3D Geographic Information System

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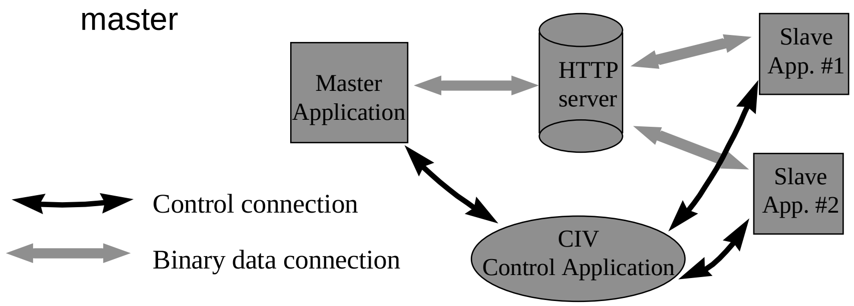
Application Model

- Master/Slave model:
  - master user choses the number of windows, their contents, changes the viewer's camera position
  - slave users simply observe reproduced behavior of the master



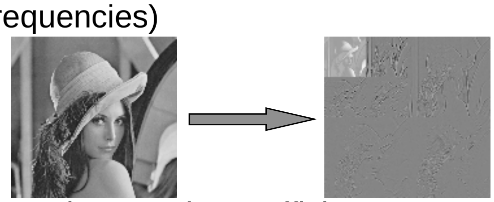
System Overview

Goal: visualization of terrain with multiple kinds of data, including satellite images, maps and weather info

- Open Inventor used as a graphic library and a windowing toolkit
- “Earth surface” is build with triangles
- Imaginary data (maps, satellite images, etc.) is projected on the surface
- DEM & imaginary data is compressed using wavelets
- Adaptive mesh simplification
- Delaunay triangulation

Wavelets

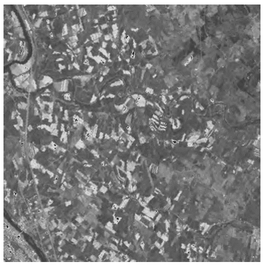
- Wavelet decomposition extracts the most important information (low frequencies) and less meaningful details (higher frequencies)

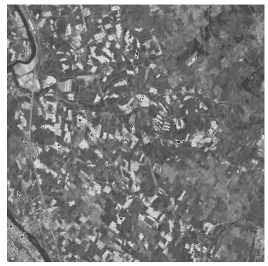


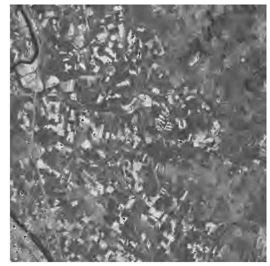
- to compress the wavelet coefficients we use Embedded Zerotree Algorithm:
  - the coefficients describing low frequencies are placed in the front of the stream, higher frequencies are placed further;
  - the coefficients can be roughly approximated using only the beginning of the stream, further part of the stream provides additional refinement information.

Wavelets (cont'd)

- Embedded stream lets any application use only a fraction of a stream to obtain some approximation of a image:


Whole stream (14times)

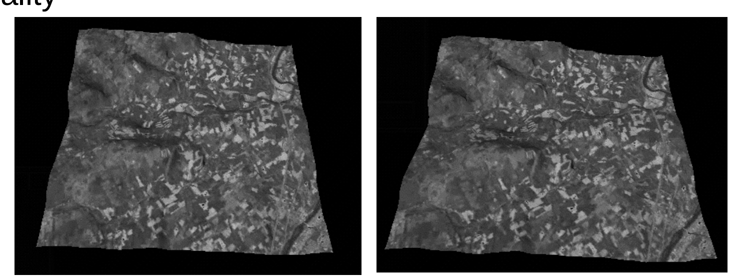

62% of the stream (22t.)


14% (100t.)

- Compression ratios used in the system: ~48 times for DEM, ~25 for textures

Mesh simplification

- A full mesh of triangles build on n^2 points (nodes) consists of $2(n-1)^2$ triangles
- Most of nodes can be removed without a visual loss of quality



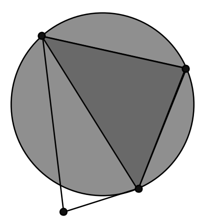
Which of the above terrains was built with only 10% of nodes???
(Answer: the right one)

Triangulation

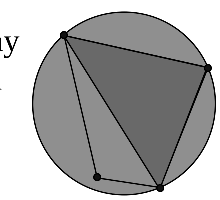
- After mesh simplification, the remaining nodes have to be connected into a set of triangles
- We use a fast divide-and-conquer 2D Delaunay triangulator.

Every triangle's circumcircle contains only the vertices of this triangle

Delaunay triangulation



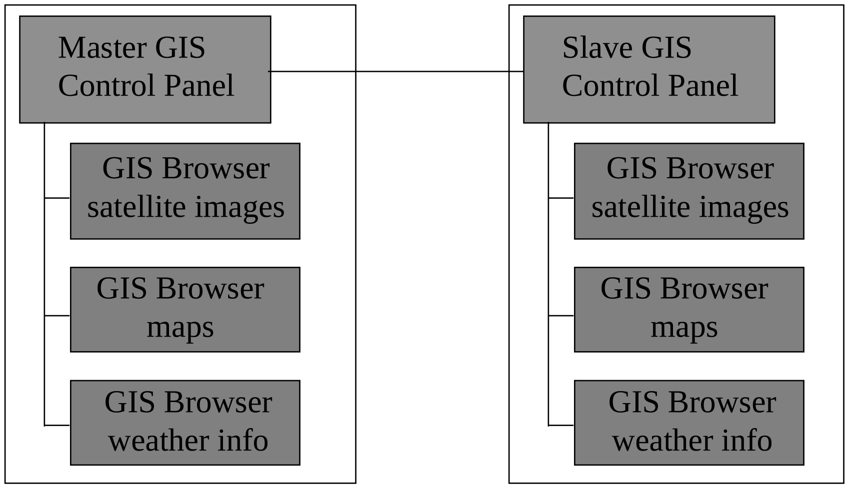
non-Delaunay triangulation



Open Inventor

- OI is a set of C++ classes designed for developing high-performance graphics applications
- Its extensibility allows to overcome some of its drawbacks:
  - ability to read & send binary data over the network
  - extensions of the default viewer, for example we can switch between textures using buttons

Overall Communication Architecture



Overall Communication Architecture (cont'd)

- Two levels of communication
  - local: between Control Panel and GIS Browsers
  - over the network: between Master Control Panel and Slave Panels via collaboratory system.

Communication with the Collaboratory System

- GIS Control Panel is connected with a collaboratory daemon by means of a socket
- Two message channels
  - CONTROL: Control Application and Master Control Panel (CIV protocol)
  - DATA: between Control Panels (GIS protocol)

GIS Protocol

- Messages sent from the master to all the
- slaves via the control application:
- Camera Position Change–the master has made a movement in his GIS window
- New URL–the new virtual world has been chosen to be displayed
- Windows Contents–the master has turned on/off one of the windows or changed its content (map/weather, walk/fly view)

Future enhancements

- Usage of the SoLevelOfDetail class to improve displaying speed
- Dynamic downloading of the necessary data while the system is being viewed
- Animation of objects according to control information received from the simulation engine