3D GIS Techniques
an overview

Ignacio Guerrero Ph. D.

Rolta India Ltd
and
Andes GeoConsulting LLC
Agenda

• Introduction to 3D Models
• 3D Model Creation and Editing
• Storage
• Model Visualization
• Model Exploitation
Model Classification

Small Scale Models
  GIS based Terrain Modeling and Analysis
  Models: Contours, TIN, GRID
  Analysis: Slope, line of sight…
  Fly-through

Medium Scale Models
  City level
  City planning, emergency response…

Large Scale Models
  Building or room level
  Simulations, games…
<table>
<thead>
<tr>
<th>LOD</th>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOD 0</td>
<td>Small Scale</td>
<td>Regional model, 2.5D Digital Terrain Model</td>
</tr>
<tr>
<td>LOD 1</td>
<td>Medium Scale</td>
<td>City/Site model, „block model“ w/o roof structure</td>
</tr>
<tr>
<td>LOD 2</td>
<td>Medium Scale</td>
<td>City/Site model, textured, with roof structures</td>
</tr>
<tr>
<td>LOD 3</td>
<td>Medium Scale</td>
<td>City/Site model, detailed architecture model</td>
</tr>
<tr>
<td>LOD 4</td>
<td>Large Scale</td>
<td>Interior model, „walkable“ architecture model</td>
</tr>
</tbody>
</table>

[aus: Gröger, Kolbe et al.: „Das interoperable 3D-Stadtmodell der SIG 3D der GDI NRW“]
Small Scale Models
Medium Scale Models
Large Scale Models
Scope of this Presentation

- Small scale (L0) models are addressed by conventional GIS Terrain Modeling and Analysis software.
- Large scale models (L4) are generally CAD based or game technology based.
- **The focus in this presentation is on medium scale models (L1, L2, L3).**
High Level Workflow

- Model Creation and Editing

- Model Storage

- Model Visualization and Exploitation
Model Creation and Editing
City Model Creation Workflow

1. Obtain landbase (2D) including building footprints from traditional GIS

2. Building extrusion
   - Height using photogrammetry (aerial or satellite) or LIDAR (Digital Surface Model – DSM)
   - Rooftop modeling using Constructive Solid Geometry (CSG) primitives

3. Texturing from oblique or terrestrial images
Roof top modeling using Photogrammetry

- Photogrammetry is used to capture a coded set of points. Codes are assigned to points based on building topology.
- Special algorithms generate 3D building geometry.
- Special editing commands are used to adjust results.
Coded points

\[ P_1, \ldots, P_{10} : \text{Boundary points (BP)} \]

\[ P_{11}, \ldots, P_{13} : \text{Interior points (IP)} \]
Building rectification
Constructive Solid Geometry (CSG)
LiDAR (Light Detection and Ranging)
DTM and DSM
LIDAR DSM and DTM

DSM (left) and DTM (right)
Classify buildings (=hits on roofs)
Run automatic building vectorization
Texturing
Software

• Highly fragmented market with no leading commercial offerings
• Non-integrated workflows requiring software from several vendors
• Content providers often used internal software with limited commercialization (Pictometry, CyberCity LLC, CAD Center Corporation…)}
Google

Google has a workflow where individual buildings are modeled and uploaded for visualization in Google Earth

Tools

1. Google Building Maker
   - Simple entry level online tool

2. Google Sketchup
   - Building footprints are captured from Google Earth and saved locally
   - Google Sketchup is used to draft the model
   - Texture is prepared using Google Picasa or Photoshop
   - Texture is added to the model in Sketchup

Models are uploaded for visualization in Google Earth
Pictometry
Storage
Standard Formats

VRML and GeoVRML
- VRML Consortium (now the Web3D Consortium)
- Older format (1994) but still widely used
- GeoVRML (geographic data extensions)

X3D
- Web3D Consortium
- Successor of VRML
- ISO standards

U3D
- 3D Industry Forum and ECMA International
- Supported by Adobe PDF

Collada
- Created by Sony for games. Now under the Khronos Group
- Supported by Autodesk Maya and Autodesk 3ds Max
- Supported by Google Sketchup
Standard Formats 2

Openflight
- Industry standard real-time 3D scene description format
- Developed by Multigen-Paradigm (now Presagis)

Industry Foundation Classes (IFC)
- From International Alliance for Interoperability (IAI)
- Highly detailed building model data
- AEC oriented. Limited georeferencing

CityGML
- New format created by OGC. Still not widely adopted
- Design for 3D urban objects
- It goes beyond geometry using a robust application schema
Oracle 11g

- Provides native support for 3D data
  - 3D Types for points/lines/polygons/solids
  - 3D Coordinate systems
  - Follows GML3, ISO 19107 Specifications
  - Supports storage of textures
- Support 3D queries (visibility, volumetric analysis…)
- Building extrusion
Abaco visualization, data in Oracle 11g
Model Visualization
General Characteristics

- Standalone 3D visualization has become a commodity with literally dozens of software programs available.
- Programs that fully integrate GIS data sources are less common.
  - ESRI ArcGIS 3D Analyst
  - Intergraph GeoMedia 3D
  - Skyline Terra Explorer
ArcGIS 3D Analyst
Sketchup works with ArcGIS

- Export Feature Classes from ArcMap to Sketchup. Option to extrude buildings using height database attribute
- Export Images to Sketchup
- Export to ArcGIS as a personal database (.mdb)
- View in ArcGIS 3D Analyst
Intergraph GeoMedia 3D

GeoData Warehouses

OGC Compliant Web Services

GeoMedia Data Connections

Pre-built city models

Surfaces

GeoMedia 3D

Intelligent Infrastructure for a Sustainable Future
Model Exploitation
Brisbane Flood Simulation (AAM Group)
City of Portland 3D Land Use Model
Existing and Proposed Buildings (St. Mary’s U.)
Tsunami waves threat (CyberCity)
Shadow Analysis  (ArcGIS)
Summary

3D City Modeling is a very active area that leverages on Photogrammetry and LIDAR technologies.

These technologies are complemented with design software with roots in graphics arts and design.

Integration of 3D models and GIS is still an emerging field.

Google has fueled significant interest with the introductions of excellent free tools and integration with Google Earth.

Many traditional and new applications can rely on 3D models.