Boundary representation, surfaces and meshes

GEO1004:
3D modelling of the built environment

https://3d.bk.tudelft.nl/courses/geo1004

3D geoinformation
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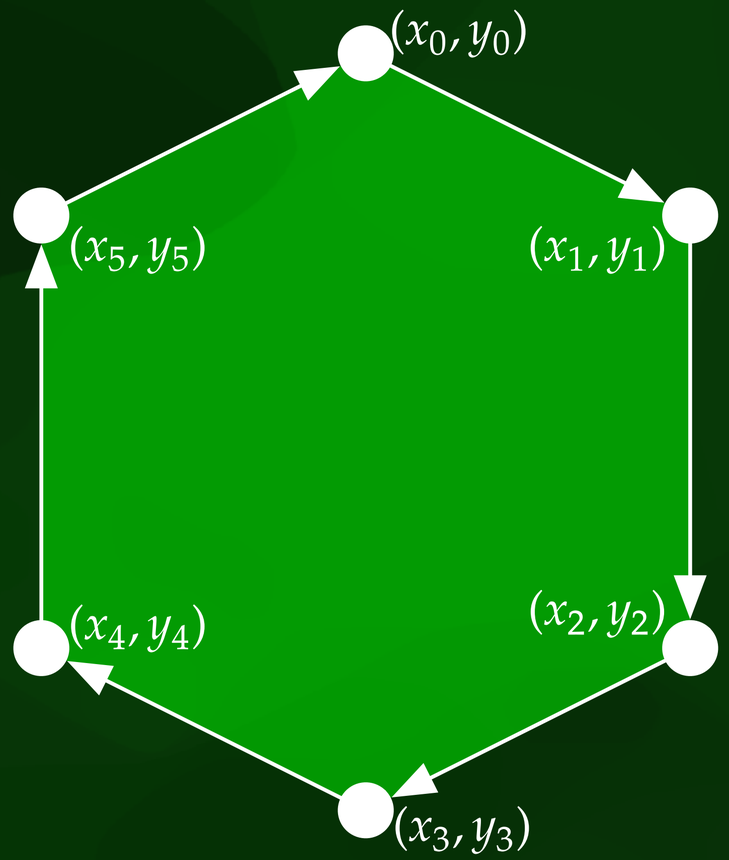
What is boundary representation?

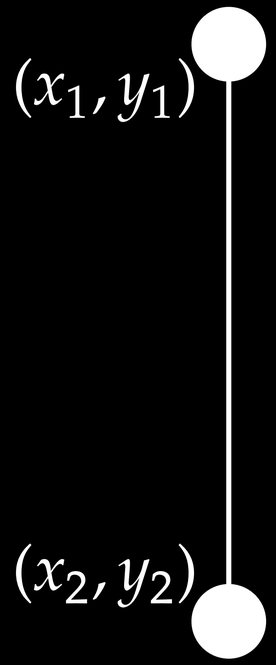
- Also known as b-rep or surface modelling
- Representing an n-dimensional object through its $(n - 1)$-dimensional boundary
- Most of the time: a 3D object through its 2D boundary

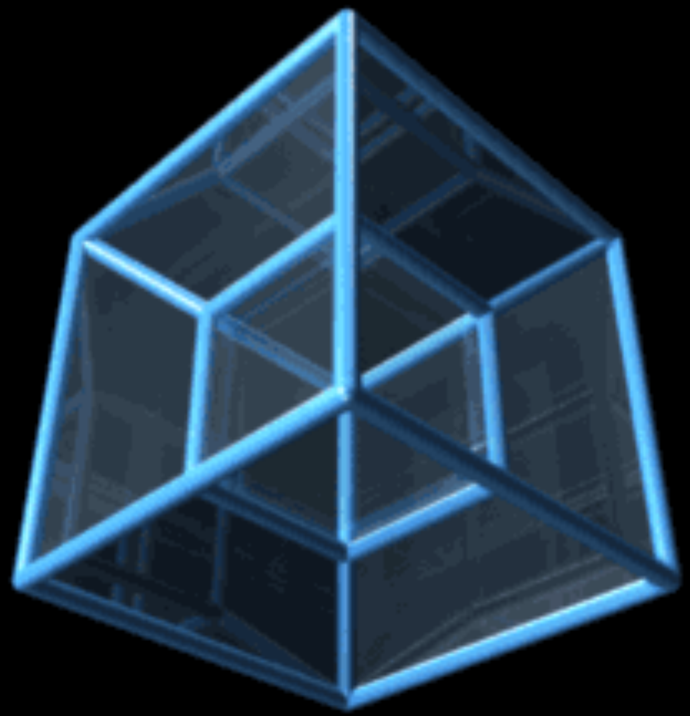
Why do it?

- Data structures for 2D are easier than data structures for 3D
  - Representing 2D polygons: as simple as a list of (x, y) vertices
  - Implicit assumption: there's a connection between each consecutive vertex and between the last and first



In any dimension





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Why does it work?

- In 2D, the Jordan curve theorem says: a closed curve separates the plane into two parts: an interior surface and an exterior surface
- In nD, the Jordan-Brouwer theorem, which in 3D says: a closed surface separates 3D space into two parts: an interior volume and an exterior volume.

b-rep in the 3D context

- store 3D objects by storing their 2D boundary
- … which can be split into a set of **surfaces** (usually triangles or polygons)
- … which can be represented using a (2D) **mesh**, i.e. a repetitive arrangement of simpler elements

- not the same as a 3D mesh (e.g. TEN)

Storing a 2D mesh

- Three basic approaches:
  - Triangle-based structures
  - Edge-based structures
  - Incidence graphs

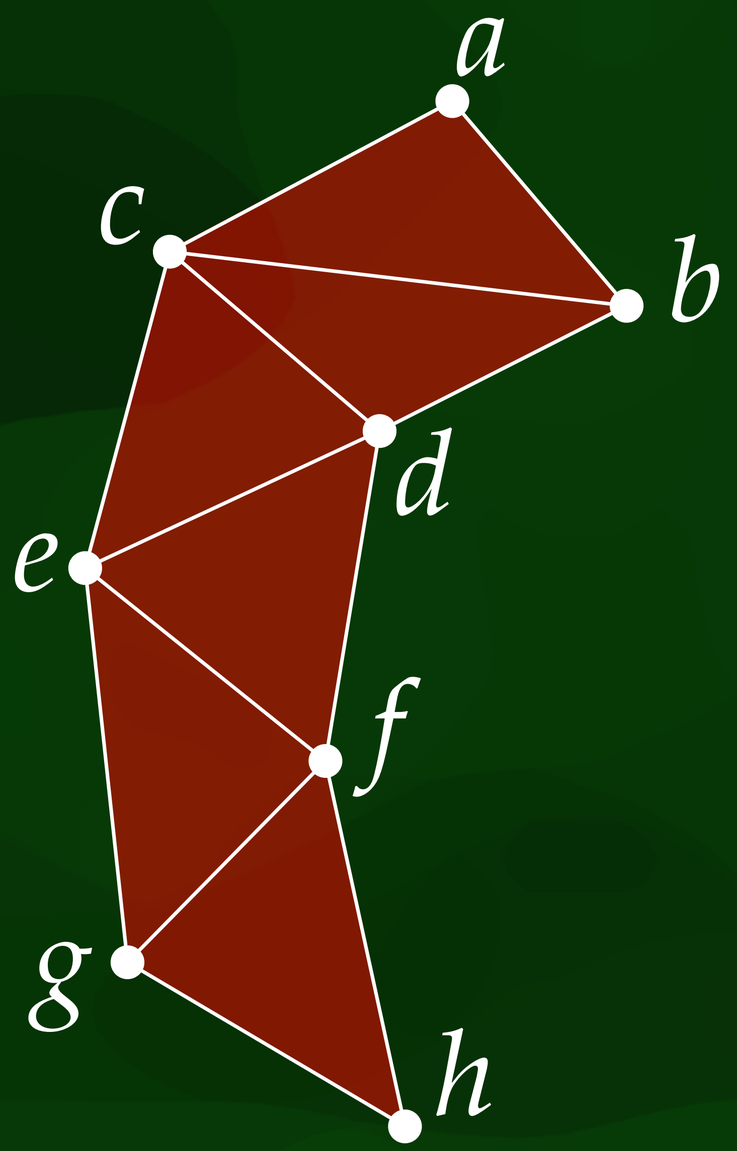
Triangle-based structures

Example from CGAL

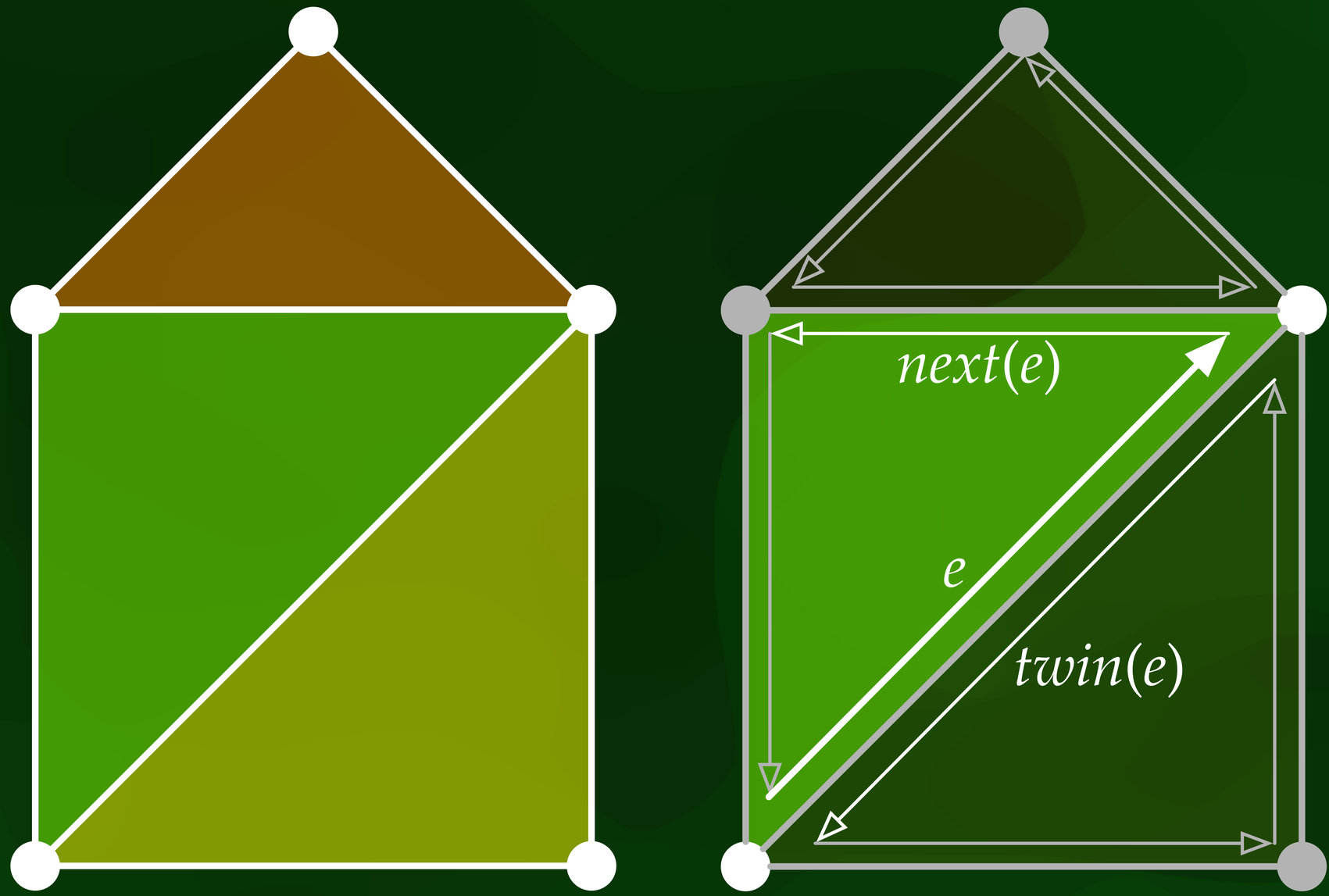
https://doc.cgal.org/latest/TDS_2/index.html

Simple compression

- Triangle strips
- Triangle fans
- Triangle stars
- …



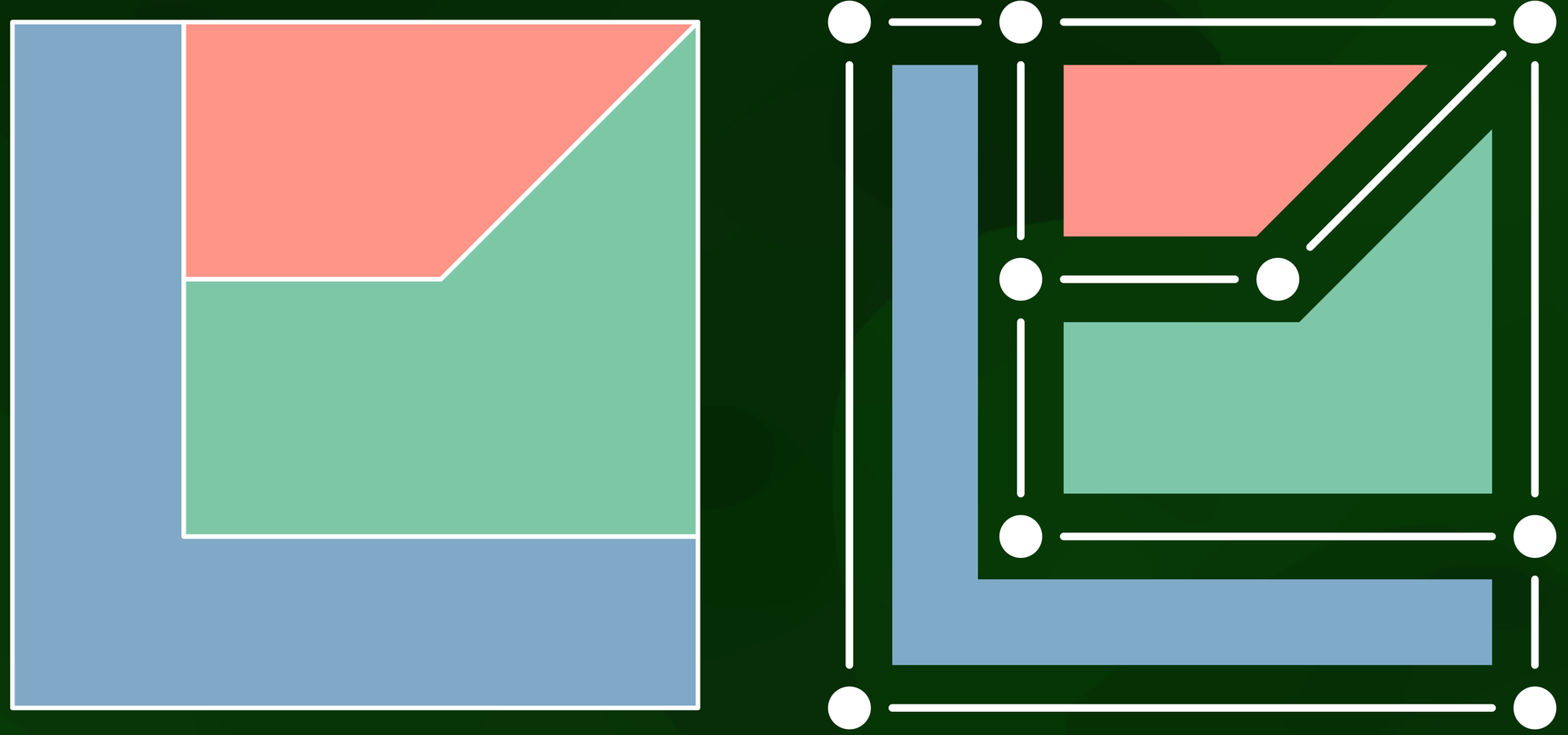
Edge-based structures



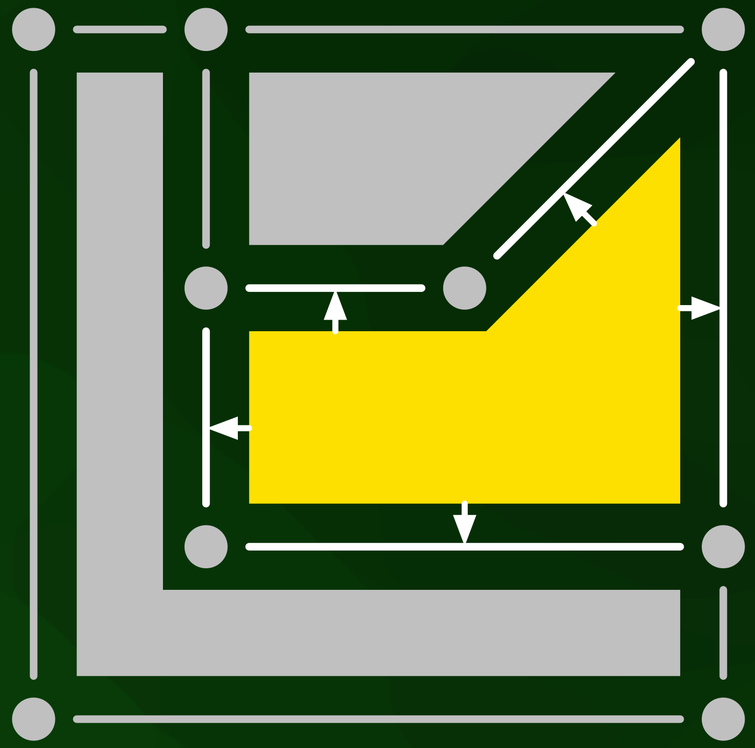
Example from CGAL

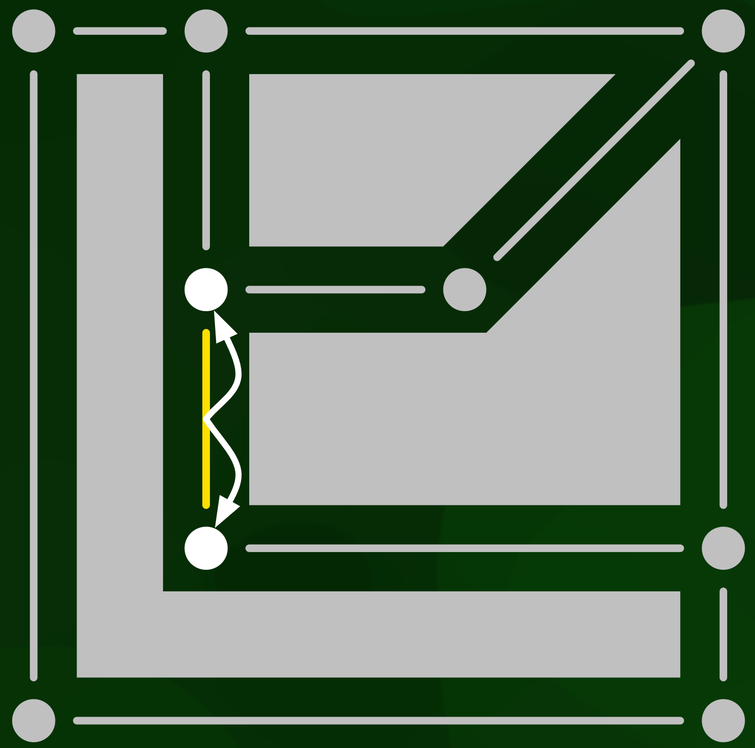
https://doc.cgal.org/latest/HalfedgeDS/index.html

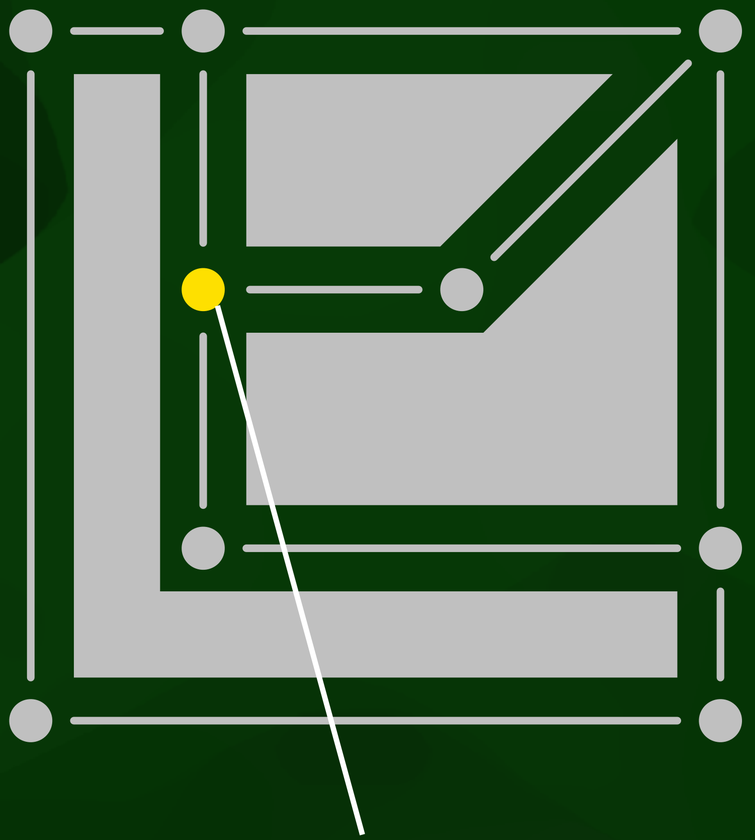
Incidence graphs



Incidence graphs



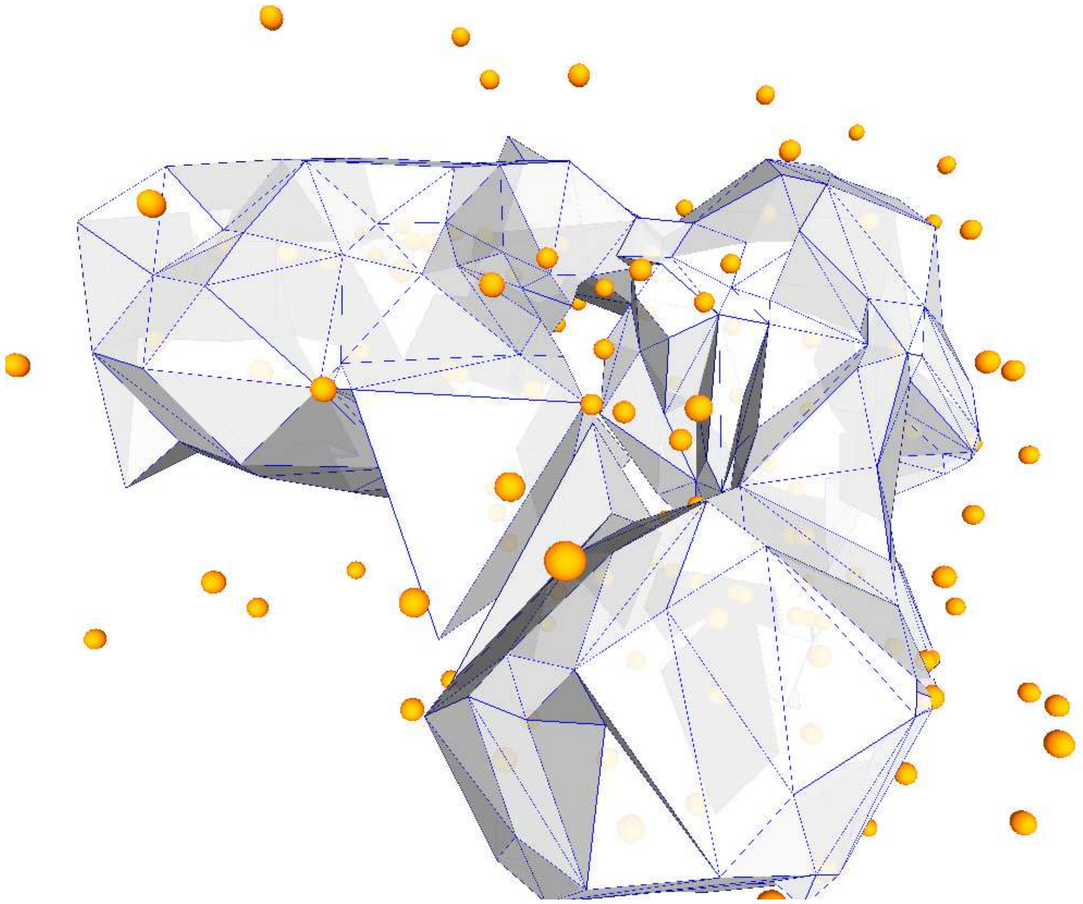


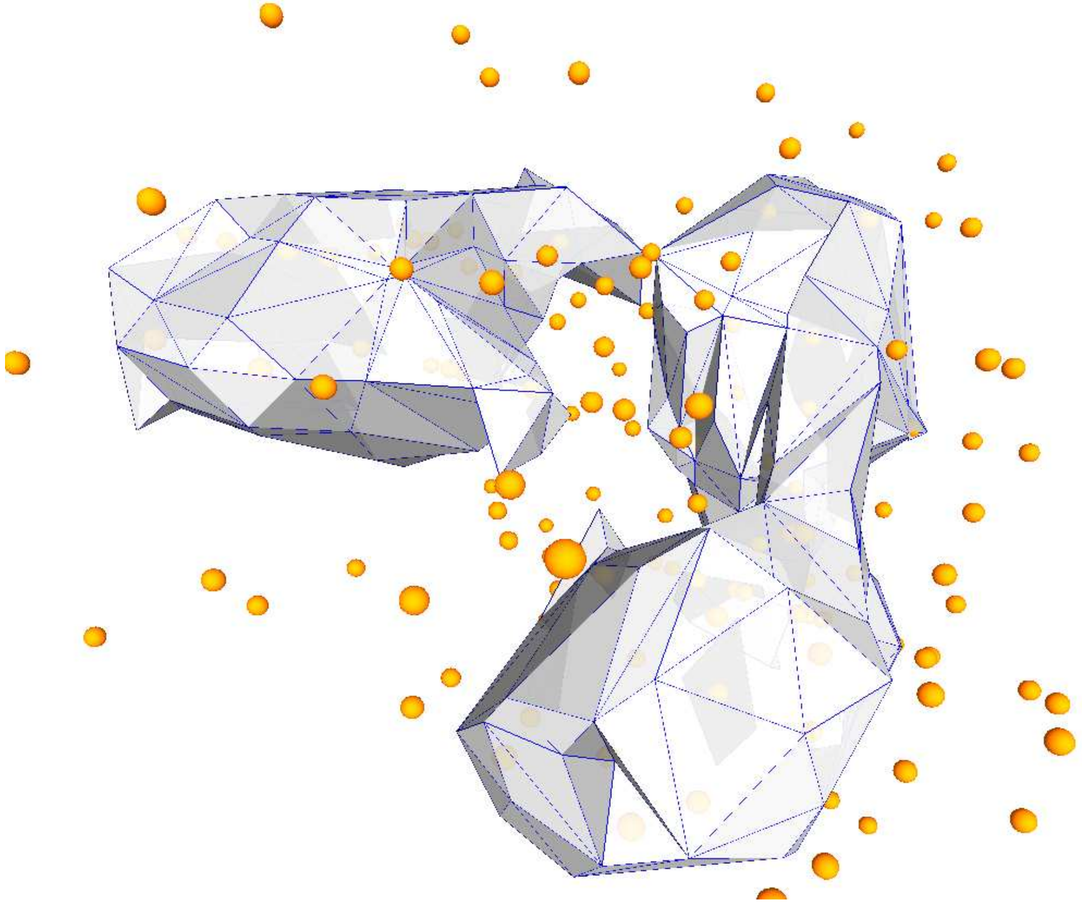


$(x_0, x_1, \ldots)$

B-rep in fields: isosurfaces

- Not boundary of object -> boundary of level set





What to do next?

1. Today:
    - Continue with Homework 0 (install required software for C++ assignments)
    - Go to geo1004 website and study today's lesson (3D book Chapter 2)
    - If you have extra time:
        - Get started with Homework 1
        - Study Monday's lesson (3D book Chapter 4)
2. Monday: short lecture/demo on voxels and help with lessons, Hw 0 or Hw 1

Homework 1 intro

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