3D SIMULATION OF RIVER WATER

DPRI, Kyoto University, Member, ○SHEN Dayong
DPRI, Kyoto University, Member, TACHIKAWA Yasuto
DPRI, Kyoto University, Fellow, TAKARA Kaoru

1. Introduction

Nowadays Computational Fluid Dynamics (CFD), Smoothed Particle Hydrodynamics (SPH) and phenomenological methods are very popular in computer graphics to simulate the motion of fluids. Based on mathematical equations, CFD method can be used to predict how fluids will flow, and what will be their quantitative effects on the solids they are in contact with. The primary drawback of CFD method is that the computations are performed on data structured in 2D or 3D grid, called an Eulerian framework. This architecture limits the combined extent and flow detail that can be computed. SPH method is very useful for simulating the scenarios of splashing, collision and breaking of water body because it is based on Lagragian framework and the fluid volume is not bound to grid geometry. Phenomenological method can get real-time rendering effect for simulating the motion of surface of water body. It is based on field phenomenology and usually represented by empirically statistical models. In this paper, we will simulate river water using the approach of GIS Flow Element (FE), GIS Soft Voxel(SV) and projected grid.

2. Methodology

2.1 GIS FE, GIS SV and projected grid

As there are not any ideal modeling methods in GIS to simulate soft geoobjects such as flood, landslides and lava flow, which will deform under forces, we explore the approach of GIS FE and GIS VS, trying to meet the challenge. Controlled by geoscientific models and built based on a pixel from remotely sensed imagery, a GIS FE is used to simulate the dynamic change of velocity and direction of soft geoobjects in 3D space and taken as a basic simulation unit. It has position, velocity and direction, but neglects volume. A GIS SV is a voxel with position, velocity, direction and volume and covered by an isosurface, which is defined by implicit functions. It is also controlled by geoscientific models and built based on a pixel from remotely sensed imagery and taken as a basic simulation unit to simulate the deformation of soft geoobjects. In computer graphics, projected grid algorithm is intended to create a grid mesh whose vertices are in post-perspective camera space. This will deliver a polygonal representation that provides spatial scalability along with high relative resolution without resorting to multiple levels of detail.

2.2 representing the volume and deformation of river flow based on GIS SVs

There is flow transport between a rectangular grid of column and its adjacent columns. To enhance the simulation efficiency, we firstly generate a column with *h_m*, which is the mean value of the sum of water heights at four vertices of the grid, as its height shown in Fig. 1 to represent the original column, and then define a GIS SV with constraints to simulate water deformation in the new column (cuboid). Eq. (1) is the basic equation of a GIS SV:

$$g(r) = \left(r - \sqrt{2d^2 + h\_m^2} \Big/ 2 \right)^2 \qquad (1)$$

where d is the length of a grid, (x, y, z) are 3D

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Disaster Prevention Research Institute, Kyoto University, Uji 611-0011, Japan

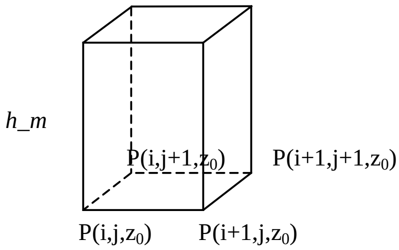

Fig. 1 "Skeleton" of a GIS SV.

coordinates of the critical point of the GIS SV and $r^2 = x^2 + y^2 + z^2$.

Navier-Stokes Equations (NSE) are the embodiment of Newton's second law in fluids, and the governing equations of general fluid flow. Fig. 2 shows the approximation of the NSE, where the arrows indicate direction of flow. Based on GIS SVs, we simulate motion of water body, where the red virtual line represents the schematic map of the profile of water surface computed using Eq. (1) and constraints.

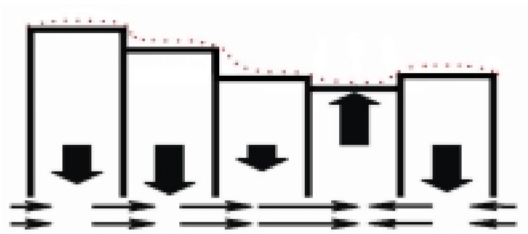

Fig. 2 Approximation of the NSE.

2.3 representing the velocity and direction of river flow based on GIS FEs

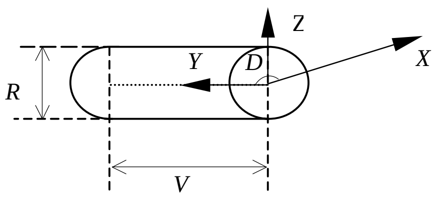

Fig. 3 GIS FE.

Velocity, direction and other parameters of routing flow in current column are simulated by GIS FEs. Fig. 3 shows the geometric structure of a GIS FE, which is represented by a cylinder in this case. Here, velocity of the flow is in direct proportion to the height of the cylinder; direction of the flow is calculated by neighborhoods tracing algorithm; depth of the flow is in direct proportion to the diameter of the cylinder; transparency of the flow is in direct proportion to the transparency of the cylinder; and concentration of sediment in routing flow is in direct proportion to the depth of color of the cylinder.

2.4 rendering waves based on projected grids

The algorithm contains four steps: wave generation; height map creation; displacement of the world-space vertices according to the height field; and CPU-based vertex processing.

3. Case study

Based on GIS FE, GIS SV and projected grid approach, we simulate a watershed and the motion of river water as shown in Fig. 4. Here, the size of the scenario is 1024 × 1024; DEM size is 512 × 512; and grid size is 5m × 5m.

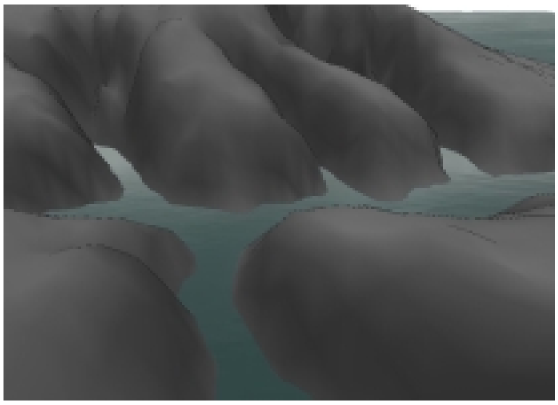

Fig. 4 River water.

4. Conclusion

We simulate river water based on the approach of GIS FE, GIS SV and projected grid. A case study shows that the approach has the advantages of CFD, SPH and phenomenological method.

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