3D GIS and Applications

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Need and Motivation behind 3D City Models

- A 3D city model is a representation of an urban environment with a three-dimensional geometry of common urban objects and structures, with buildings as the most prominent feature.
- 3D City Models may be applied in a multitude of application domains for environmental simulation and decision support.

3D Data Models are of 2 types:

- **Geometrical Models**: defines the geometric objects and elements types. They consist of different spatial objects (points, linestrings, etc.) with the representation of their properties.
  
  *e.g.* COLLADA, VRML, X3D, etc.

- **Semantic Models**: defines entities and their non-spatial characteristics and relationships among the entities.
  
  *e.g.* CityGML, IFC, gbXML, etc.
Main 3D data types to used in 3D data models:

- 3D objects are represented by its boundaries (B-Rep),
- 3D objects are represented by voxel elements,
- 3D objects are represented by a combination of the 3D basic block (CSG).

![Surface based representation.](image1)
![Solid based representation.](image2)

### General Taxonomy of 3D Use Case

<table>
<thead>
<tr>
<th>Category</th>
<th>3D Analysis</th>
<th>Application</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Applications based on Geometry</td>
<td>Estimation of the shadow</td>
<td>![Image1]</td>
</tr>
<tr>
<td>2.</td>
<td>Analysis based only on geometry and semantic information</td>
<td>Estimation of the solar potential</td>
<td>![Image2]</td>
</tr>
<tr>
<td>3.</td>
<td>Analysis based on domain specific extension and external data</td>
<td>Noise emission calculation</td>
<td>![Image3]</td>
</tr>
</tbody>
</table>

*But categories are not mutually exclusive in all cases*
Features:

- Open data model.
- XML-based format.
- Used for storing and exchanging virtual 3D objects and city models among applications.
- Has both Geometrical & Semantic model of information.
- Implemented as an application schema for the Geography Markup Language 3 (GML3).
- Supports Multi-Scale Modeling according to the details level required in different applications.

Multi-scale modeling of IIRS Campus & Gymnasium

- LOD-0: A 2D footprint.
- LOD-1: Block Model of Building.
- LOD-2: Adds differentiated roof structure and thematically differentiated surfaces.
- LOD-3: Architectural model with detailed wall and roof structure.
- LOD-4: Adds interior structures for 3D objects like rooms, interior doors & stairs, etc.
3D Acquisition Techniques

High resolution satellite data

Space/Airborne LiDAR, Cartosat Stereo, VGI

Airborne LiDAR, Close - Range Photogrammetry, VGI

Terrestrial Laser Scanning, VGI

Terrestrial Laser Scanning, Procedural Modeling, VGI, Close range photogrammetry

CityGML : Building Module (LoD3) Illustration

Illustration of LoD3 building: spatial representation (left) and CityGML feature structure as UML instance diagram (right)
CityGML (Spatial-Semantic Coherence) vs KML

CityGML: (Up to) Complex objects with structured geometry

KML: No semantics, only (unstructured) geometry

IIRS Initiatives
3D GIS - CityGML based Interoperability

- Study of 3D data models viz. Collada (*.dae), gbXML, IFC and OGC based CityGML
- Mapping of base elements for storage and exchange of virtual 3D City models
- Improving 3D models with Geometry & Semantics in a single model considering all Level of Detail Modelling (LOD-0 to LOD-4)
- Surface model (BRep) for 3D representations.


3D City Modeling for harnessing solar energy to develop solar cities

- To estimate effective percentage of roof/wall/window of a building contribute to harness solar energy
- To simulate solar heat potentials of buildings on monthly/daily or hourly basis considering sun-earth geometry

Stage 1
- 3D Building Model Generation
  - Building footprints captured from Cartosat-1
  - 3D model of LoD 3 created using sketch-up/ CityEngine
  - Conversion of sketch-up to Collada model (*.dae)

Stage 2
- Semantic Dissection of 3D Model
  - Transformation of Collada model to CityGML using Feature Manipulation Engine (FME)
  - Loading CityGML to PostgreSQL/ PostGIS and storing semantic information into RDBMS for semantic queries

Stage 3
- Simulating Sun Illumination for Solar Energy Estimation
  - Conversion of CityGML to (green building) gbXML
  - Enrichment of semantic information with additional energy simulation class attributes
  - Simulation of building information model (BIM) into solar energy estimation using Sun-Earth geometry


Traffic Noise Modelling using 3D GIS for Smart City Planning

Stage 1 - Field Data Collection
Collection of Traffic Data and Noise Level Samples
Traffic Noise Analysis using Empirical Relationship

Stage 2 - 3D Model Generation
LoD0 (Level of Detail) Model Reconstruction (Satellite Image Processing)
LoD2 Model Reconstruction (Terrestrial Laser Scanner)

Stage 3 - 3D GIS analysis & Visualisation
Storage (PostGIS, 3D City DB) & conversion to CityGML for Semantic analysis and integration
Spatial query at semantic level, rendering & visualisation

Laeq = 37.36 + 9.839 log(10^Q) + 3.1 Ptw + 0.7 Pthw + 1.1 Pfw + 6.1 Phw

Time: 05:00 Hrs
Noise Level: 55 dB(A)


3D GIS - Indoor Logistics

Indoor mapping: This includes accurate floor plan mapping and 3D visualization.
Indoor positioning: This includes mapping points of interest and static content.
Indoor locating: This includes locating mobile devices and other dynamic content.
Indoor routing & analysis: This includes indoor routing and the management of business processes with GIS analysis tools.
Indoor asset tracking: This includes tracking mobile assets for dispatching and other operational efficiency purposes.
3D GIS - Indoor Mapping, Routing & Navigation

3D Citymodel of IIRS Campus

3D Indoor, Outdoor and Subsurface Mapping & Navigation

3D Network based Routing

3D Routing Navigation

3D Indoor Routing of IIRS Campus

3D Models of buildings created in SketchUp and imported as Collada Model into ArcScene.

3D Network dataset created in ArcScene, including pathways and staircases, inside and outside the buildings.

Points Chosen as starting and end points.
Routing model designed in Model Builder of ArcScene.
Optimal Route shown by the Network Analyst.

Optimal Route

Start Point
End Point

Route between two rooms in two buildings
THANK YOU

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