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3D Cadastres Best Practices, Chapter 4: 3D Spatial DBMS for 3D Cadastres

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Chapter 4: 3D Spatial DBMS for 3D Cadastres

- **3D Spatial database management systems** (DBMS) should enable:
  - data models that handle a large variety of 3D objects,
  - perform automated data quality checks,
  - search and analysis,
  - rapid data dissemination,
  - 3D rendering and visualization with close linkages to standards.

Chapter 4: **3D Spatial DBMS for 3D Cadastres**

- **Addressed topics**:
  - the different types of 3D spatial representations (vector, voxel and point cloud),
  - 3D spatial indexing and clustering,
  - 3D geometries and 3D operations,
  - 3D topology structures,
  - the road from theory to practice,
  - state-of-the art in spatial databases, and
  - what is available and what is needed?

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- 3D spatial representations: **vector**
  - ISO 19107 Geographic information – Spatial schema
  - ISO 19125 Geographic information – Simple feature access
    - Part 1: Common architecture
    - Part 2: SQL option
  - Well supported (Oracle Spatial, PostGIS, …)

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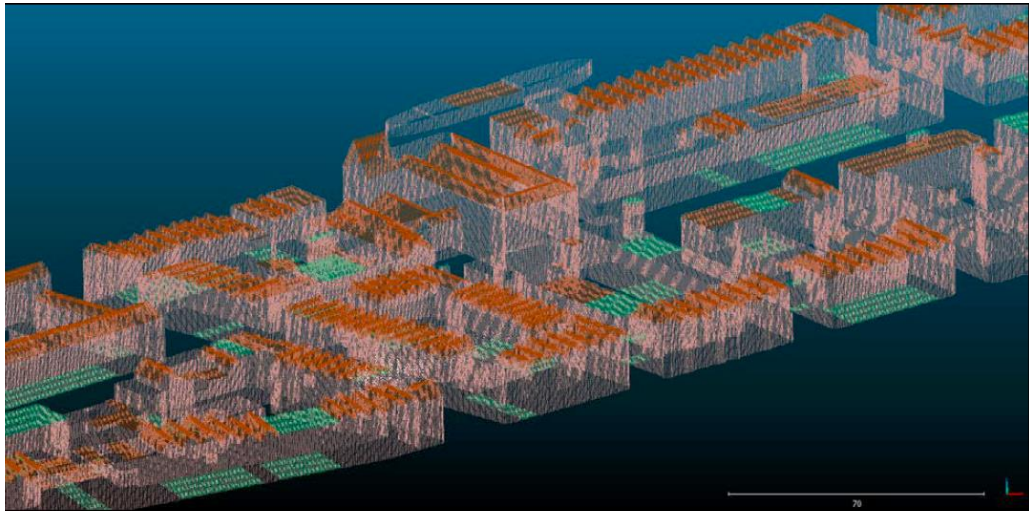
- 3D spatial representations: **voxel** (a volumetric pixel)
  - Better representation of the various levels of detail (LOD)
  - Challenges: Storage a efficient handling
  - RasDaMan, MonetDB
  - GRASS GIS



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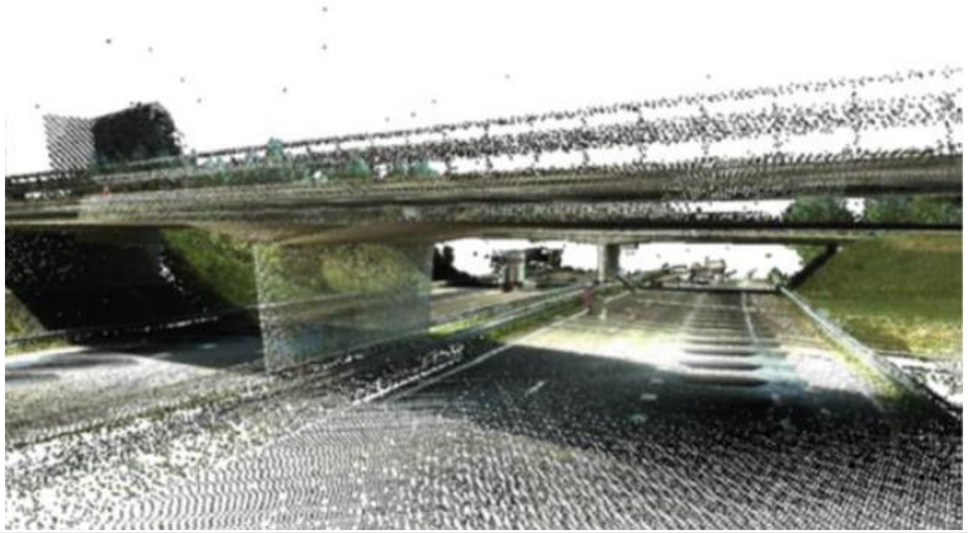
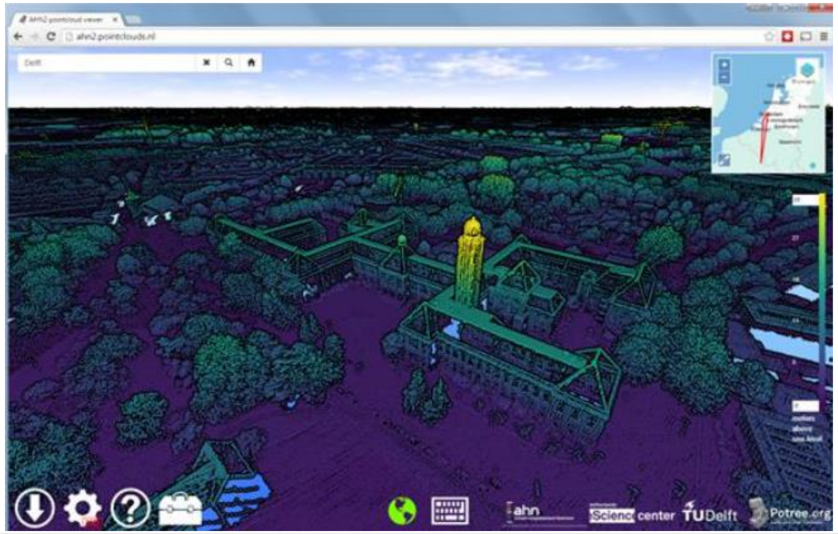
- 3D spatial representations: **point clouds**
  - 3D reference and input for the creation of 3D parcels
  - Native point cloud support: Oracle Spatial, PostGIS





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- **The point cloud data type** and **its operators** should cover:
  - Attributes per point
  - Efficient storage with compression techniques
  - Data pyramid support
  - Temporal aspects
  - Operations/functionalities (loading, selections, simple analysis, conversions, towards reconstruction, complex analysis, LoD use/access, updates)

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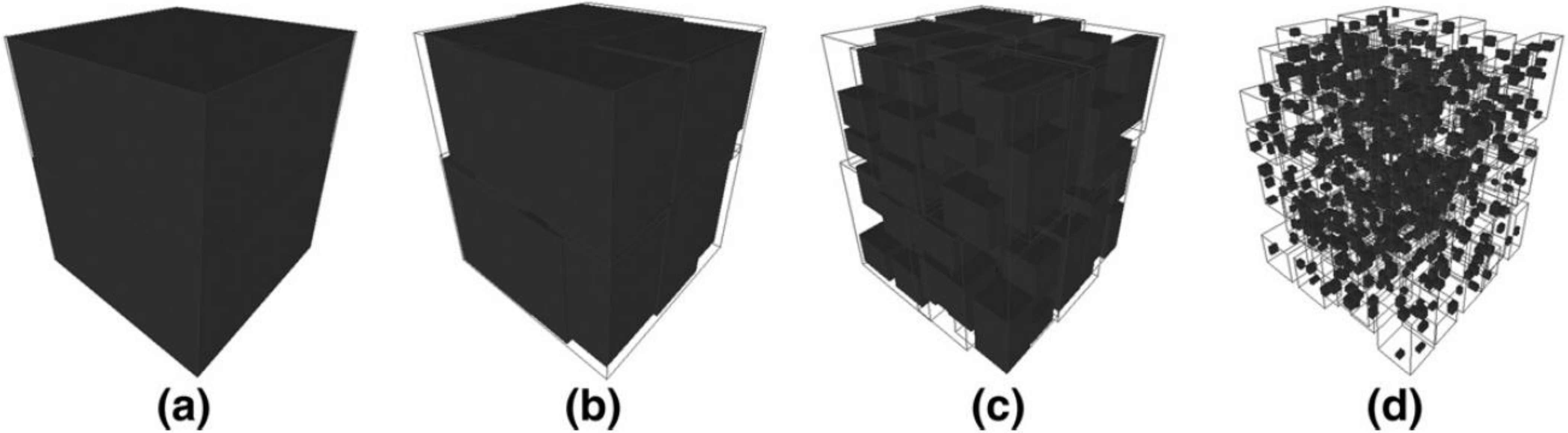
- 3D spatial indexing: **3D R-Tree**



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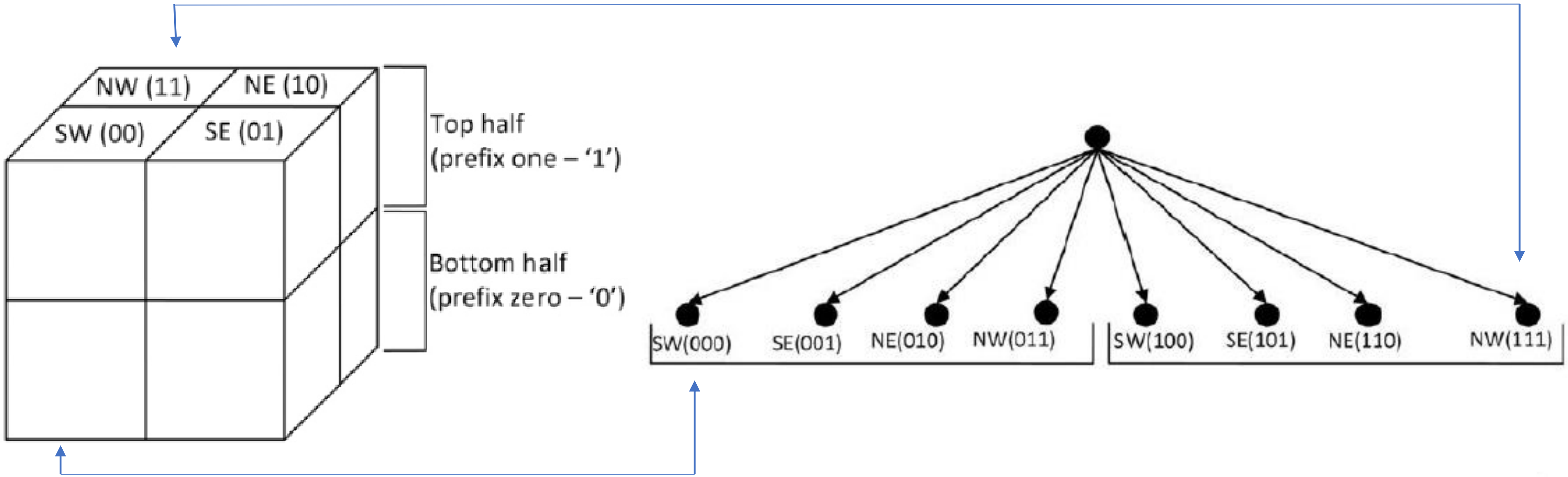
- 3D spatial indexing: **Octree**



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- **3D operations**
  1. Basic methods on geometric objects
     - Dimension ( ); GeometryType ( ); SRID ( ); Is3D ( ); …
  2. Methods for testing spatial relations between geometric objects
     - Intersects (anotherGeometry: Geometry); Touches (anotherGeometry: Geometry); …
  3. Methods that support spatial analysis
     - Intersection (anotherGeometry: Geometry): Geometry; …

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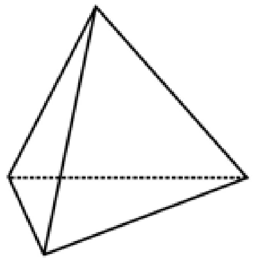
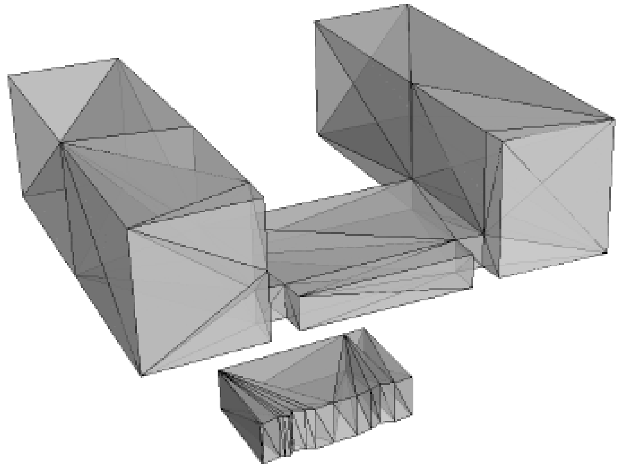
- **3D Topology**
  - 3D topology is not natively supported in Spatial DBMSs.
  - A solution based on Tetrahedral Network (TEN) is promising.





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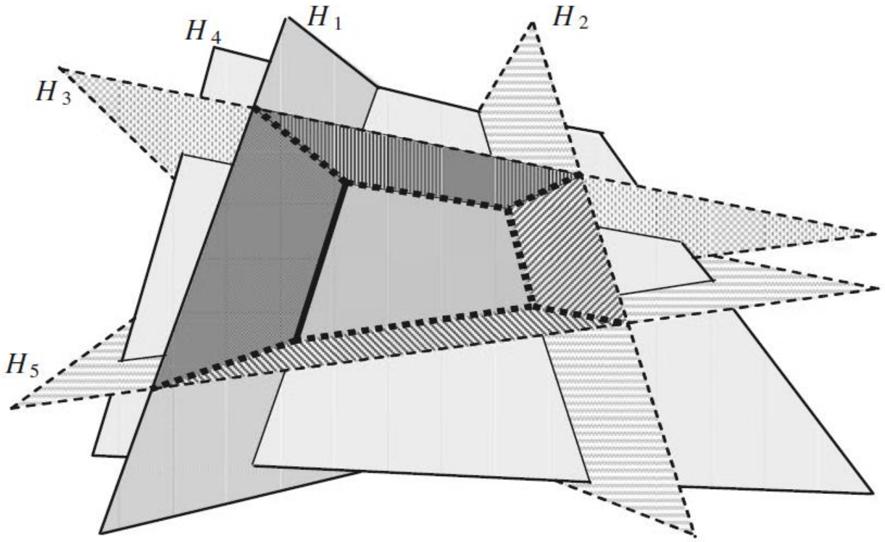
- Further Research: **Modelling and database storage of 3D parcels**
  - Freeform shapes (NURBS) and partially open solids



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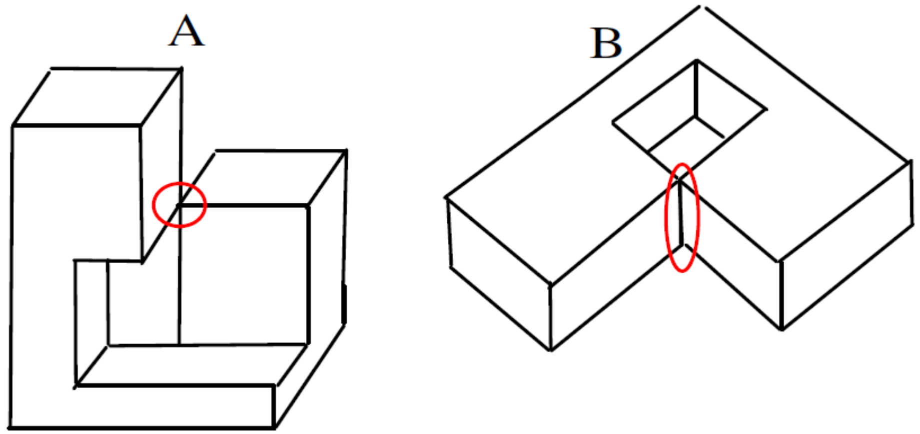
- Further Research: **Validation of 3D solids**
  - ISO/OGC x Software vendors definition
  - Using semantics information
  - The automatic repair of invalid solids could be considered



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- Further Research: **3D Spatial Constraints**
  - Spatial constraint: ‘a road cannot cross a building’
  - Extend Object Constraint Language (OCL) code generation tools to enable automatic model translation from OCL (esp. spatial constraints) to SQL
  - Corresponding functions in Spatial DBMS need to be developed.

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- Further Research: **3D Topology**
  - A full topological model for the 3D cadastre is needed:
    1. to utilize the surveying boundaries to generate the 3D cadastral objects;
    2. to represent the 3D volumetric objects with high quality, and consistent topology without intersection; and
    3. for rapid topological queries necessary for real-time user interaction and management
  - The data structure should consider ISO 19152 LADM.

Thank you very much for your attention!

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Key words: 3D Spatial Database Management System, 3D Cadastre, 3D Representation, 3D Spatial Indexing and Analysis

SUMMARY

Subdivision of land parcels in the vertical space has made it necessary for cadastral jurisdictions to manage cadastral objects both in 2D as well as 3D. Modern sensor and hardware capabilities for capture and utilisation of large point clouds is one of the major drivers to consider Spatial Database Management Systems (SDBMS) in 3D and organisations are still progressing towards it. 3D data models and their topological relationships are two of the important parts of 3D spatial data management. 3D spatial systems should enable data models that handle a large variety of 3D objects, perform automated data quality checks, search and analysis, rapid data dissemination, 3D rendering and visualisation with close linkages to standards. This chapter asserts that while there has been work done in defining 2D and 3D vector geometry in standards, it is still not sufficient for 3D cadastre purposes as 3D cadastral objects have a much more rigorous definition. The Land Administration Domain Model (LADM), which is an ISO Standard, addresses many of the issues in 3D representation and storage of 3D data in a database management system (DBMS). The chapter further discusses the various approaches to storing 3D data such as through voxels, or point cloud data type and elaborates on the characteristics of a 3D DBMS capable of storing 3D data. Approaches for spatial indexing to improve the fast access of data and the various available options for a 3D geographical database system are presented. Several spatial operations on and amongst 3D objects are illustrated with linkages to the current standards including the LADM. Next, construction of 3D topological and geometrical models based on standards and including their characteristics is discussed. Current 3D spatial database managements systems and their characteristics, including some comparison between selected DBMS including the hardware capabilities are elaborated in detail. Finally, the chapter proposes a 3D topology model based on Tetrahedron Network (TEN) synchronised with LADM specifications for 3D cadastral registration. This topological model utilises surveying boundaries to generate 3D cadastral objects with consistent topology and rapid query and management capabilities. The definition for validation of 3D solids also considers the automatic repair of invalid solids. Point cloud and TEN related data structures available in SDBMSs are also investigated to enable storage of non-spatial attributes so that database updates would store all spatial and attribute information directly inside the spatial database.