Modeling of Erosion Impacts on the Terrain

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1 Introduction

In the field of computer graphics, we often find ourselves in the need of visually plausible models of terrain. Creating such a terrain using a modeling software would be very time-consuming and the results may not be as good as we would need. For that reason many techniques solving this problem were developed; erosion-based terrain modeling is one of the possible approaches. It has been an important part of computer graphics for more than twenty years but many problems still remain unsolved. Many solutions are only capable of working with 2.5D terrain, these solutions do not allow formations such as caves or overhangs. Other group of solutions supports the fully 3D terrain but these methods are usually very memory consuming and not capable of running with real-time response.

Our solution is addressing the problem of hydraulic erosion, which has the greatest influence on the terrain alterations. The solution is representing the fluid as a particle system and the terrain is stored as a triangle mesh, leading to lower memory requirements while keeping the ability to simulate fully 3D phenomena.

2 Proposed Solution

The solution is based on Smoothed-particle hydrodynamics (SPH), an approximative numeric solution to equations describing the fluid dynamics. SPH represents the fluid as a set of particles that interact over a specified distance called the *smoothing radius*. The advantage of the SPH simulation is that the particles are localized only in the regions where the fluid is present and so we can limit the computation to this locations. For the implementation of SPH we use a library *Fluids v.2* by Hoetzlein (2009).

The terrain in erosion simulations is usually represented as a height field or a voxel grid. These regular data structures simplify the erosion calculations but they have significant drawbacks as well. A height field does not allow the creation of a fully 3D features of the terrain; voxel grids are capable of describing a fully 3D scene but they are very memory consuming. Our solution represents the terrain with a triangle mesh, which leads to lower memory requirements. Furthermore, the resolution of the triangle mesh can be adjusted according to the complexity of the scene, allowing higher resolution in the regions with great details and lower resolution in the homogeneous regions.

The SPH particles simulate the motion of the fluid and interact with the terrain when a collision occurs. On collision, the erosion or deposition amount is calculated using the equations published in Krištof et al. (2009). The erosion sediment exchange is calculated for all the particles in the scene and after that the triangle mesh is updated. During the modification of the mesh, an inconsistency can be created when two parts of the mesh intersect. The solution to this problem was suggested but it is not yet successfully implemented, due to the numerical imprecision issues.

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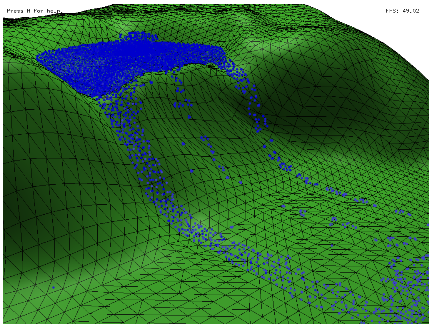
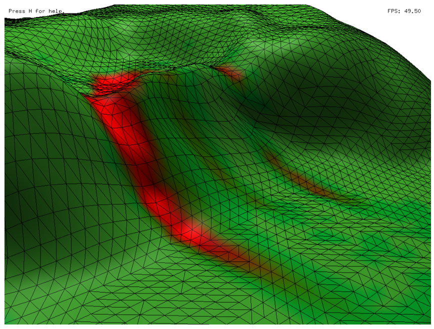
3 Results

In erosion-based terrain modeling it is very complicated to confirm the correctness of the generated results. To confirm it, the simulated scene would have to based on real data and the results would have to be compared to a sequence of images capturing the process of erosion in the real world. Unfortunately, erosion is a very long term process and thus it is almost impossible to obtain the real data for testing purposes. Most authors then validate their algorithms only visually, evaluating if the resulting scenes look visually plausible.

The algorithm was tested on several scenarios, the results were visually acceptable. Better results could be achieved with more detailed terrain models. An example of a scene generated by the implementation is shown in Figure 1.



(a) The terrain is being eroded by flowing water.



(b) The resulting terrain. The red color marks the eroded regions.

Figure 1: An example of a lake being eroded by water.

4 Conclusion

A novel solution to the erosion-based terrain modeling was proposed which is capable of representing both fully 3D terrains and fully 3D water effects. The results of the erosion were shown and visually confirmed, however, it is impossible to prove their correctness as we do not possess any real data of a similar scene.

During the modification of the terrain, an inconsistency can be created in the mesh; the implementation of this subproblem was not successful due to the issues of numerical imprecisions. The solution to this subproblem will be a part of future work, along with the extension of the algorithm to support different materials and the optimization of the implementation.

Acknowledgement

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References

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