Real time Erosion simulation

River erosion computer simulation

OpenGL river

Shallow water computer simulation

Physics based erosion methods use different types of fluid simulations. Most of them are expensive to run and contain data dependencies that make it hard to execute on parallel hardware.

The first method was a partial simulation of valleys and rivers. Another one uses Navier stokes equation on a 3D regular grid that simulates the erosion and another used a simplified Newtonian physics model for velocity computation on a 2D grid.

Some methods were found to help make this process a lot less expensive and able to be ran in real time. these include, 2D Navier-Stokes equations, a shallow water simulation which allows for a simulation with real time erosion**[2]** and a method that uses virtual pipes which is key for executing in parallel.

Erosion model uses 2D uniform grid where each cell holds – terrain height, water height, suspended sediment amount, water outflow (being the pipes to adjacent cells), velocity vector, thermal erosion outflow flux.

They also use a scale that dampers the erosion equation the deeper the water gets because water moves slower the deep down you go which means the sediment is less disturbed.

**Notes from [1]**

Different types of erosion – weathering is a small scale type of erosion that usually affects stones and rocks. It creates rifts on their surface in a thermal or chemical way. Thermal weathering causes disintegration of material by thermal shocks in the presence of moisture that has bigger dilatations that the rock. Chemical weathering is caused by a chemical reaction between a liquid on the surface and the material itself.

Denudation is another type of erosion. The first type of denudation is gravity-conditioned mass movement where gravity pulls pieces of sand and gravel down the slope. The next type of denudation it splash erosion which is caused by raindrops falling onto a material causing an elliptical footprint. The last type of denudation is fluvial. This is the most important for this project as it is when water flows down a surface picking up different materials as it moves.

Full 3D hydraulic erosion was a paper that uses Navier-Stokes equations which are coupled with material transportation and solved on a 3D grid. This simulation is able to simulate receding waterfalls, river bed and river bank erosion, meander break, etc. this model provides high quality results but is also very expensive to run which makes it impossible to run in real time.

**Notes from [2]**

The contributions of this paper are: integration of three erosion algorithms, extension to a layered terrain representation, adaptation of the existing algorithm to use the pipe-model for water transportation, implementation of the algorithms on the GPU and selective erosion of sub-tiles on the GPU.

Terrains can be created by using regular height fields. These are useful as they are efficient for erosion simulating and rendering. But they do not support using multiple materials for different layers. A technic that would be able to support this is layered representation where each 2D grid location holds a 1D array of all the materials that are layered in that location with each one having their own height depending on how much of that material there is**[4]**.

The fluid simulation technic used in this paper is the hydrostatic pipe-model also called the column-based model which categorizes the water volume into columns with constant physical properties. This method gets the pipes are used to stabilize the water pressure cased by differing levels between pipes. This process is easily parallelizable which makes it well suited for usage on a GPU. Calculation description on page 4.

Three erosion algorithms are used in this paper. Forced-based, dissolution-based and direct material transportation through sediment slippage.

[1] <https://diglib.eg.org/bitstream/handle/10.2312/EG2011.short.057-060/057-060.pdf?sequence=1>

[2] <https://www.cs.purdue.edu/cgvlab/www/resources/papers/Benes-2007-Real-Time_Erosion_Using_Shallow_Water_Simulation.pdf>

[3] <https://cgg.mff.cuni.cz/~jaroslav/papers/2008-sca-erosim/2008-sca-erosiom-fin.pdf>

[4]<https://data.exppad.com/public/papers/Layered_data_representation_for_Visual_Simulation_of_Terrain_Erosion.pdf>

NEEDED

USEFUL

<https://developer.nvidia.com/gpugems/gpugems/part-i-natural-effects/chapter-1-effective-water-simulation-physical-models> - nvidia gpu gems book. Chapter 1 – 2 might have useful material.

<https://xing-mei.github.io/files/erosion.pdf> - erosion simulation

<https://hal.inria.fr/inria-00402079/document>

<https://www.modeemi.fi/~daemou/mindtrek12.pdf> - comparison of different water sim methods

COULD BE SOMEWHAT

<https://matthias-research.github.io/pages/publications/hfFluid.pdf> - water sim.

<https://creativecoding.soe.ucsc.edu/courses/cs488/finalprojects/shallow/shallow.pdf> - shallow water sim that introduces the famous techniques

<https://www.tandfonline.com/doi/pdf/10.1080/19475683.2015.1050064> - another shallow water sim