Analytical and Computer Cartography

Lecture 15:
Technical Issues for 3D rendering

Virtual Globes: Wikipedia

- A **virtual globe** is a 3D software model or representation of the Earth or another world. A virtual globe provides the user with the ability to freely move around in the virtual environment by changing the viewing angle and position. Compared to a conventional globe, virtual globes have the additional capability of representing many different views on the surface of the Earth. These views may be of geographical features, man-made features such as roads and buildings, or abstract representations of demographic quantities such as population.
- In 1998, Microsoft released a popular *offline* virtual globe in the form of *Encarta Virtual Globe 98*. The first widely publicized *online* virtual globes were NASA World Wind (released in mid-2004) and Google Earth (mid-2005).

Examples

- NASA World Wind*
- CitySurf Globe
- Bing Maps
- SkylineGlobe
- Google Earth
- Marble, part of the K Desktop Environment, with OpenStreetMap*
- ArcGIS Explorer
- EarthBrowser
- Software MacKiev's 3D Weather Globe & Atlas
- Earth3D*
- WorldView
- Bhuvan

Virtual Geographic Reality

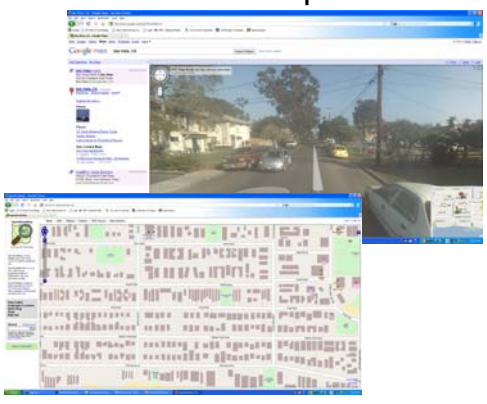
- Immersive Virtual reality
- Personal virtual reality
- Group immersion environments
- Web-based virtual reality
- Augmented reality


Some issues in 3D rendering

- Level of Detail and Map generalization
- Media and devices
- Image cross registration: geometry
- Interactivity
- Tools
- Realism: Differs in 2D, 3D, AR and VR
- Virtual environment vs. reality
- Models

Realism and human perception


Streetview vs. Openstreetmap



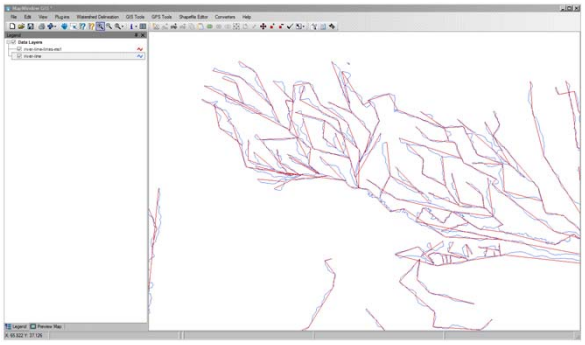
Modeling in a 3D World

- Cartographic Generalization
- Level of Detail
- 3D measurement systems
- 3D modeling and data structures
- 3D standards for Geospatial data
- Open Source Programming Libraries
- 3D in Geobrowsers (Google Sketch-up, Earth and Bing Maps)

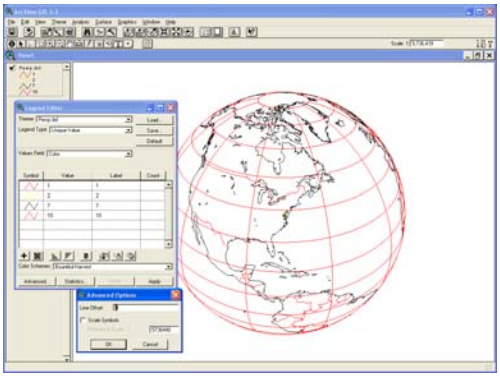
Generalization in Cartography

- Selection
- Simplification
- Combination
- Displacement
- Exaggeration

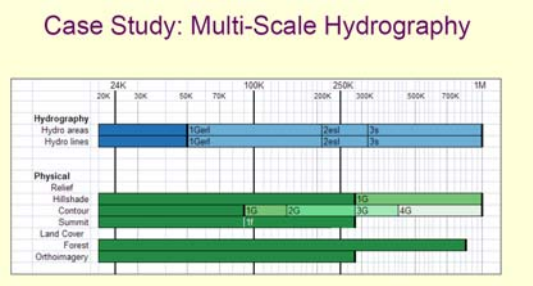
MapWindow GIS Douglas-Peucker



GIS: Scale Range Viewing

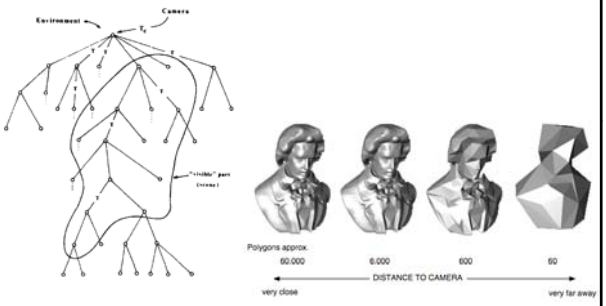


Scalemaster (Buttenfield and Brewer)



Generalization in Computer Graphics: Level of Detail

- James H. Clark (1976) *Hierarchical Geometric Models for Visible Surface Algorithms*. Communications of the ACM, October 1976,19, 10. pp 547-554.



LoD demonstration tools

- Meshlab
- Simplygon
- Vizup
- Rational Reducer
- Pro Optimizer
- OpenSG

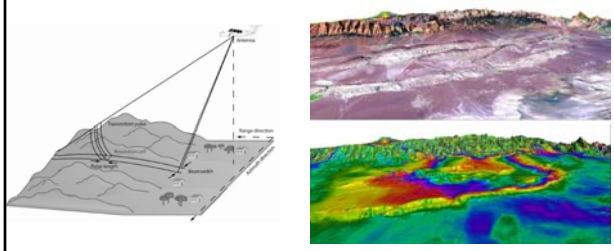
VRML 2.0 LOD Example

```
#VRML V2.0 utf8
LOD { range [20,40] level [
#full detail 16 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 } }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0.866 0 0.5, 0.5 0 0.866, 0 0 1 , -0.5 0 0.866, -0.866 0 0.5, -1 0 0, -
    0.866 0 -0.5, -0.5 0 -0.866, 0 0 -1 , 0.5 0 -0.866, 0.866 0 -0.5, 1 0 0 ] } }
#intermediate detail 8 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 } }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0.707 0 0.707 , 0 0 1 , -0.707 0 0.707, -1 0 0,-0.707 0 -0.707, 0 0 -1 ,
    0.707 0 -0.707, 1 0 0 ] } }
#low detail 4 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 } }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0 0 1, -1 0 0, 0 0 -1 , 1 0 0 ] } }
]
}
```

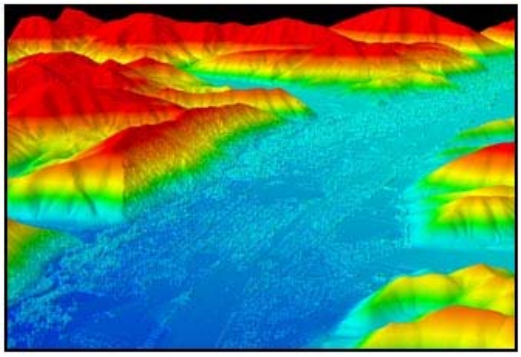
3D measurement systems

- First generation DEMs, photogrammetry and contour conversion
- Second generation based on SAR and IFSAR
- SRTM near global coverage, 30m/90m
- NED completed at 30m, then 15m+
- LIDAR now taking over
- New variants on LiDAR (Flash, Full waveform)
- IR mapping e.g. Microsoft Kinect
- Camera systems: image to 3D model

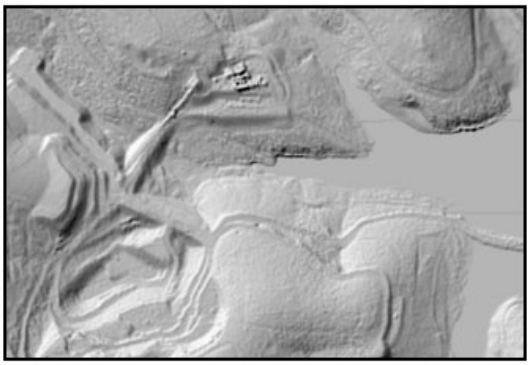
IFSAR: 2 stages



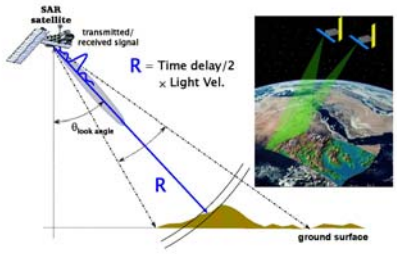
Terrain Model from IFSAR (Hailey, ID)



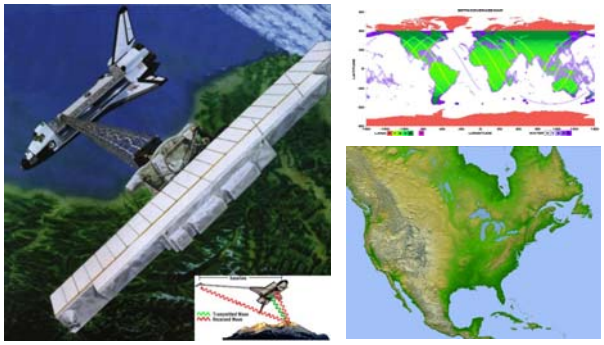
IFSAR DEM



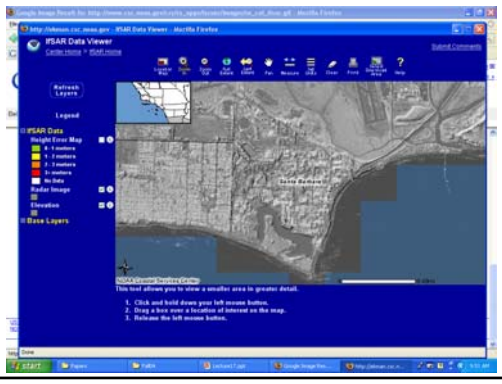
SAR from Space



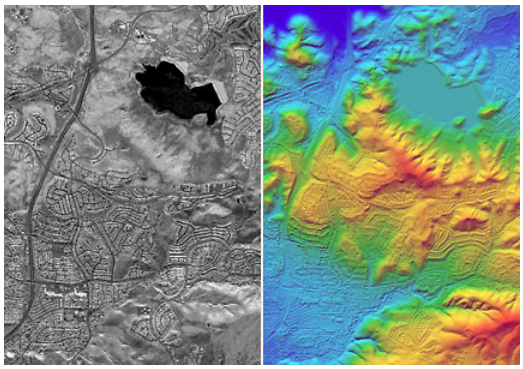
SRTM: Global topo map



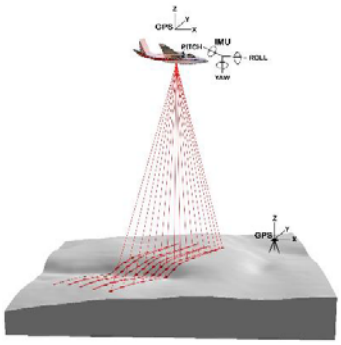
NOAA Southern Cal. IFSAR viewer



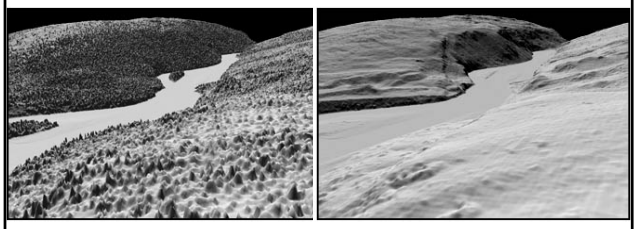
IFSAR: Thousand Oaks, CA



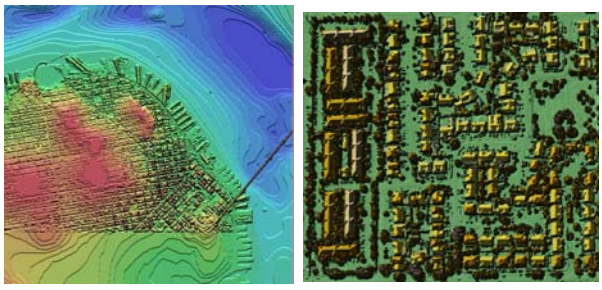
How Lidar works



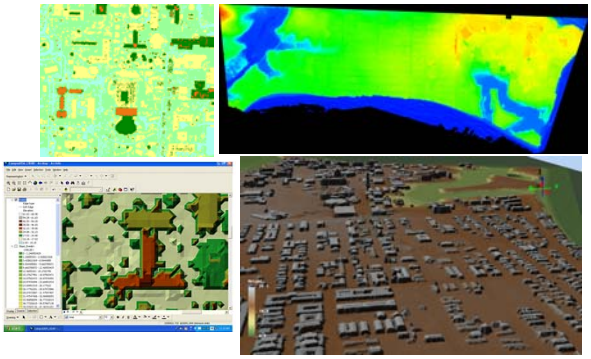
LIDAR first and last pulse



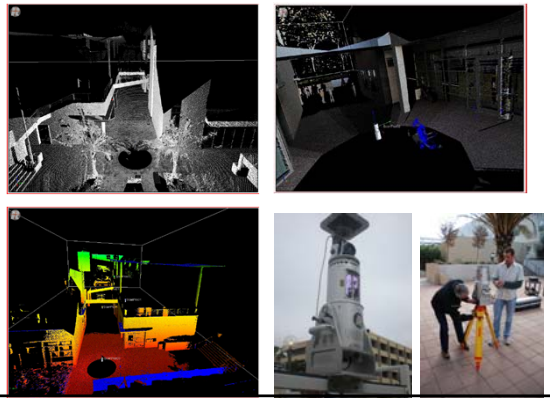
LIDAR terrain detail



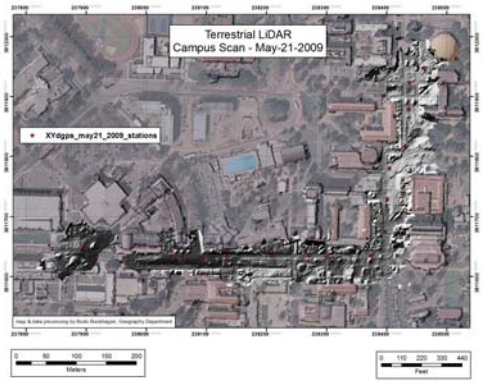
3D Models LiDAR



Terrestrial Scanning LiDAR



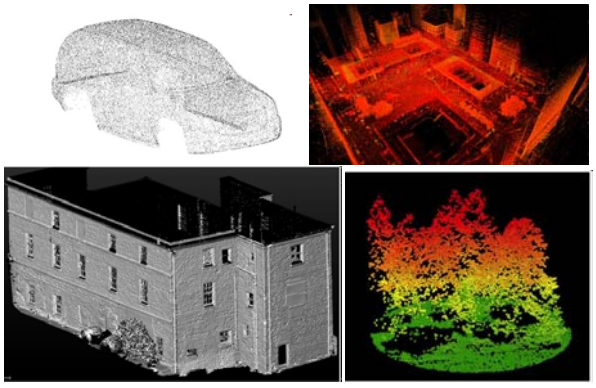
Campus scans



3D modeling and data structures

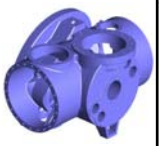
- Longley et. al. 6 models: gridded points, irregular points, cells, irregular polygons, TIN and contours
- Extensive use of TIN and surface patches
- Computer graphics and games favor Voxels
- LIDAR returns a POINT CLOUD

Point Clouds



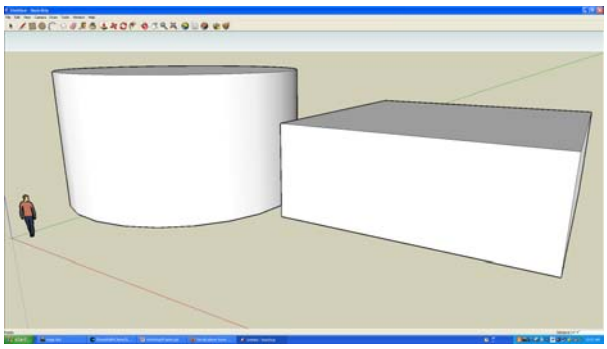
Feature extraction

Measurement vs. Modeling



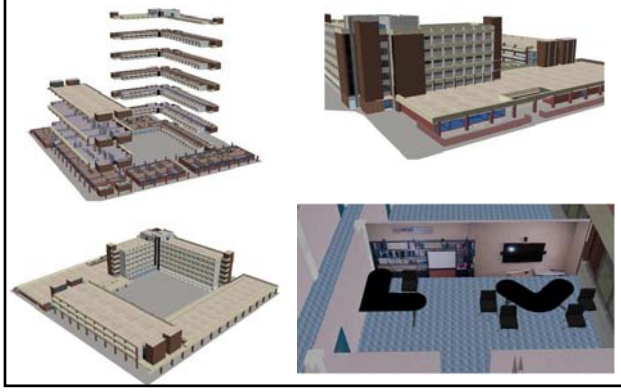
- Select key surface points, edges
- Generalize remaining surfaces
- Solids modeling
- Feature extraction; Buildings, trees (e.g. LAStools, Lidar analyst, Feature analyst, Quick Terrain modeler, TerraSolid (Microstation)
- Geometric vs. natural objects
- Realism vs. Size e.g. Google Object Warehouse

Simplest 3D tool: Sketch-Up (KML)



3D Buildings/Flat trees

Polygon extrusion (ArcScene)



Software (See: wiki entry)

- 3dsmax
- AC3D
- Ayam
- AOI
- Blender
- Carrara
- Cheetah 3D
- Cinema 4D
- CityEngine
- Cobalt
- Electric Image Animation System
- Form-Z
- Houdini
- Hypershot
- Hypermove
- Lightwave3D
- MASSIVE
- Maya
- Modo
- plugin3D
- POV-Ray
- Pro/Engineer
- Quest 3D creative
- Quest 3D Power
- Quest 3D VR
- Relux Professional
- Rhinocerous 3D
- Silo
- SketchUp/Pro
- Softtimage
- Solid Edge
- solidThinking
- SolidWorks
- Swift3D
- trueSpace
- ViewBuild3D
- VR4MAX
- Vue
- ZBrush

3D standards for Geospatial data

- VRML and GeoVRML
- X3D and OGC, Geospatial component and X3D Earth (e.g. Planet9 London)
- OGC CityGML
- Web3D Service
- LandXML.org
- COLLADA /KML (SONY, Google)
- National 3D-4D-BIM Program (USGSA)
- 3DVIA (Bing Maps)

Open Source Programming Libraries

- VTK
- Gorgon
- G3D Engine
- Cairo graphics
- OGRE
- OpenScene Graph
- Expression 3D
- libAfterimage
- Libart
- Interactive Visualization Framework
- Graphix
- Dislin
- MESA
- LibXML
- SciTech MGL
- ImageMagick
- LibWMF
- Paintlib
- PNG, TIFF, shape, JPEG
- gdLib

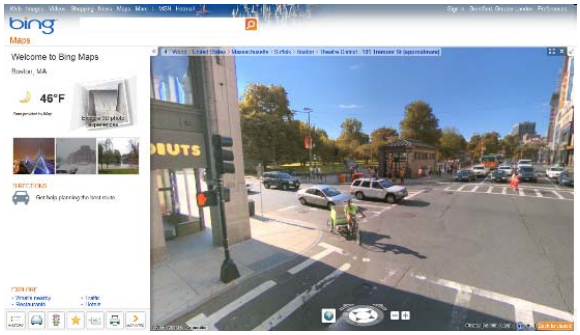
3D in Geobrowsers

- Picture and panorama inclusion
- Google streetview
- GoogleEarth 3D Buildings
- Bing Maps 3D and oblique views
- Microsoft Photosynth
- Most geobrowsers include topography

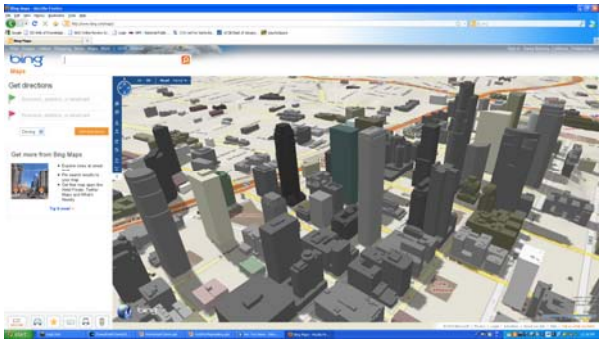
Google Streetview

Streetview navigation

Bing Maps

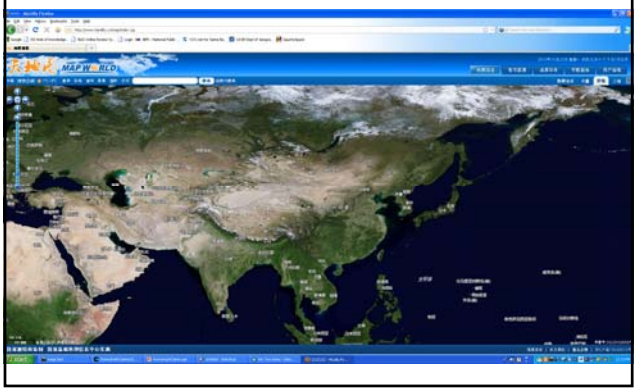


BingMaps 3D Selected Cities (LA)



Everyscape

Map World



Visualization

- Volunteered 3D information and multimedia: participatory sensing
- Visual Analytics
- Visualization of Uncertainty
- Spatialization

Volunteered 3D information and multimedia

- Volunteered Geographic Information
- Use Contributed Content
- Examples: Google MyMaps, Flickr, Panoramio, YouTube, 4Square, Geocaching
- Can be institutionalized: e.g. National Map Corps.
- Data can be mined for content

Tweets during the Japanese Earthquake & Tsunami

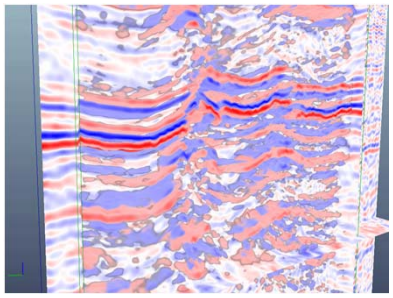
Microsoft Photosynth

- Use of multiple volunteered images to create camera viewing geometry
- Create zoom/pan view in great detail
- Others include PhotoFly (Autodesk) and bundler

Bundler

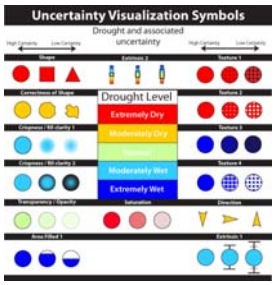
- Structure-from-motion system for unordered image collections (for instance, images from the Internet) written in C and C++. Opensource, UWash+Cornell
- Outdoor game: http://photocitygame.com/
- “Our ultimate goal is to reconstruct the entire world, one photo at a time.”

Visualization of Uncertainty



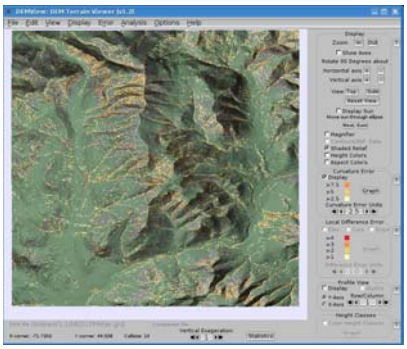
Prof. Dr. Bernd Fröhlich
Visualization of Uncertainty: Visualizing Errors and Uncertainties in Geo-Scientific Data
http://www.uni-weimar.de/cms/medien/vr/research/visualization/scivis/uncvis.html

Uncertainty issues



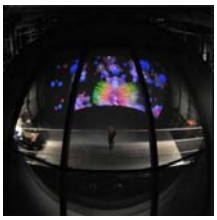
Spatialization

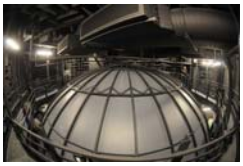
DEMView

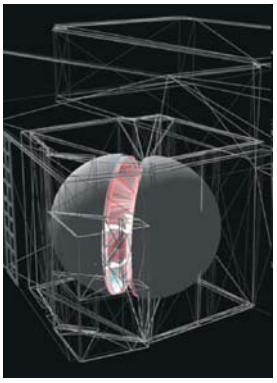


M. B. Gousie. Wheaton College. http://cs.wheatoncollege.edu/~mgousie/research.html#errorviz

Virtual Reality: The Allosphere







A globe inside a globe?

Augmented Reality