Interactive Terrain Modeling using Hydraulic Erosion

Bedřich Beneš[1], Ondřej Šťava[2],
Jaroslav Křivánek[2],Matt Brisbin[1]
[1]Purdue University [2]CTU Prague

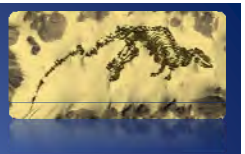
Introduction

- The typical ways to model a terrain

1) Procedural techniques
   a) Fractals (low controllability)
   b) Example-based (not realistic)
   c) Physics-based (very slow)

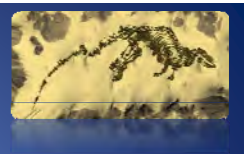
2) Manual Modeling (tedious)

Key Observations



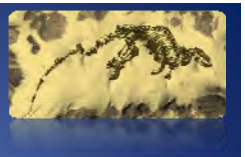
- Physics is “right” – let’s use it
- We do not need a full 3D phenomena (caves, overhangs, etc.)
- Interactivity is the key
- Recently – GPGPU techniques for modeling

Key Observations



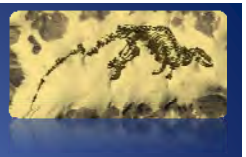
- Erosion is the most important morphogenetic phenomena
- Water erosion is the most important erosion of all kinds

Contribution

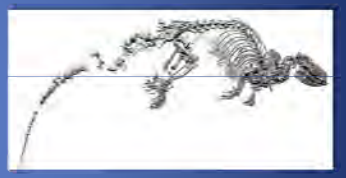


A set of techniques for interactive 3D terrain modeling using various types of erosion

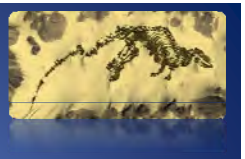
Scene Description



- Layers – loaded as images. Easy to
  - define (few parameters)
  - edit
  - manipulate.

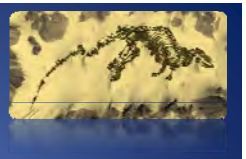


Water Simulation



- Using the *pipe model*
- Simplification of the shallow-water equation
- Commonly used in CG
- Fast and efficient 2.5D solution

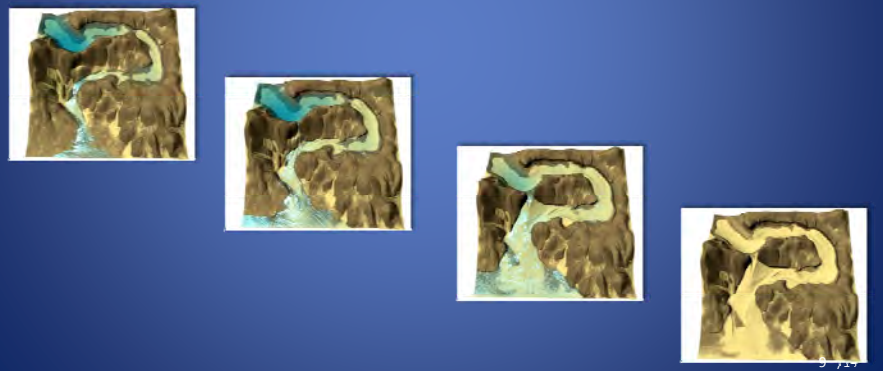
Erosion Algorithms



- Three kinds:
  - Force-based hydraulic erosion
    First used by Mei et al in 2007
  - Dissolution-based hydraulic erosion
    defined here
  - Weathering
    Described by Musgrave in 1998, extensively used

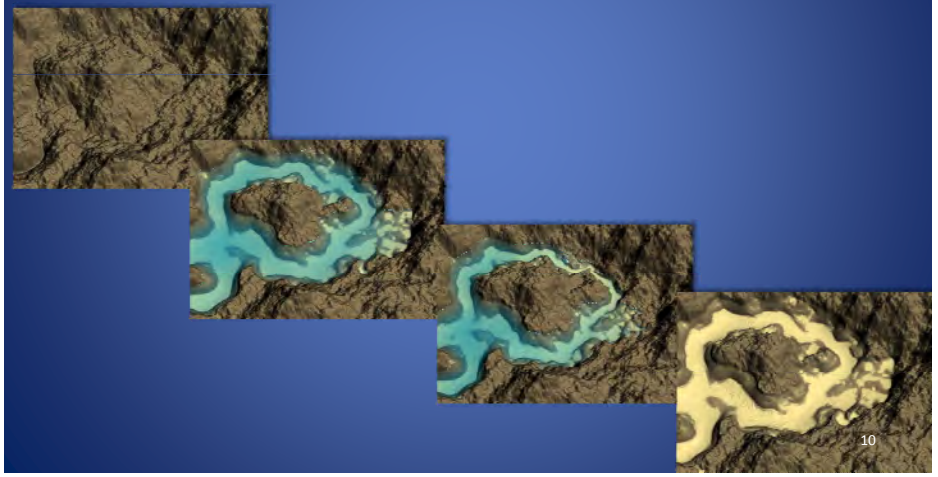
Force-Based Erosion

- Force hits a material and kicks it out
- Then it is captured and moved



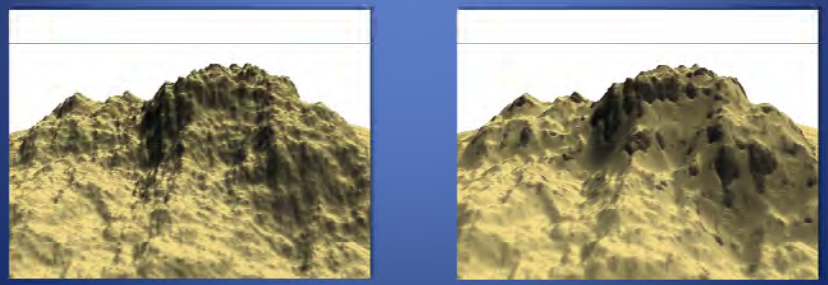
Dissolution-Based Erosion

- Slowly moving water erodes banks



Slippage

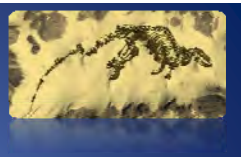
- Solid material is moved
- The speed depends on so called talus-angle



Material Changes

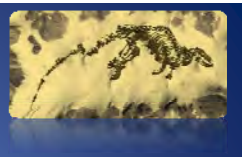
- Erosion:
  Any layer is changed into sediment
- Deposition:
  Sediment is changed to its underlying layer
- No new layer need to be defined

Implementation and Results



- 100% on the GPU
- Uses CUDA, Cg, OpenGL
- Fully interactive
- 1024x2048@100 fps
- Exports to Mental Ray
- Supports tiling (ready to Multi GPU)
- Intuitive operations - rain, dig, add, erode, etc.

Conclusions



- Fully interactive set of operations for terrain modeling
- Allows for features never seen before in CG
- Extremely easy-to-use
- Neatly blends with commercial software