Scalable Visualization of Massive Point Clouds

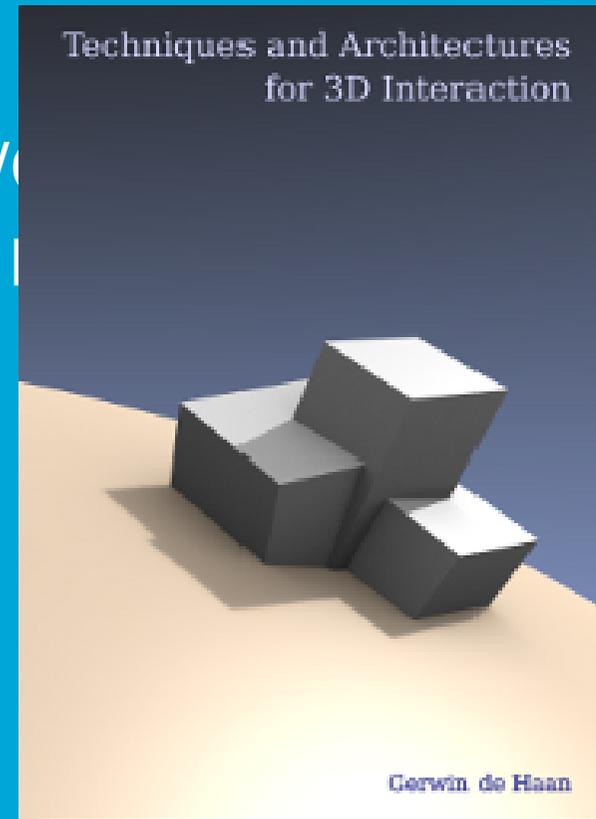**Dr. Ir. Gerwin de Haan**

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About me

- TUDelft Computer Graphics & CAD/
- Msc (2002), Visualization in Virtual
- PhD (2004 - September 2009)
- PostDoc

PointClouds: 2008 RGI 3DTOPO (TuDelft GIS group)

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Why Visualize Point Clouds ?

- Because we can !

Because we need to:

Visual inspection of "raw"measurements

Visualization: **"From numbers to insight"**

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# Scalable Visualization?

- From bigger (?) **data** to bigger **insights** ?
    - Too big for one graphics card
    - Too big for one machine
    - Too big to see on one screen
    - Too big for one person to comprehend
    - Too big to physically distribute

- Rendering >> Visualization >> Interaction

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Our Tools of Choice

- **OpenSceneGraph**
  - Most popular FOSS **scene graph** engine
  - Integration, Compatibility, File Formats
  - Based on Flight-simulator software (not GIS)

- OpenSceneGraph-based **VRMeer** software
- Python abstraction layers

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Real-Time Terrain Rendering

- OpenSceneGraph + **VirtualPlanetBuilder**
  - **TIN** generation, Level-Of-Detail, Tiling
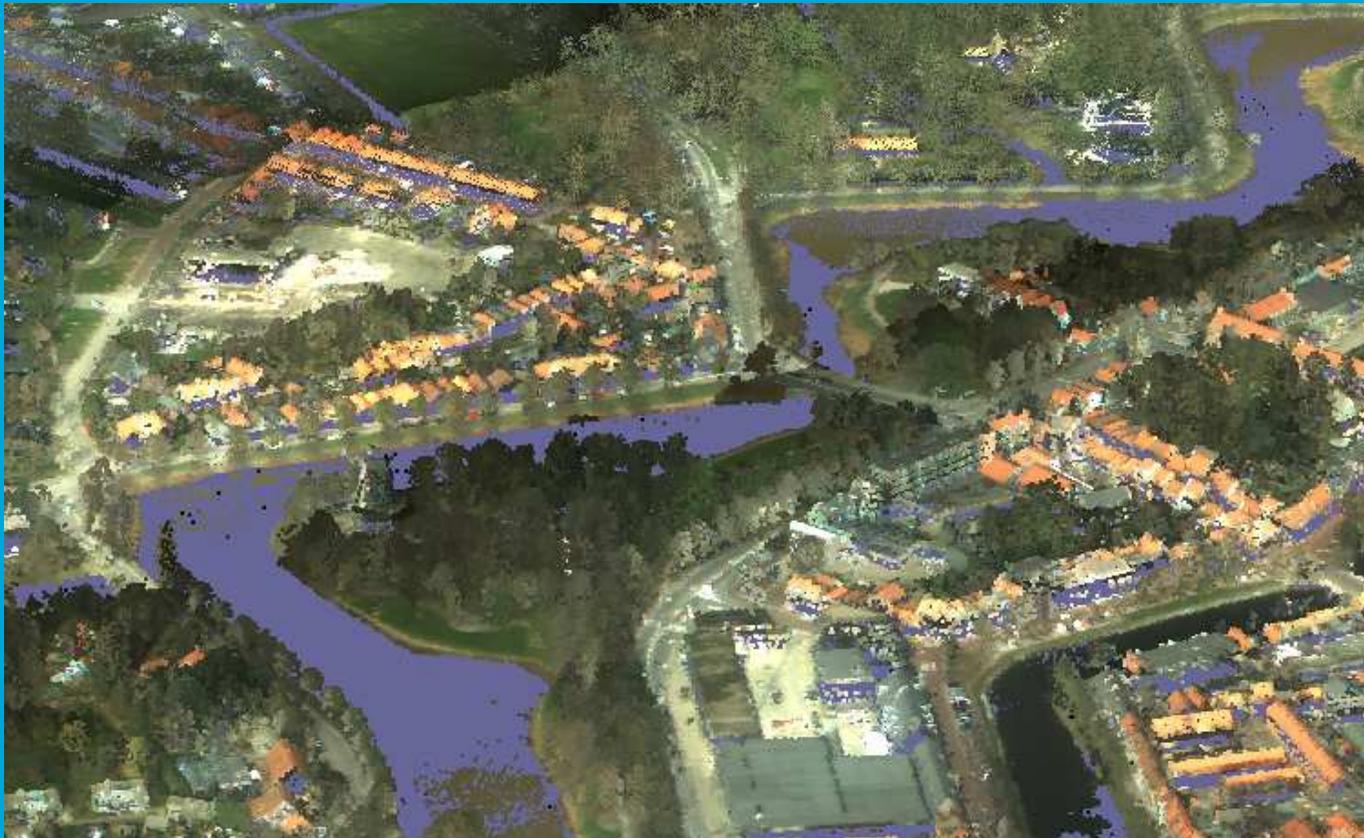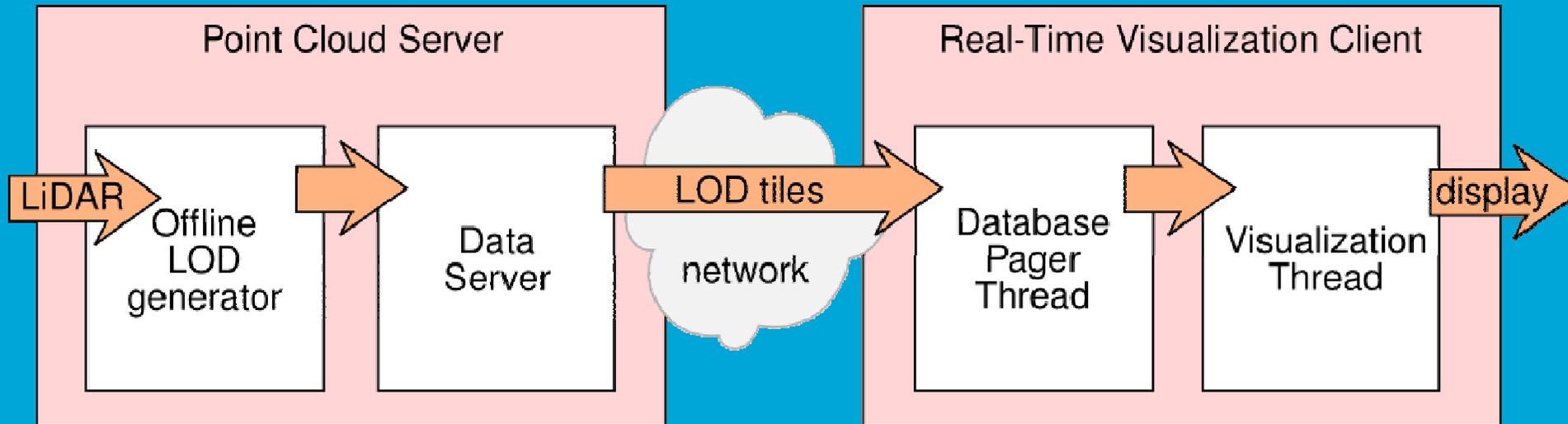 - **Paged** file-based access, also from **network**

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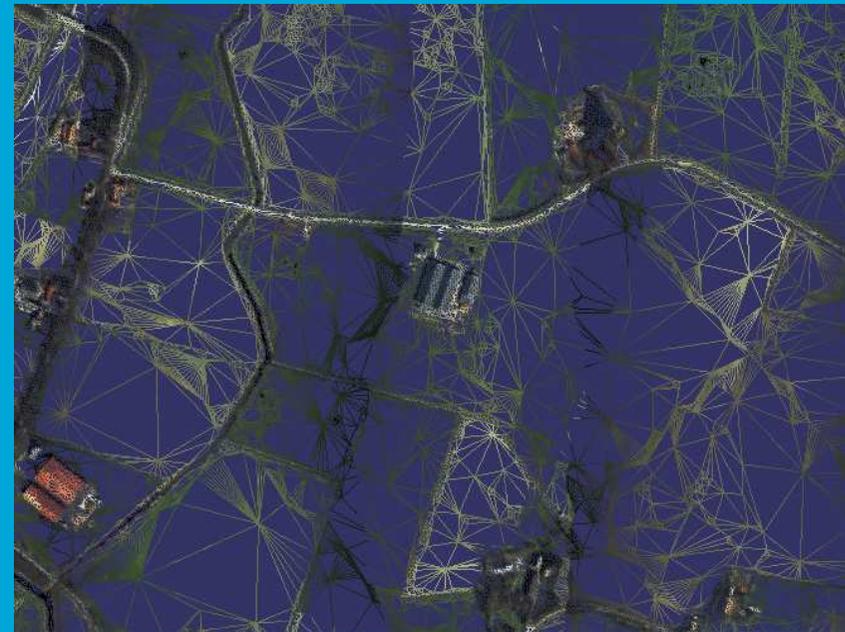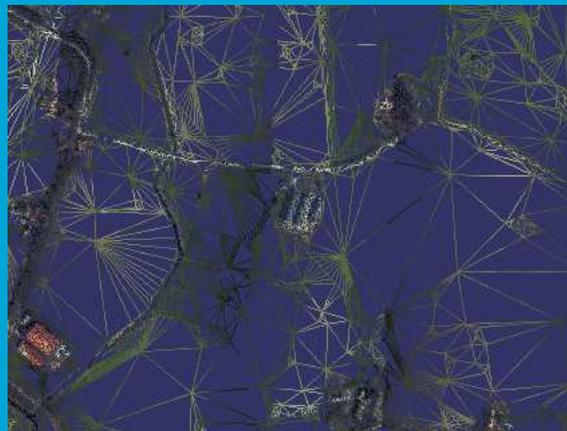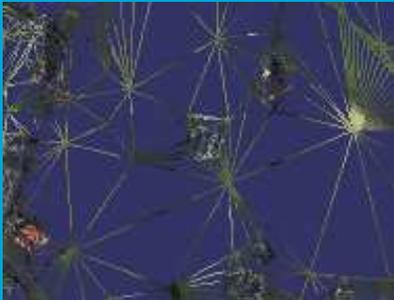
From Terrain ...

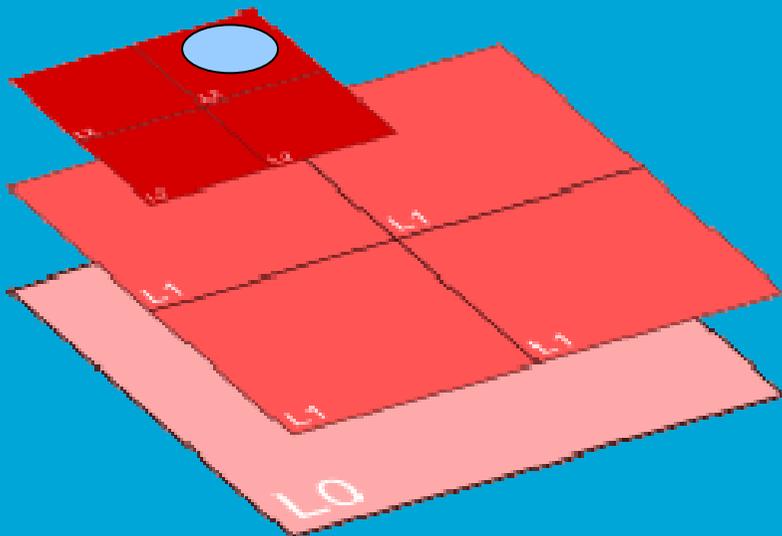- AHN2 "raw" DEM 0,5m grid size, RGB "raw" photos

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... to Point Clouds

- ~2 million points at interactive rates, but which ones ?

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Our Current System

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Point Cloud Datastructure

- Discrete LOD, Tile-based, Quad-Tree,
- Simple sampling , no duplication

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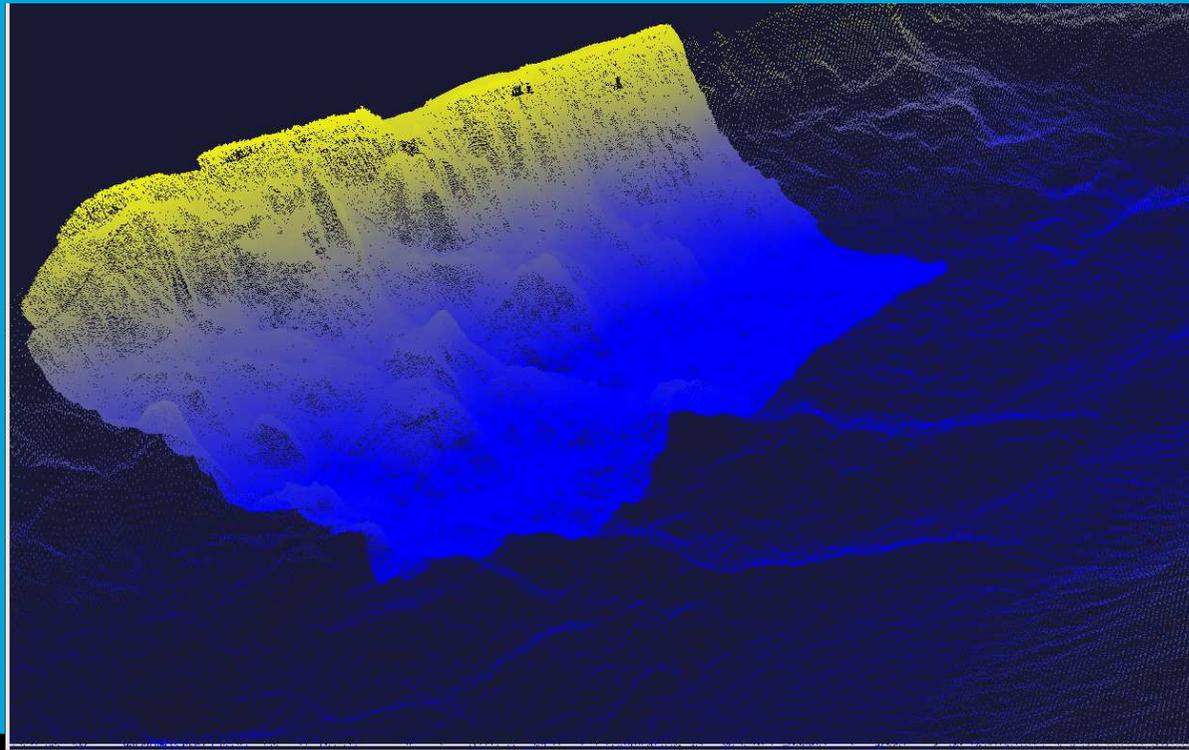
Point Cloud Visualization

Point Cloud Rendering Issues

- Sampling vs. Density (what is important?)
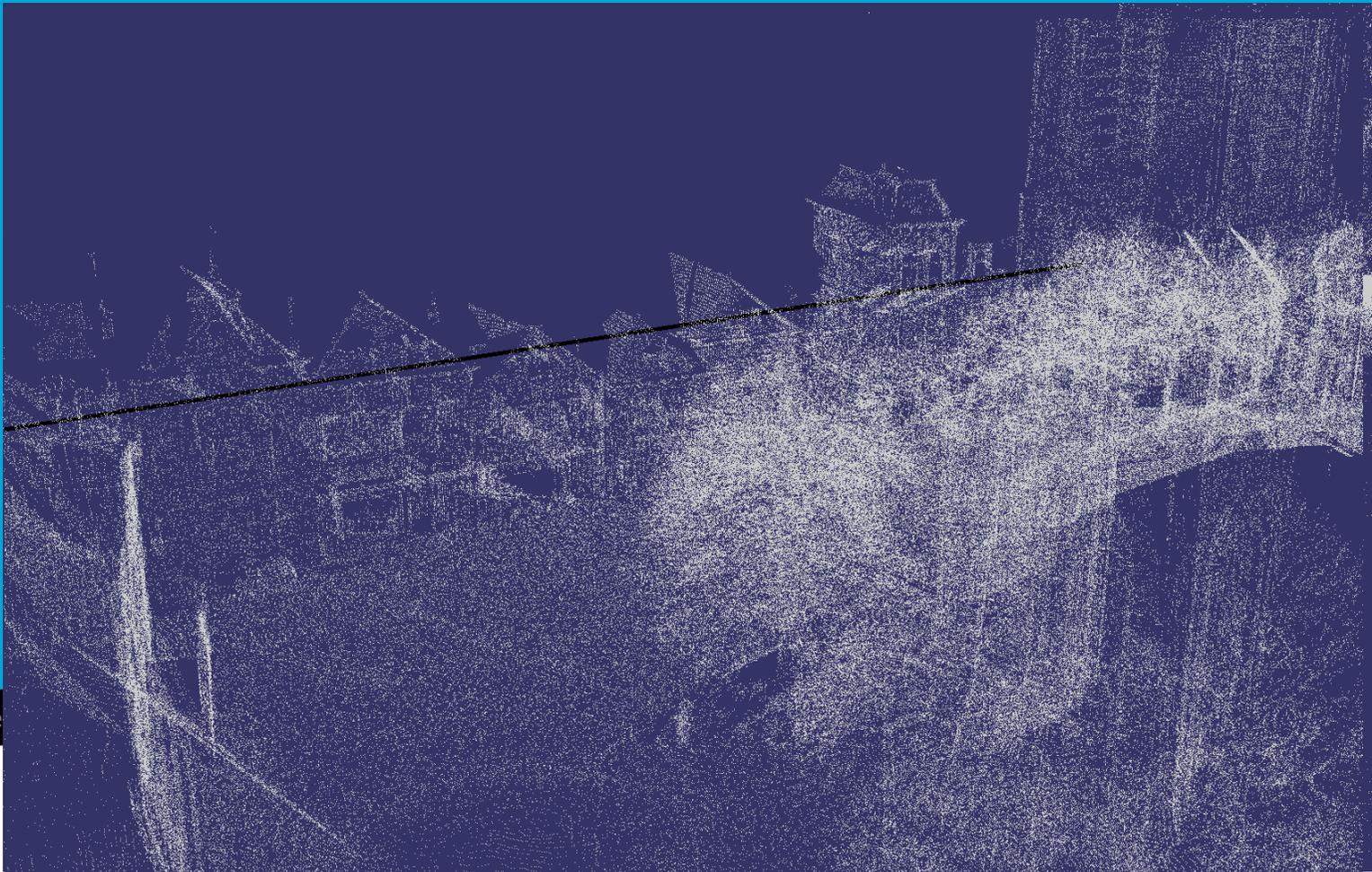- Rendering Scalable Enough? (It depends!)

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Importance Sampling

- 10%, Random vs. Metric (e.g. Surface-ness)
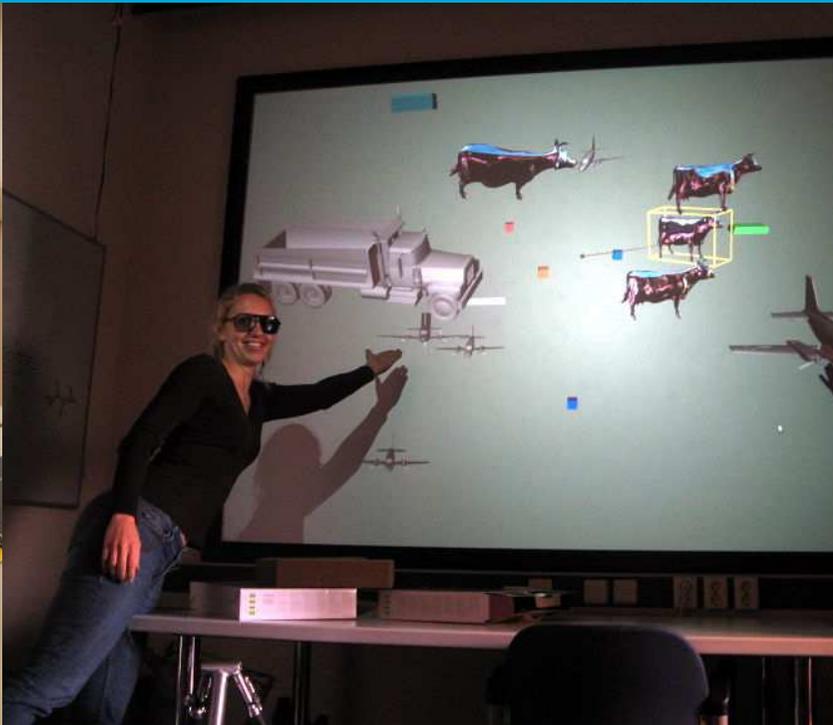- Pre-processing, region/case-specific metric

? | Delft (NL) | — | ✕

Scalable Comprehension: Display

- Correct view
    - 3D Perspective setup / head tracking
    - Stereoscopic display!
- Planar, Powerwall, Workbench, PDRIVE (CAVE)

Scalable Comprehension: Interaction

- 3D Interaction modelling + prototyping
  - Mouse-based, animated 3D navigation
  - Simple Sketching on models
 - Space-mouse, Wii balance board interaction

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Application: Flooding

- Hoogheemraadschap Delfland
  - Fast, High Accuracy Flooding Simulation
  - High Fidelity Visualization
  - Communication to general public (color, please)

- [video]

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State of the Art (Academic)

- Much "Point-based Graphics", but Single Object focus

- [Wand 2008] Point Cloud Rendering & Editing
  - Demonstrated 63GB, limited by disk space

- [Kreylos 2008] VR pointcloud editor, shape matching
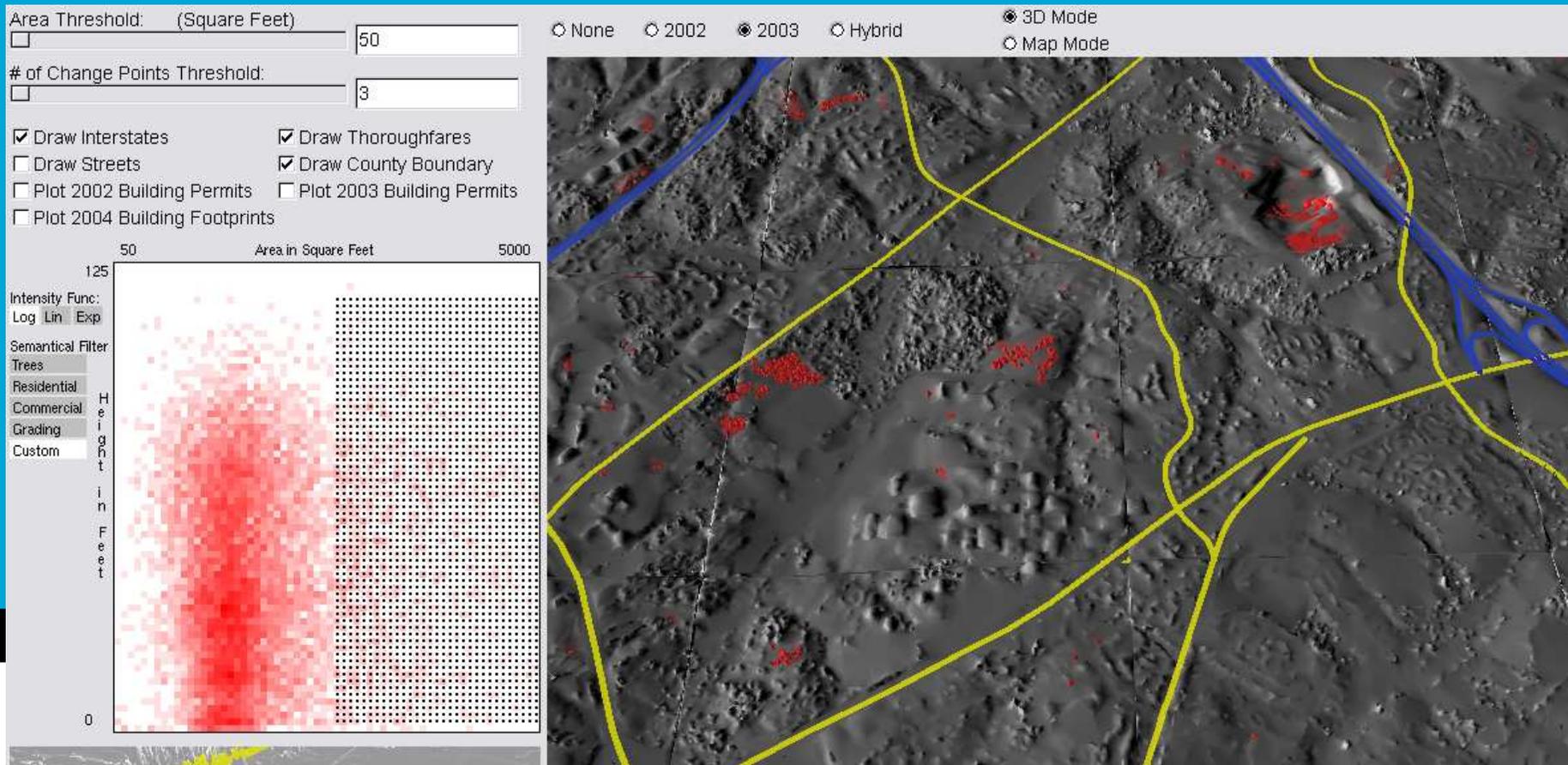

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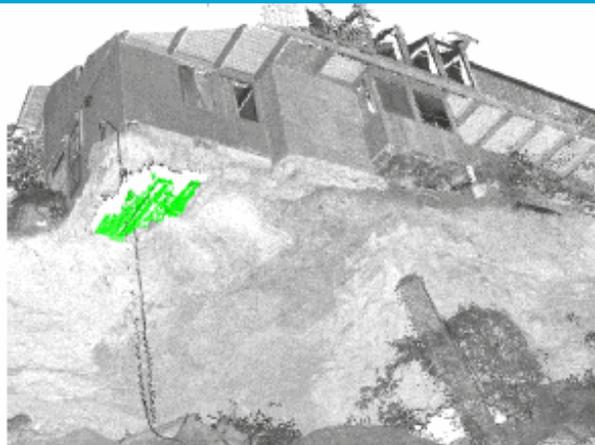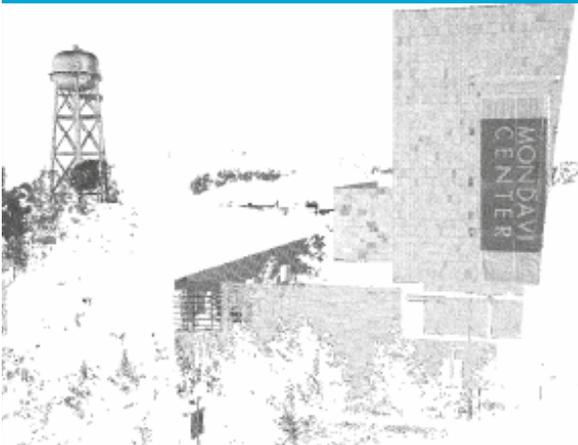
Future Scalable Approaches

- **Continuous** Level-of-Detail from **Geo Databases**
  - Balance bandwidth + memory vs. visual quality

- **Service-based Visualization** (& processing)
  - Data locality & security
  - Integration with "legacy" GIS apps
  - Tile-server for Web-based Maps (Bing, Gmaps)
  - Mobile Front-end

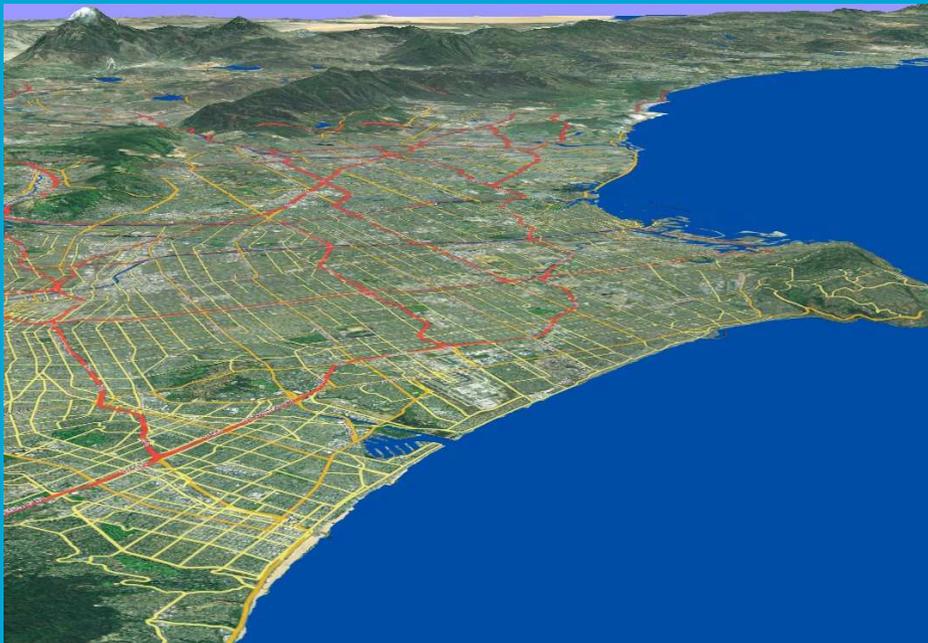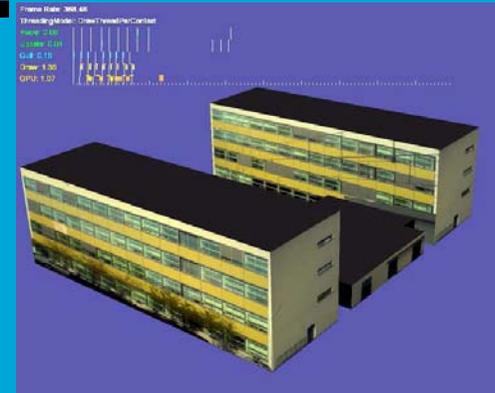- From Rendering to **Visual Data Analysis**

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Visual Data Analysis

- Urban Change Visualization [Butkiewicz 2008]
- Linking Abstract Views with Spatial Views

OpenSceneGraph leverage ...

- Integration, Compatibility, File Formats
- GIS: GDAL, COLLADA, etc.
- From high-end <-> mobile

[OSGGis, OSGEarth]

[4K projectors]

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Software, Videos or Demos ?

- E-mail: gdehaan@tudelft.nl
- Web: graphics.tudelft.nl/GerwinDeHaan

- Datasets and cases are welcome !

  (minor 3D Virtual Earth)

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Additional Slides

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Agenda

- Why
- Current system
- Data structures
- Results and Videos
- State of the Art
- Future Directions

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Terrain Rendering

- AHN2 Test Dataset

  - "Raw" pointcloud

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