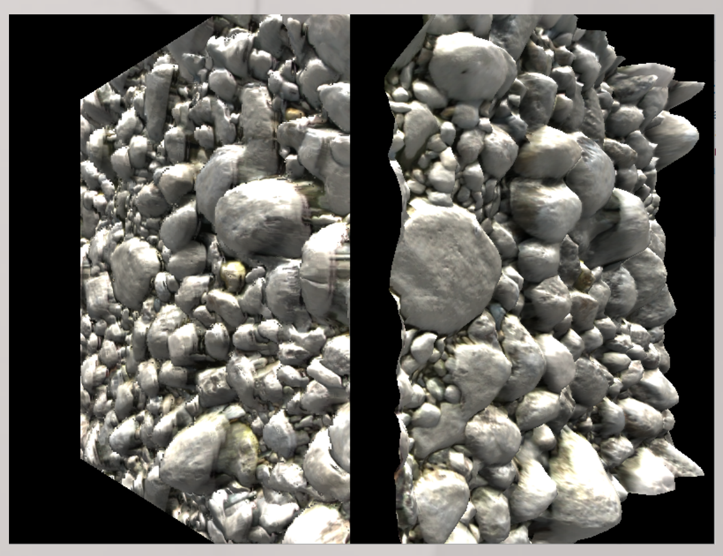
The execution is made before the rasterization process and it can involve vertex, geometry and/or tessellation shaders. The OpenGL 4 tessellation stage was used to generate the right mesh in Preliminary Results below with a uniform quad tessellation level.

- Best for organic mesh models
- Best for medium to high displacement
- Supports geometry based shadow algorithms

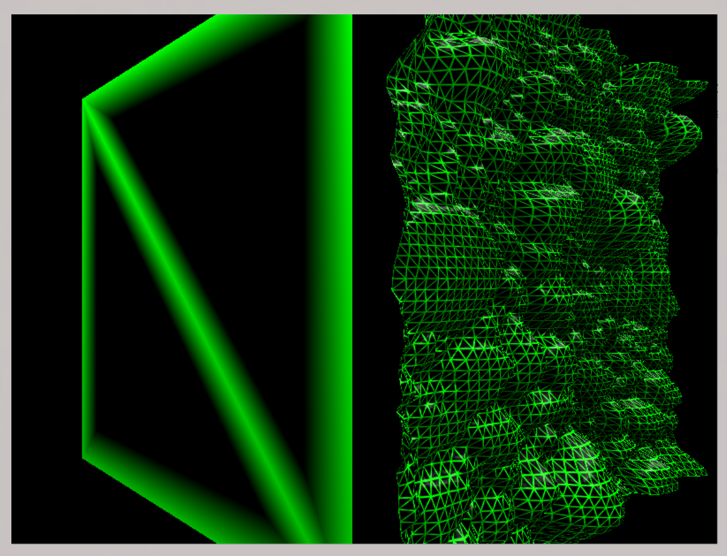
Preliminary Results



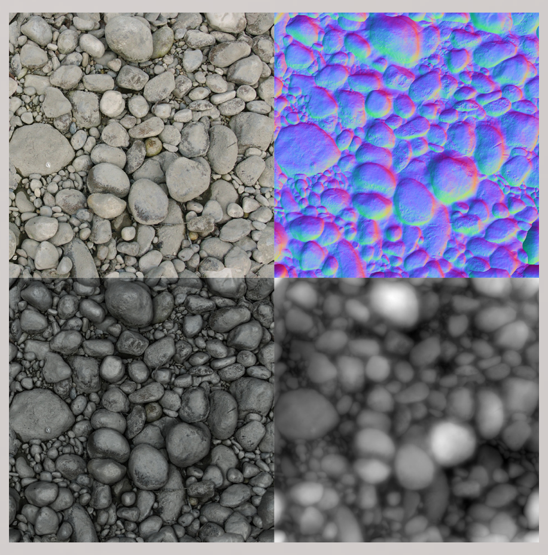
Height Map Gradient



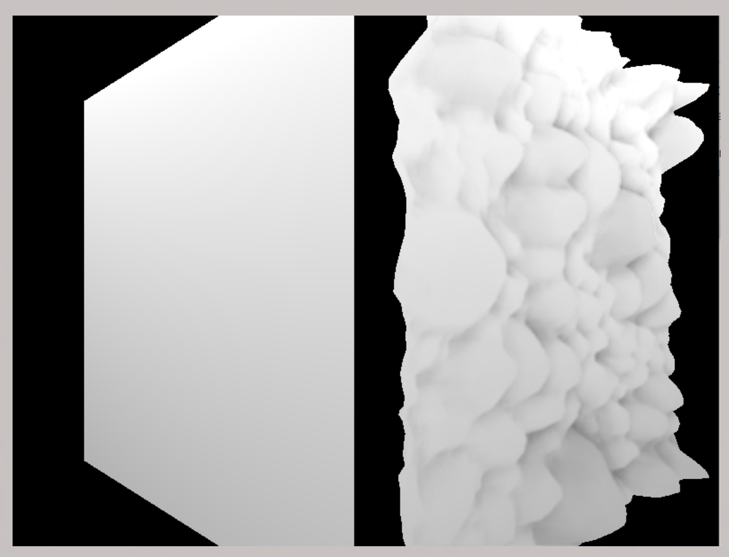
Final Render



Wireframe



Diffuse, Normal, Specular, Height Map



Screen Space Ambient Occlusion

riccardo.loggini@gmail.com