The 3D Studio Max plugin for simulation of the footprints on the ground surfaces

J. Fedorova, A. Kryachko
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Motivation

- Implementation of the algorithm for visualization of the footprints, appearing on the ground surface after the interaction with the moving object (for creation of the more realistic 3D scenes)

- Implementation of the algorithm as the plugin for some 3D modeling program (3DStudioMax), using standard instrumental tools (AppWizard, class library)

- Provision of the comfortable work with the module and its high performance during the scene visualization (usage of the adaptive representation of the object)
**Algorithm basics**

- **Model of ground material**
  - Collision test for affecting object (object is not necessary in mesh representation)
  - Material displacement to the object periphery
  - Erosion (downhill redistribution)

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Parameters

- Height field resolution
  - correct proportion between the feature size of affecting object and cell size: 4-5 cells per “feature”

- Compression ratio $\alpha$
  - (defines the amount of material, distributed from the affecting object to the periphery)

- Roughness (irregularity of the ground deformations) $\sigma$
  - (the amount of material, moved from one cell to another during erosion)
Parameters (continuation)

- Inside and outside slopes toward the object $\Theta_{\text{in}}, \Theta_{\text{out}}$

Table of parameter values for the three ground materials

<table>
<thead>
<tr>
<th></th>
<th>Sand</th>
<th>Mud</th>
<th>Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.95</td>
<td>0.99</td>
<td>0.00</td>
</tr>
<tr>
<td>$\sigma$</td>
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<td>0.2</td>
<td>0.2</td>
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<tr>
<td>$\Theta_{\text{in}}$</td>
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<tr>
<td>$\Theta_{\text{out}}$</td>
<td>0.436</td>
<td>2.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
Usage of the Adaptive Mesh for surface representation

Without Adaptive Mesh usage
16641 points, 32768 triangles

Using Adaptive Mesh
1668 points, 3318 triangles
Adaptive Mesh

- Mesh bases on the 2D uniform grid (the most detailed mesh level)

- In every grid node user defines a set of attributes

- Based on the attribute’s values, continuous level of detail mesh is extracted
Structure of the Adaptive Mesh
it bases on the sequence of the regular local updates

Directed Acyclic Graph - DAG

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Adaptive Mesh: surface extraction

- Every cut in the Adaptive Mesh DAG defines certain surface approximation
- Cut (surface) is naturally represented as the triangulation
- Cut is built, basing on the error function, which is defined in DAG nodes

Note: directed acyclic graph (DAG) is widely used structure in multiresolution modeling
Mesh features, provided for the update’s regularity

- Compact data structures ->
  - DAG creation and mesh extraction algorithms are more simply
  - Significant reduction of memory usage (more than 4 times)

- Extracting triangulation can be represented as 1 strip
Time complexity of the mesh extraction algorithm

Computer:
Pentium II 400 MHz, 192 MB RAM
OS: Windows NT
Usage of the Adaptive Mesh in plugin allows:

- to speed ground surface displaying in the 3DStudioMax viewports (during the scene modeling)
- to reduce memory usage for mesh storage
- to reduce time of scene rendering:

![Graph showing the comparison of rendering time with and without adaptive mesh](image-url)
**Input:** current mesh state, affecting objects (not necessary in mesh representation)

- Height calculation for the modified height field's cells
- Entry of the cell heights in the adaptive mesh as the attribute values
- Calculation of the triangle errors, according to the attribute’s values
- Extraction of the continuous level of detail triangulation

**Output:** modified ground surface mesh (according to the objects’ position)
Demonstrations