Manipulating higher dimensional spatial information

Ken Arroyo Ohori
Filip Biljecki
Jantien Stoter
Hugo Ledoux

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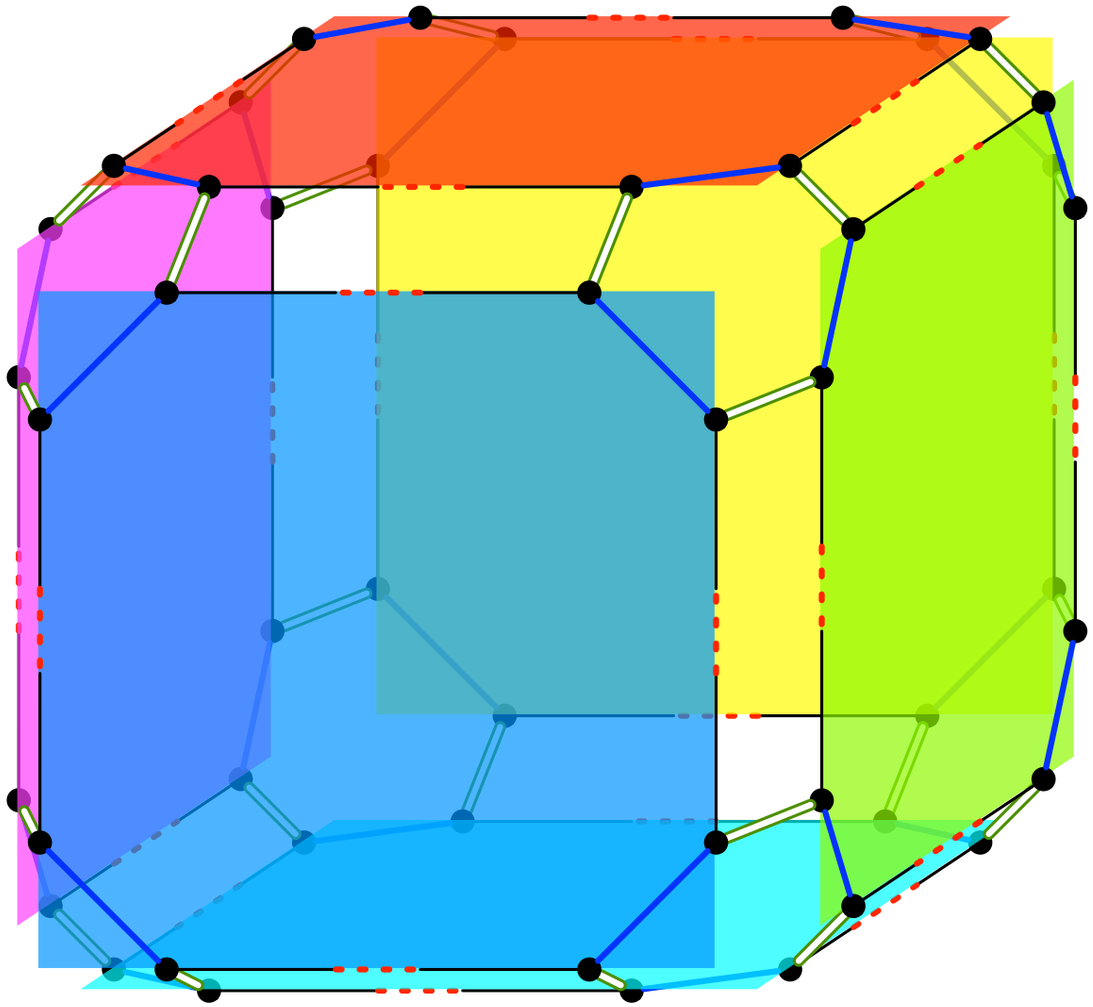
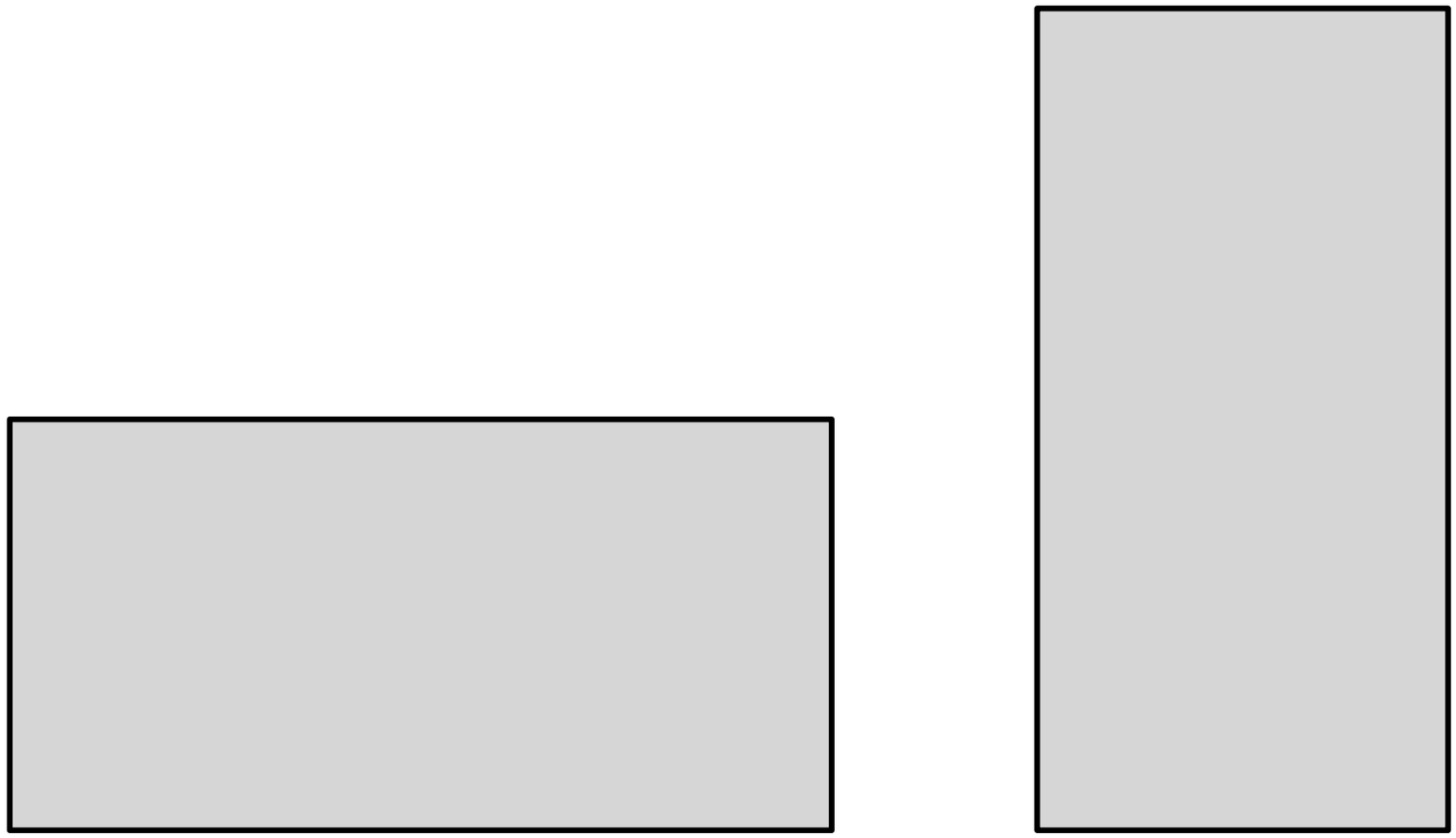
TU Delft
Delft University of Technology

What do we mean?

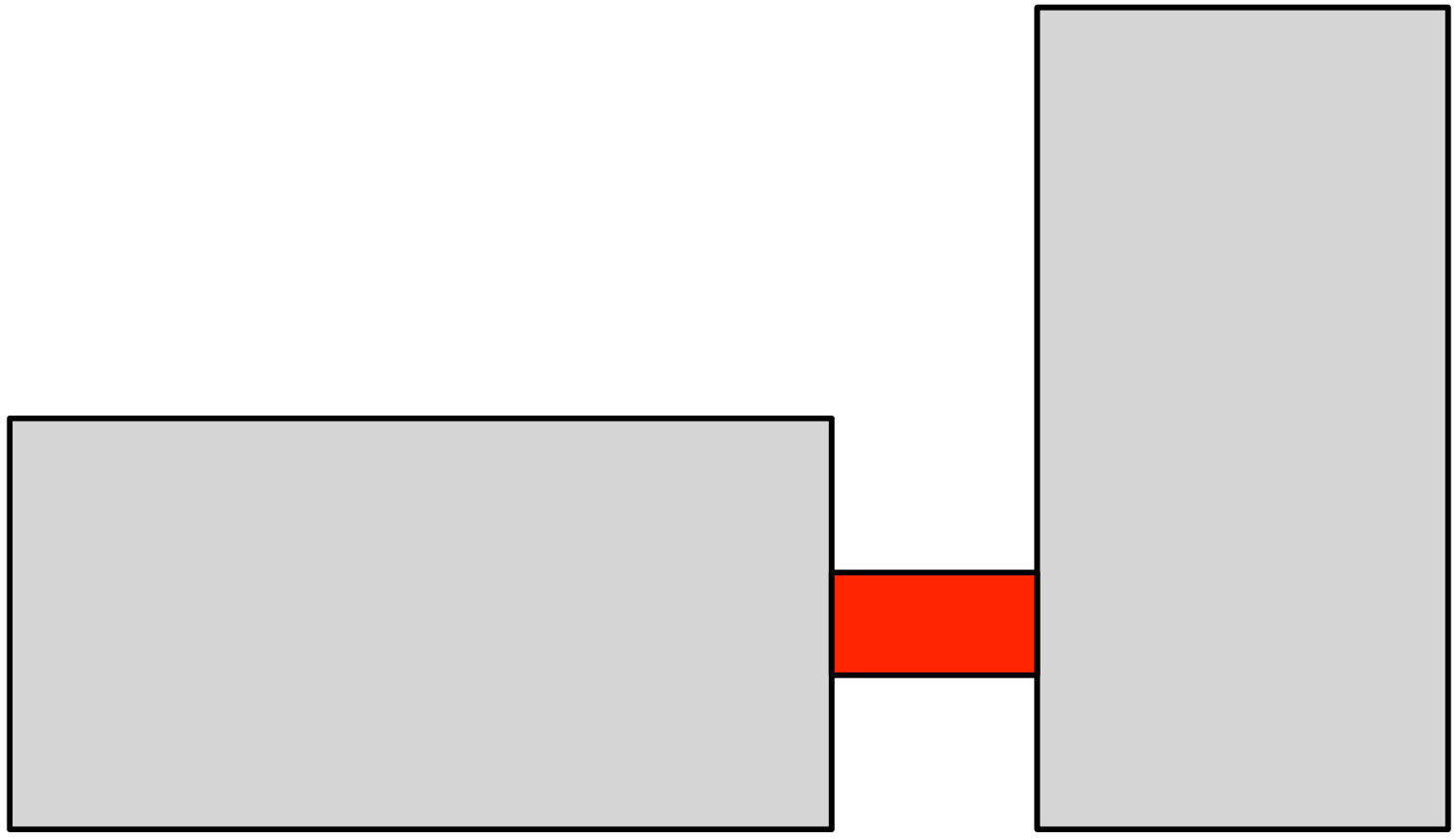
- Manipulation (creation, analysis, 2D/3D output)
- Higher-dimensional (> 3D)
- Information (structured objects)
- Geometry + topology

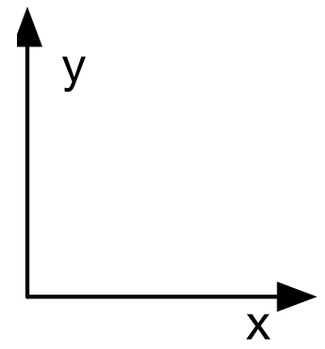




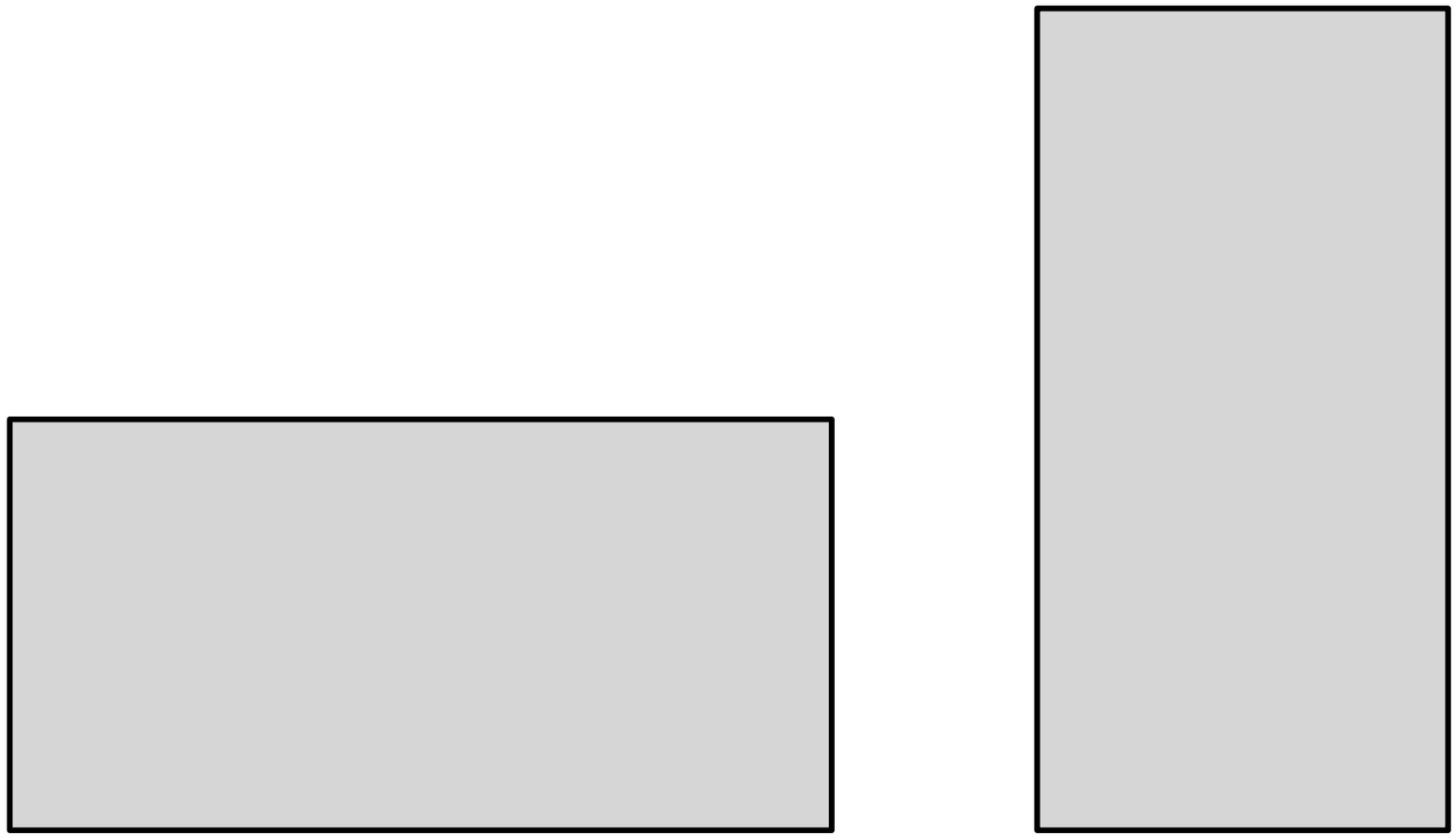
Examples

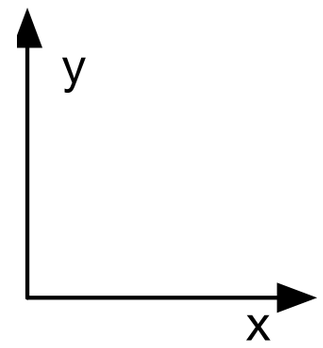
2D



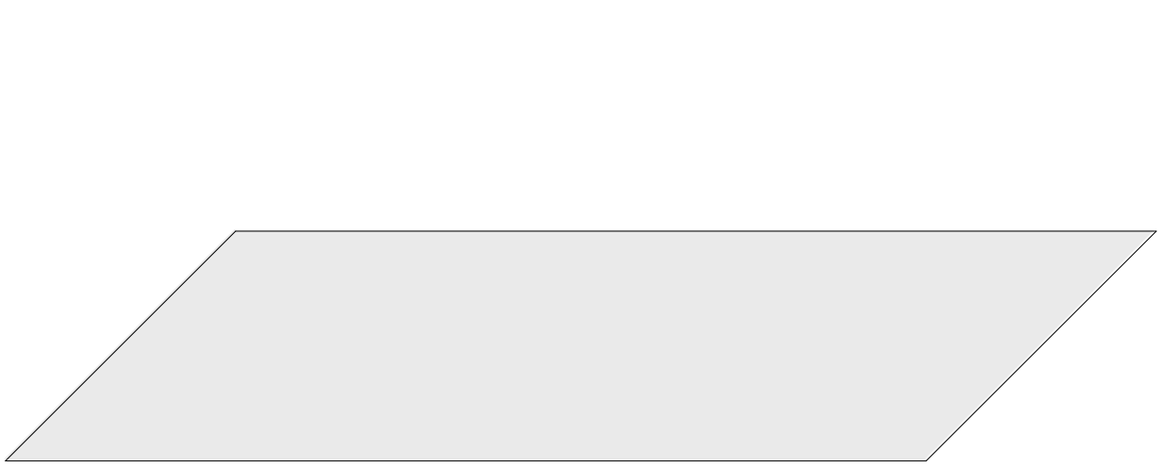


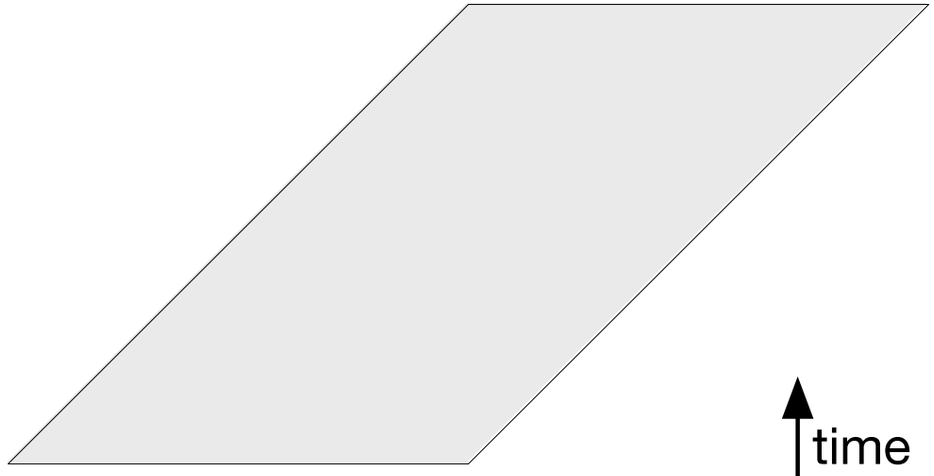
Examples | 2D

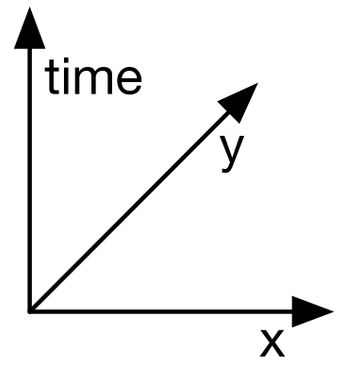




Examples | 2D

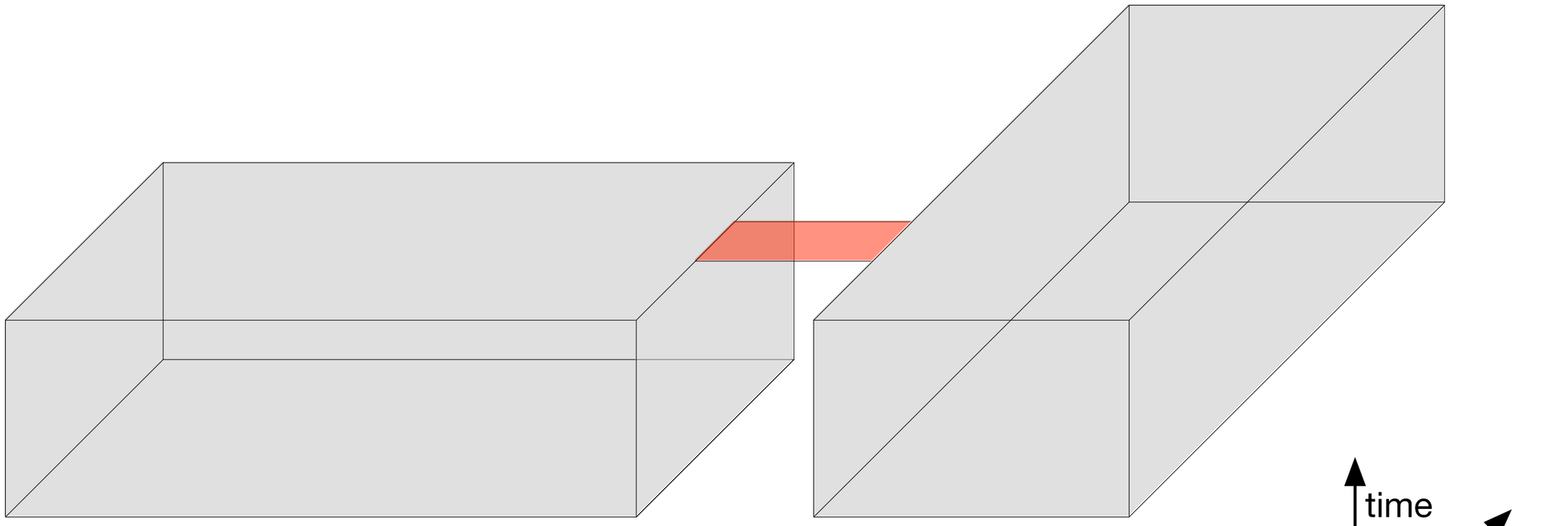






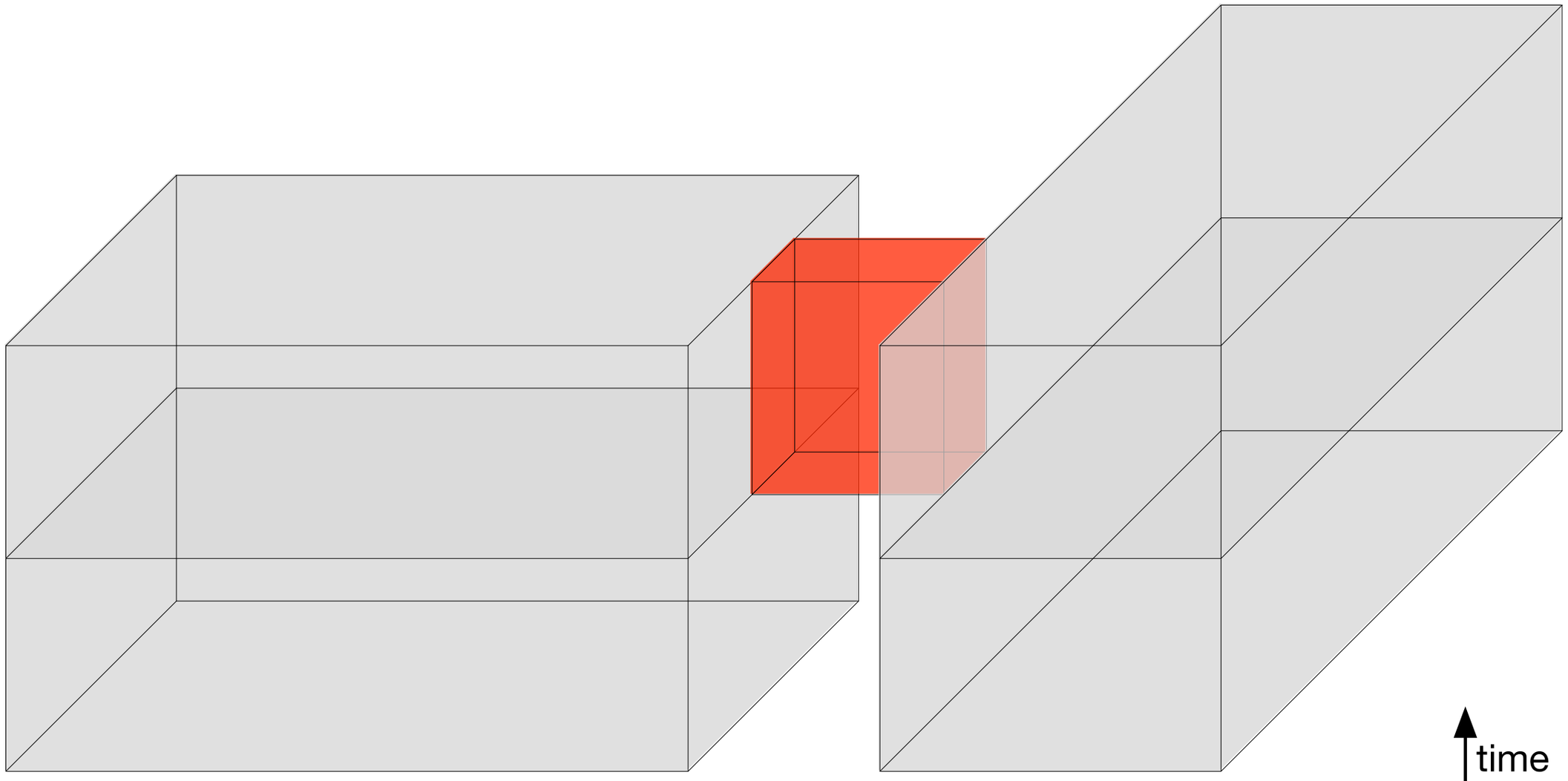
Examples

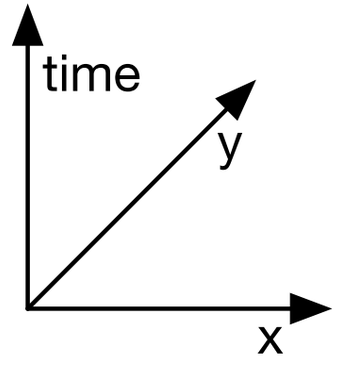
Move to 3D



Examples

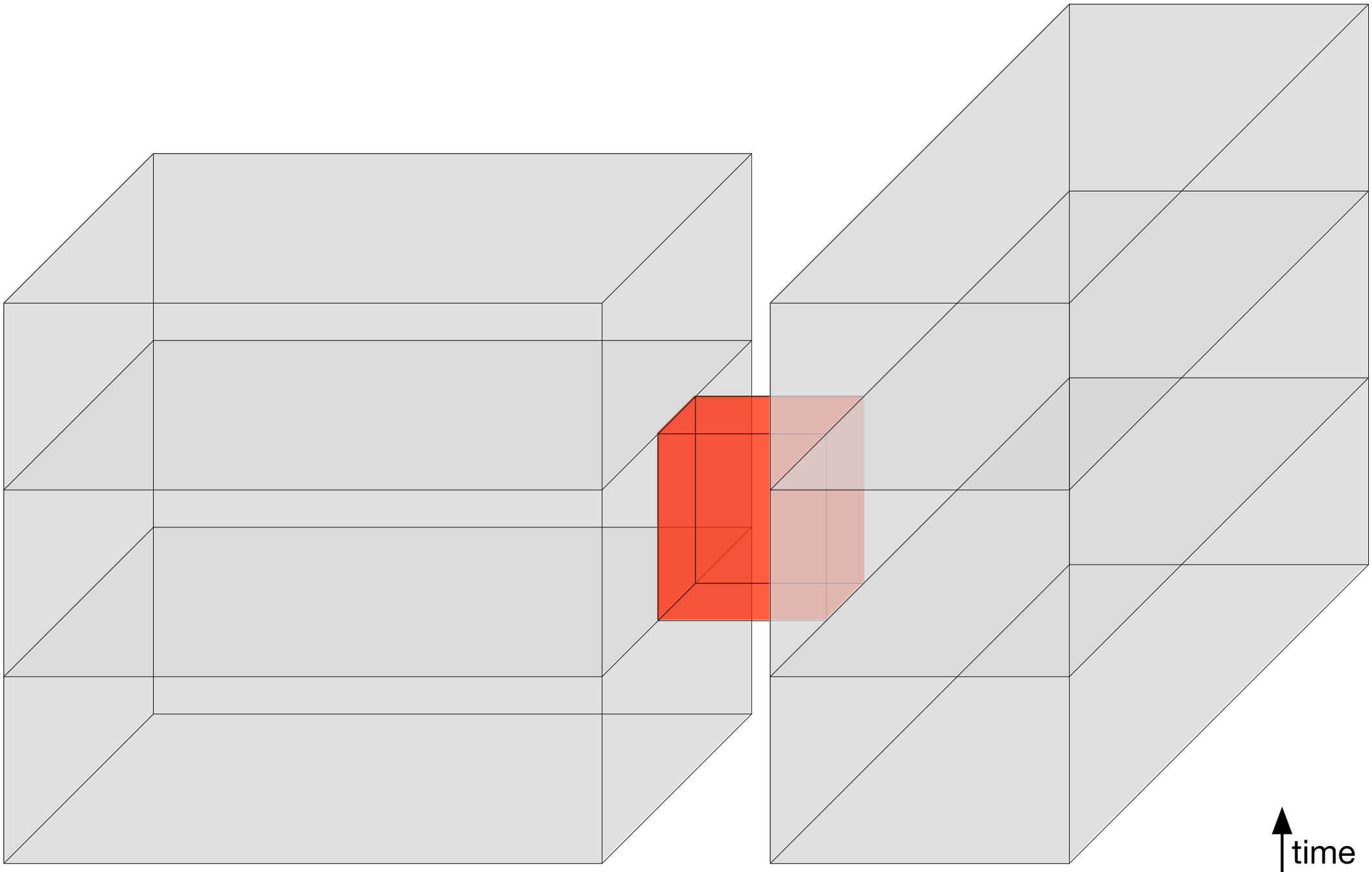
Move to 3D

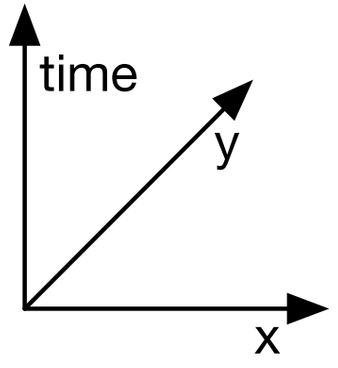




Examples

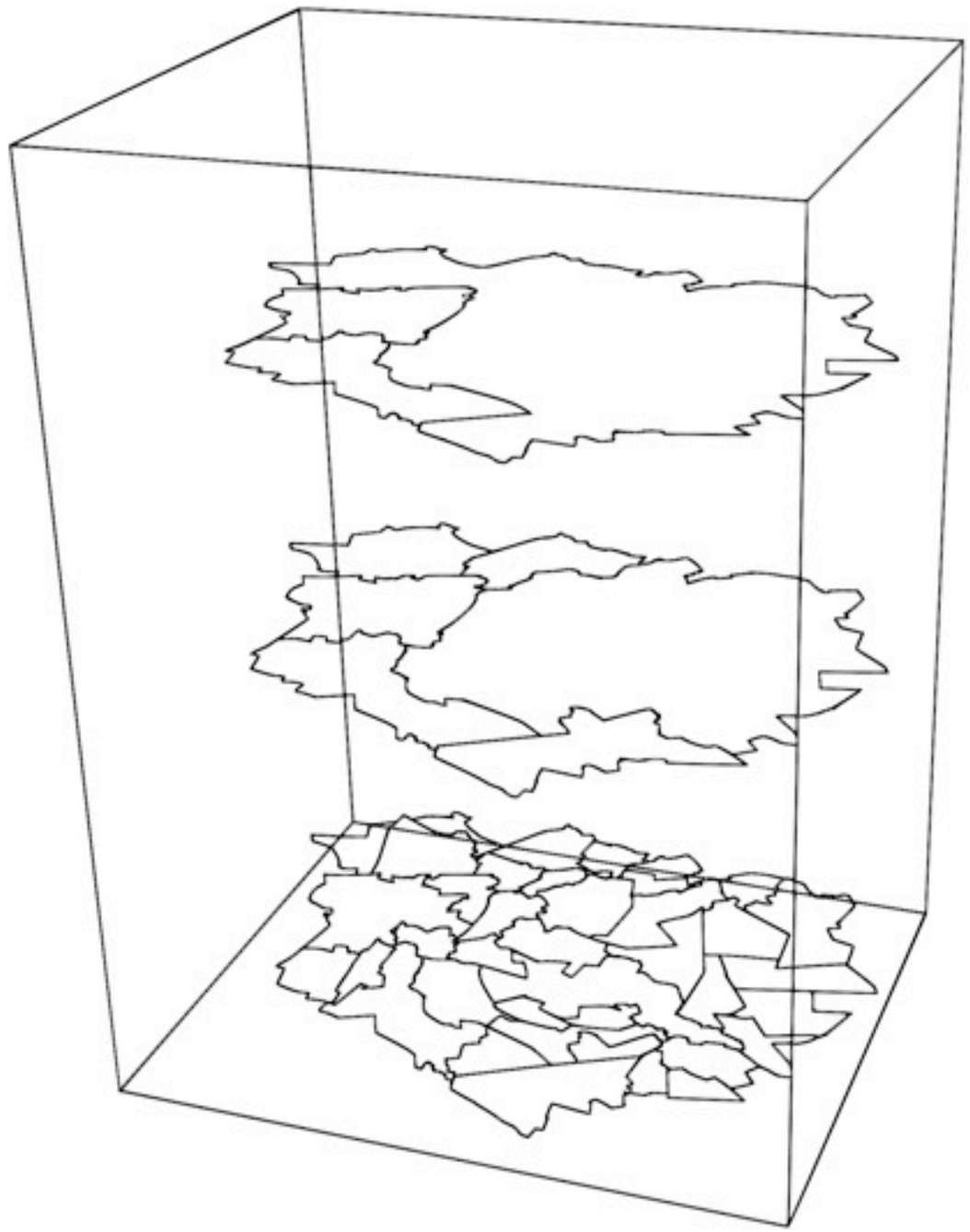
Move to 3D





Examples

Move to 3D



Meijers and van Oosterom (2011)

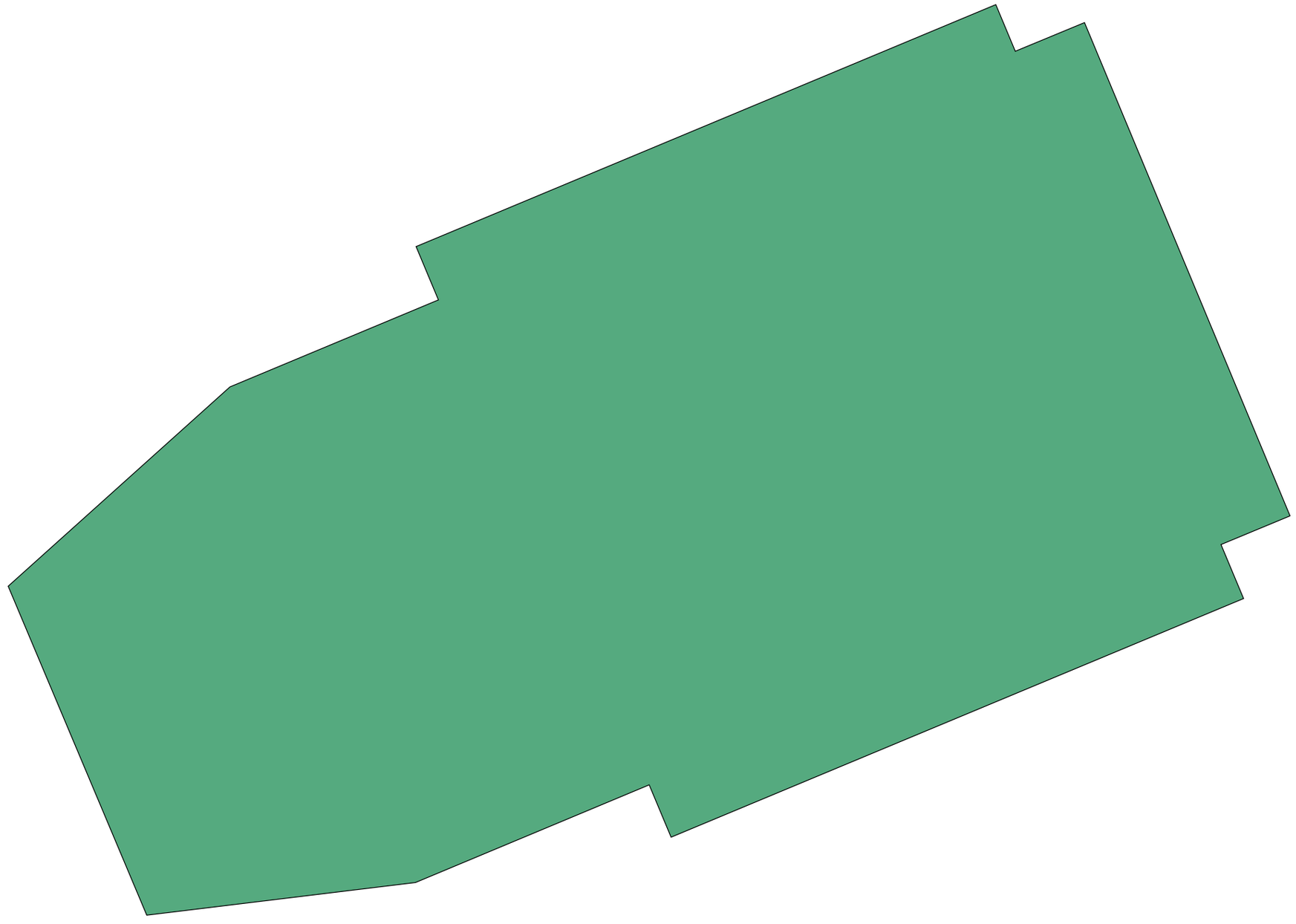
Other possibilities

Scale

Flickr

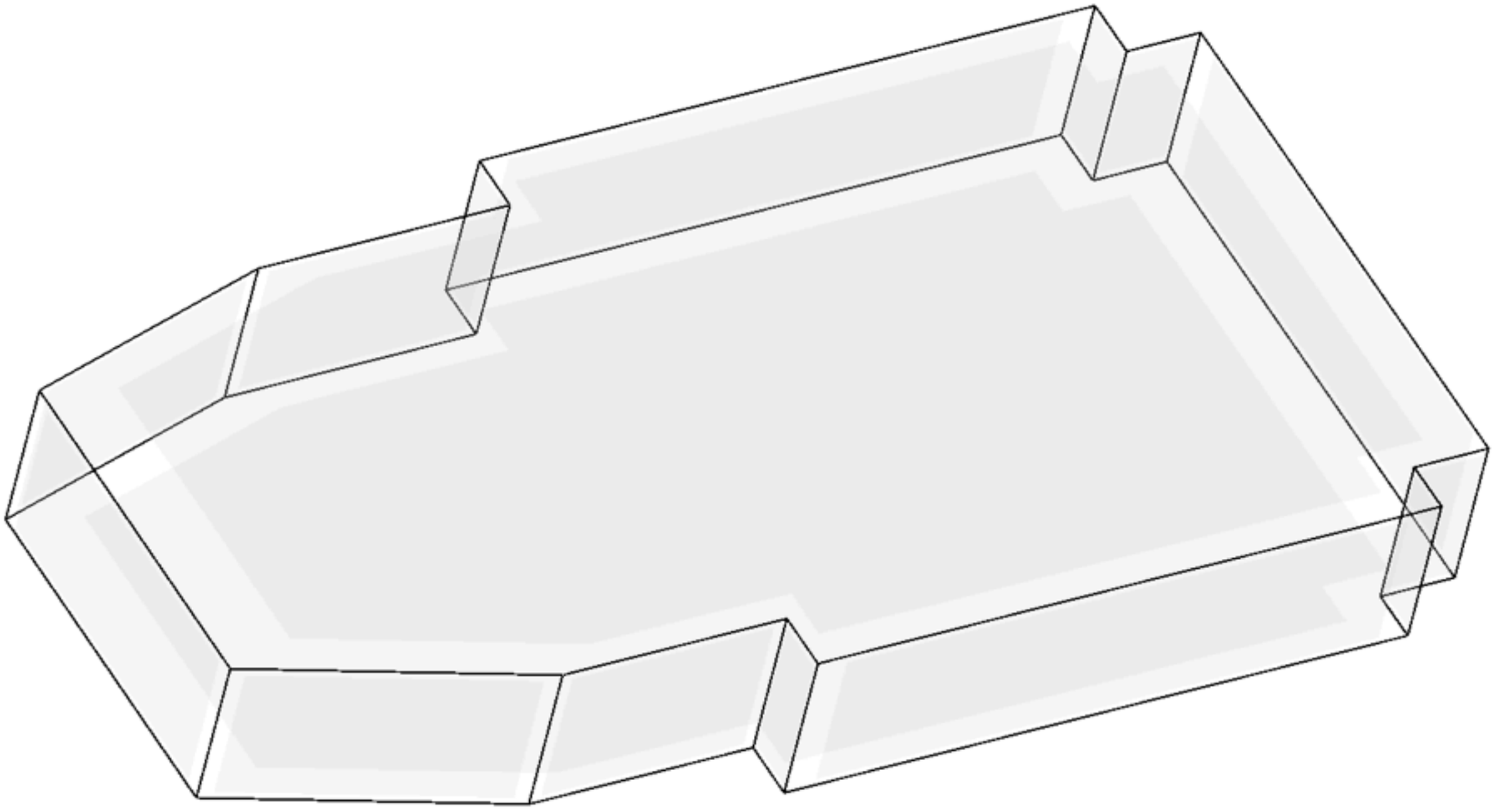
Other possibilities

Extruded data



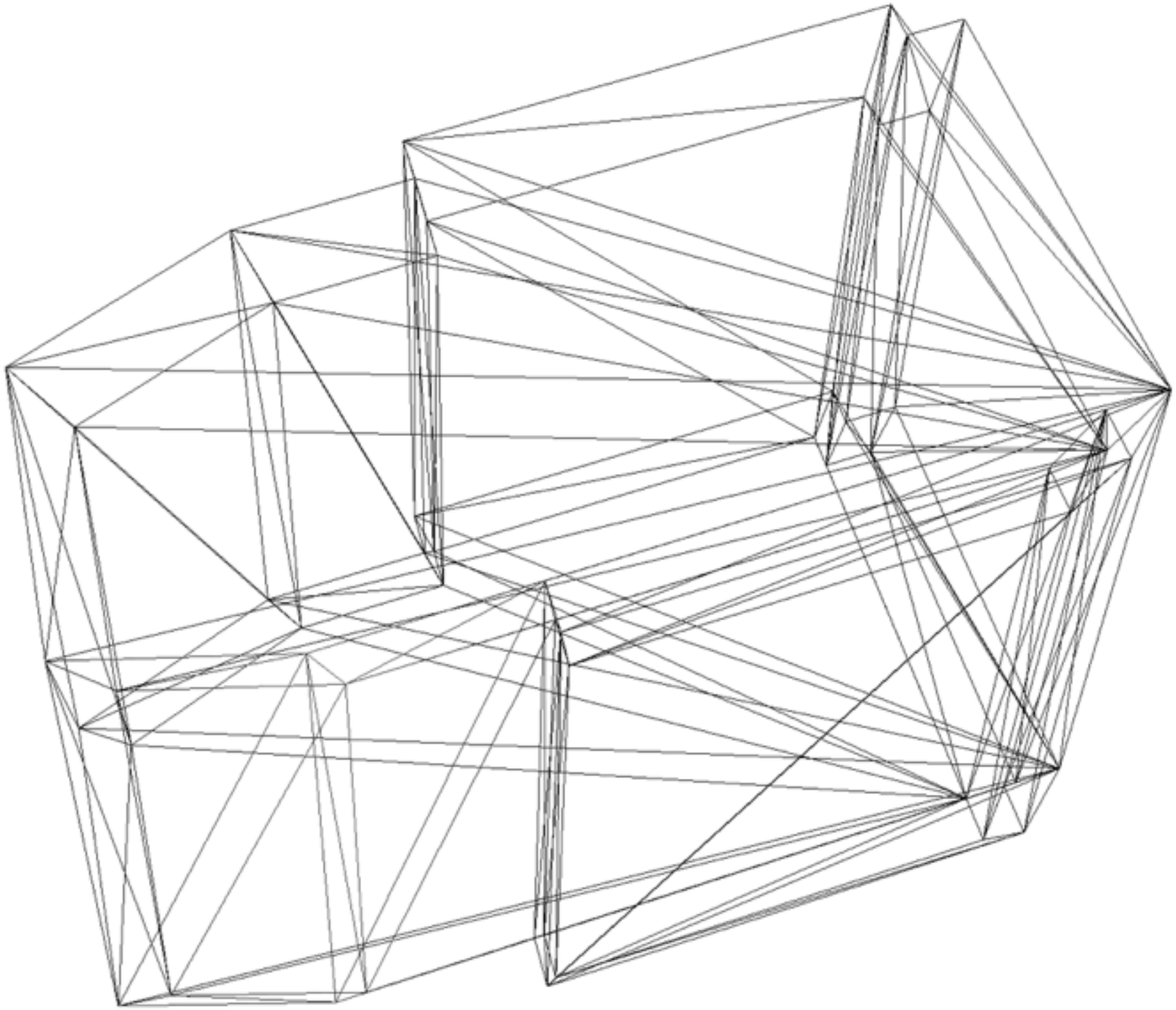
Other possibilities

Extruded data



Other possibilities

Extruded data

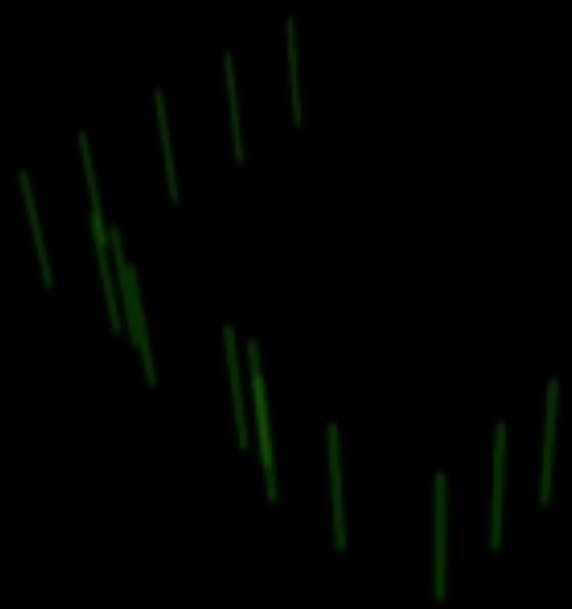


Other possibilities

Extruded data

4D data sources

woensdag 0:00:00 18-8-2010 Day=1 Week=1



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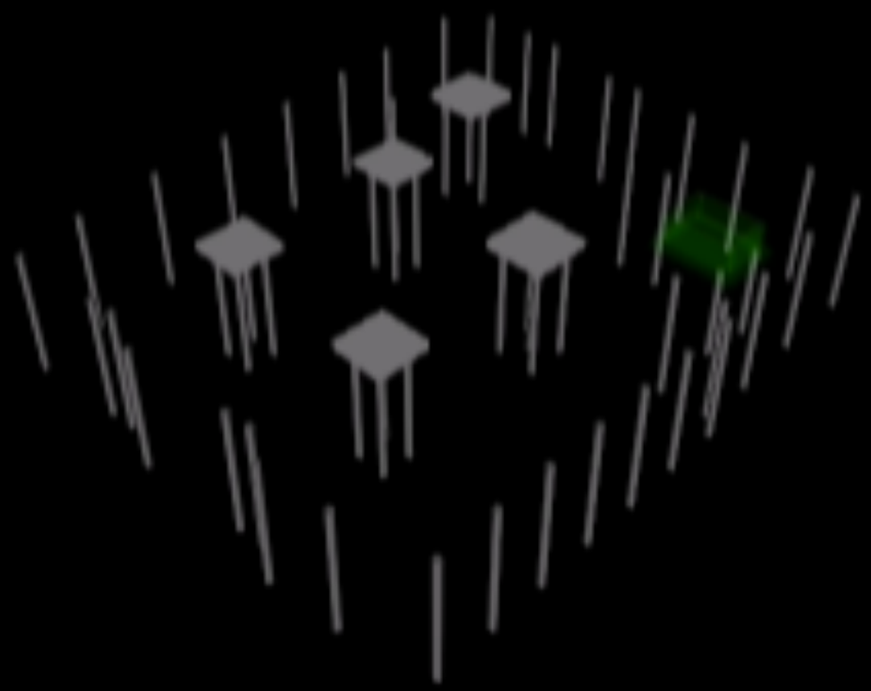
dinsdag 5:31:12 31-8-2010 Day=14 Week=2



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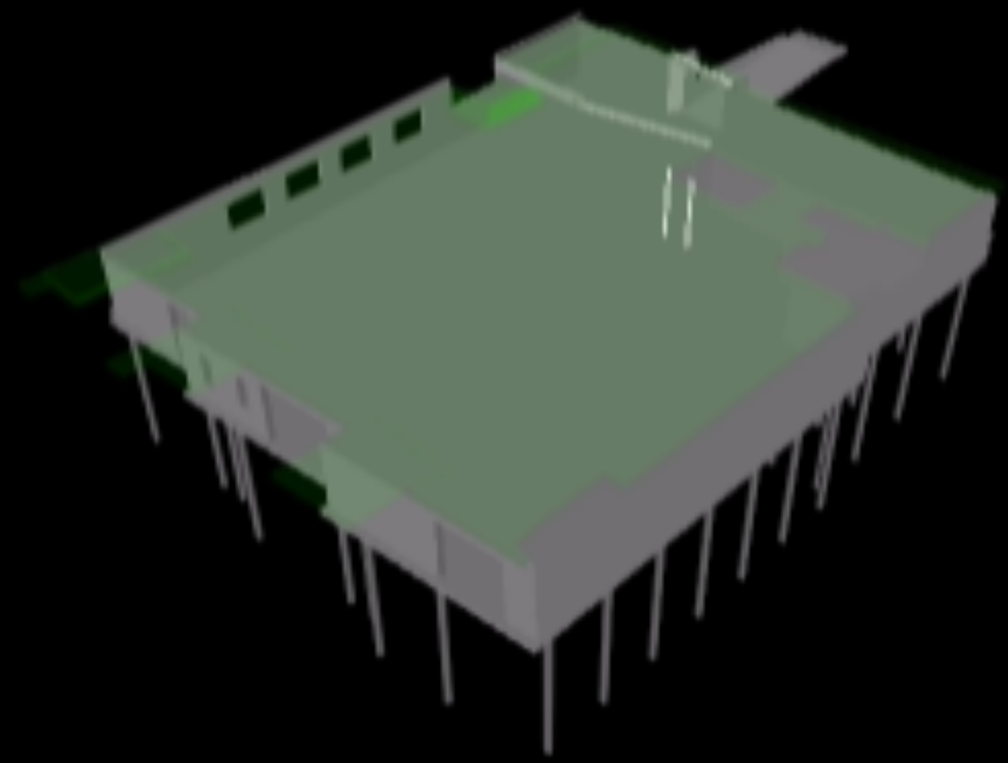

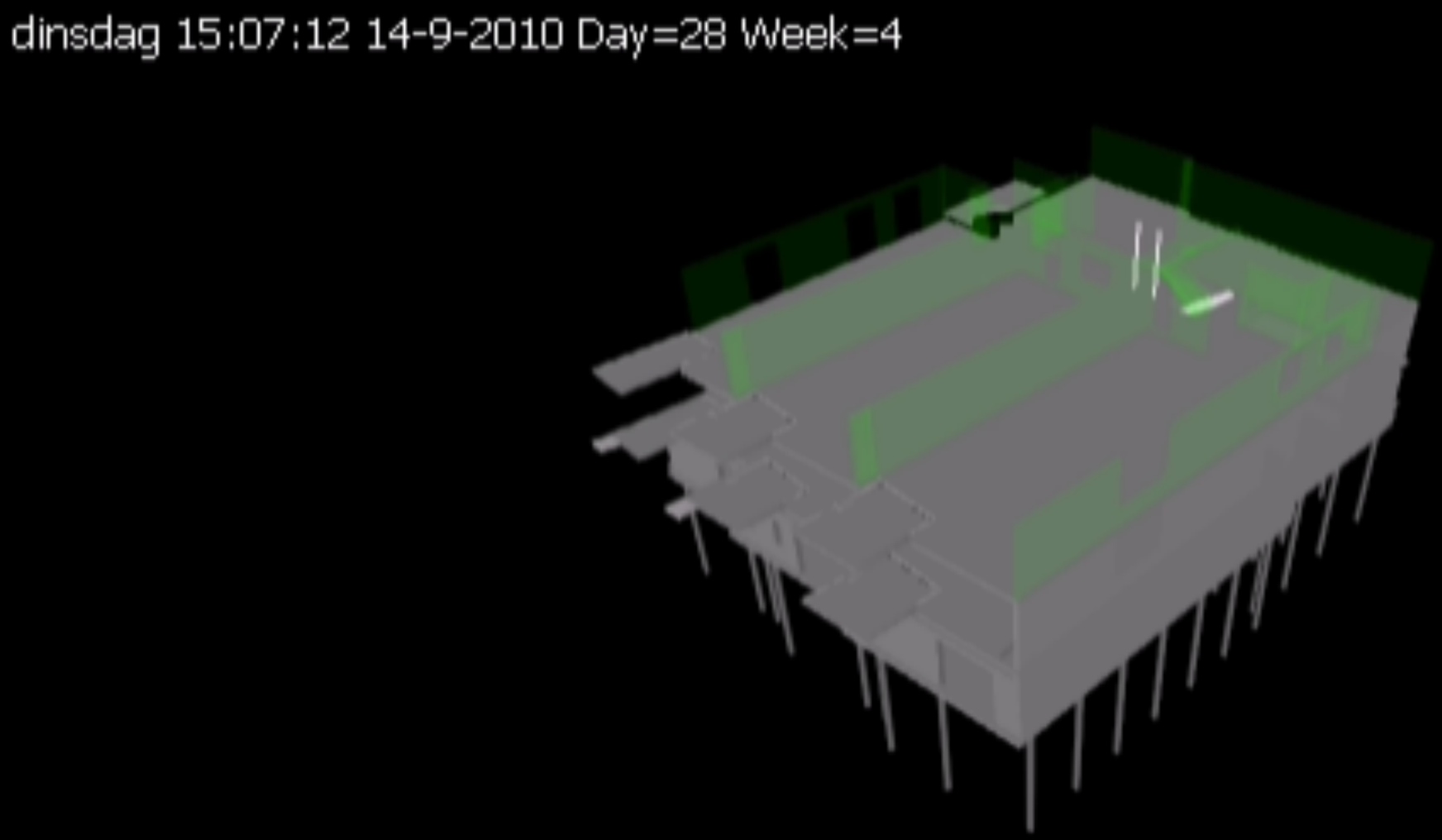
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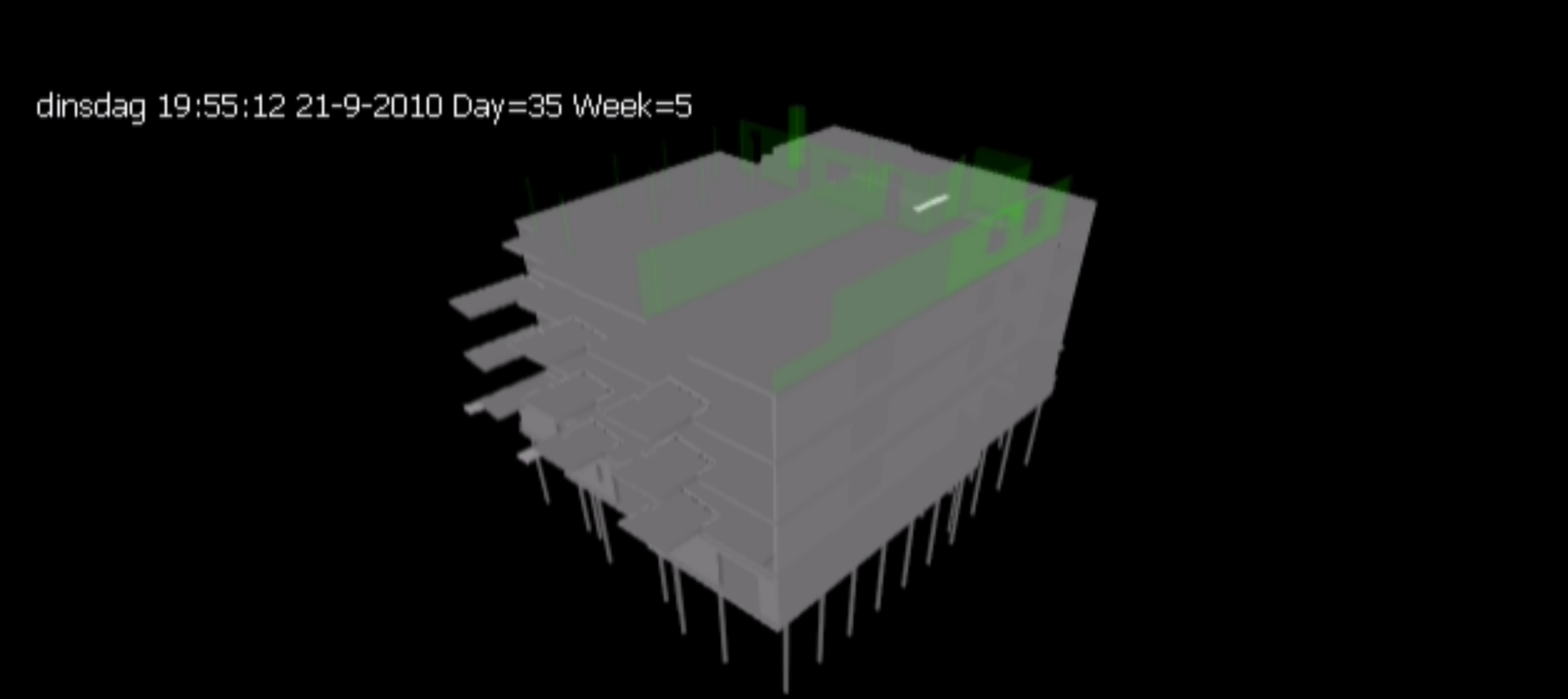
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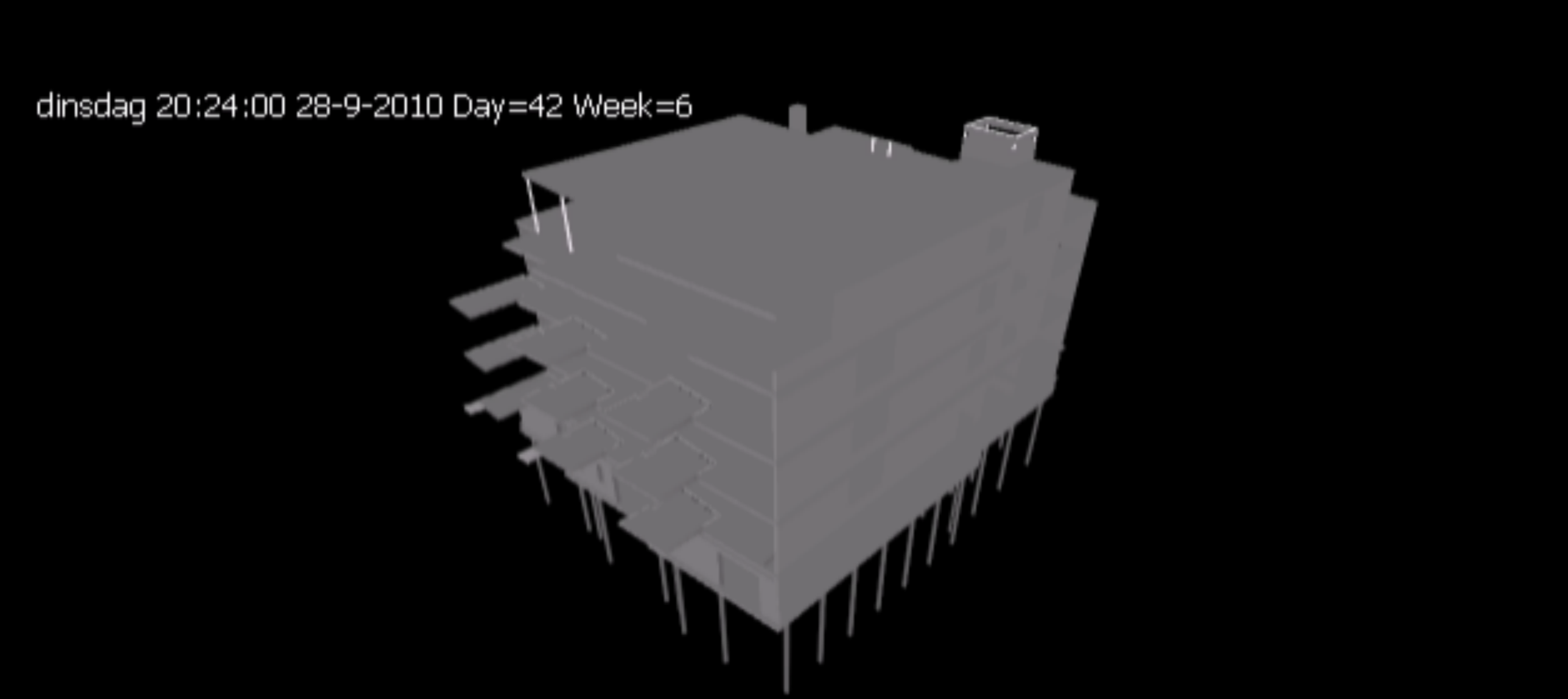
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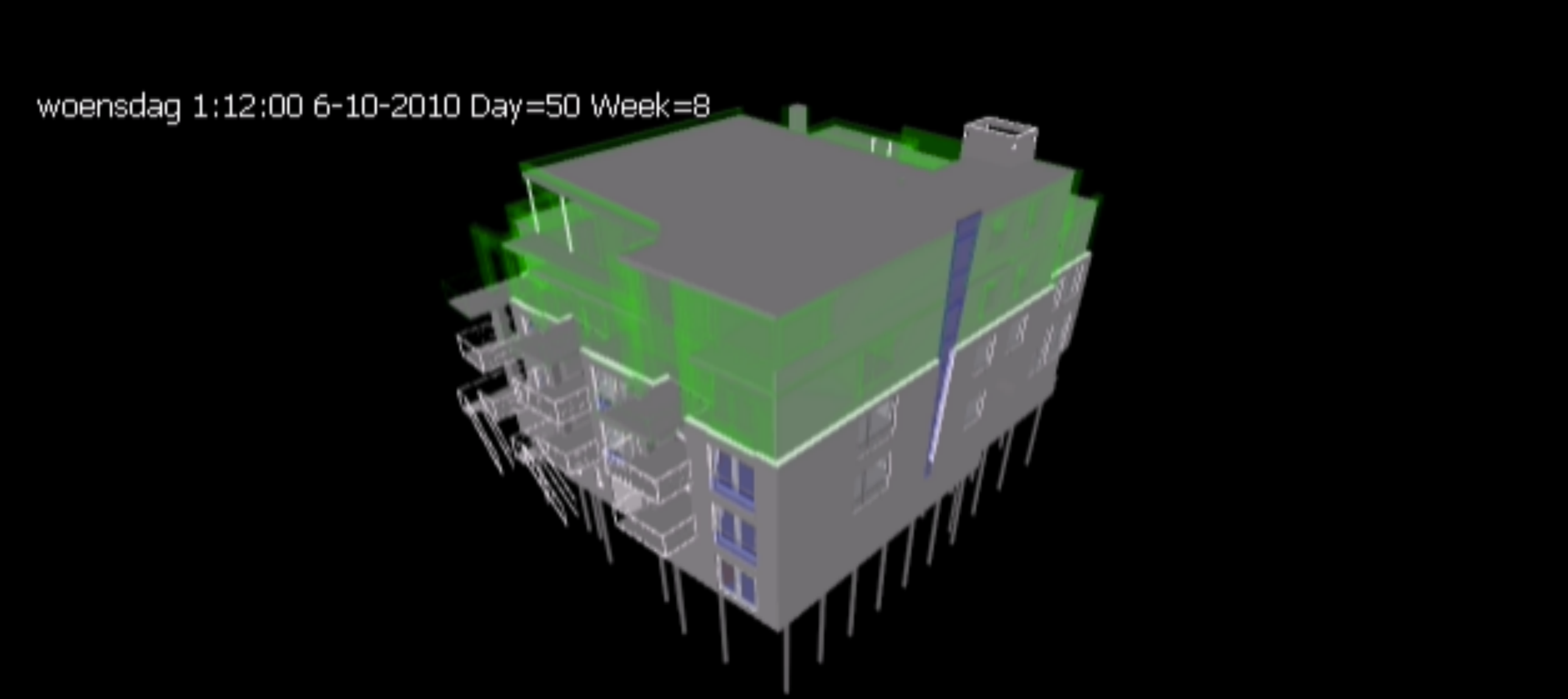
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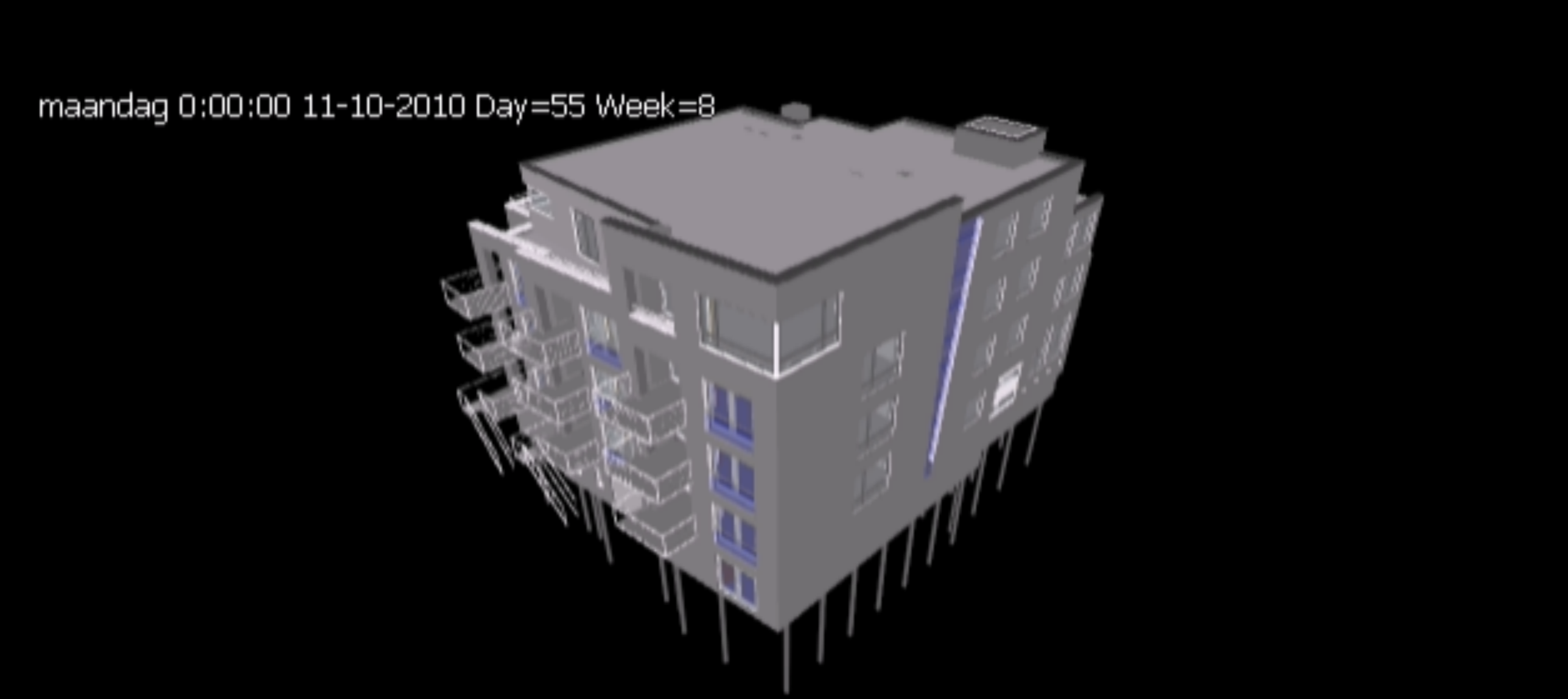

maandag 0:00:00 11-10-2010 Day=55 Week=8

Why higher dimensional information?

- Full topology, i.e. all links exist
- Analyse using queries along all dimensions
- Consistency of data
- Genericity, i.e. add anything that makes sense as a dimension
- n-d data models
- n-d data structures
- n-d algorithms

Why higher dimensional information?

Functional

- Full topology, i.e. all links exist
- Analyse using queries along all dimensions
- Consistency of data
- Genericity, i.e. add anything that makes sense as a dimension

Technical

- n-d data models
- n-d data structures
- n-d algorithms

Why higher dimensional information?

Functional

- Mathematically strong models that work on any type of data and can be extended

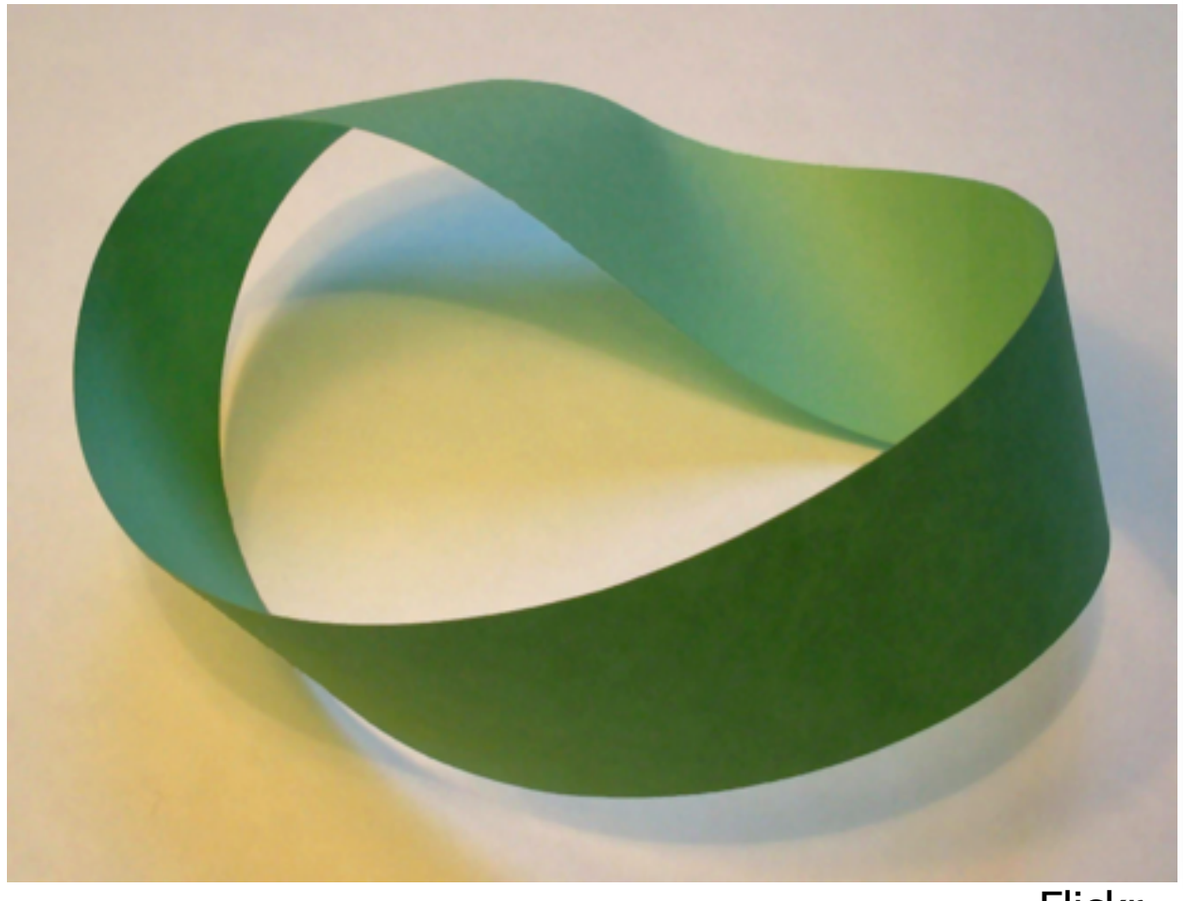
Technical

- Ongoing research on higher dimensional models, structures and algorithms

Why higher dimensional information?

Functional

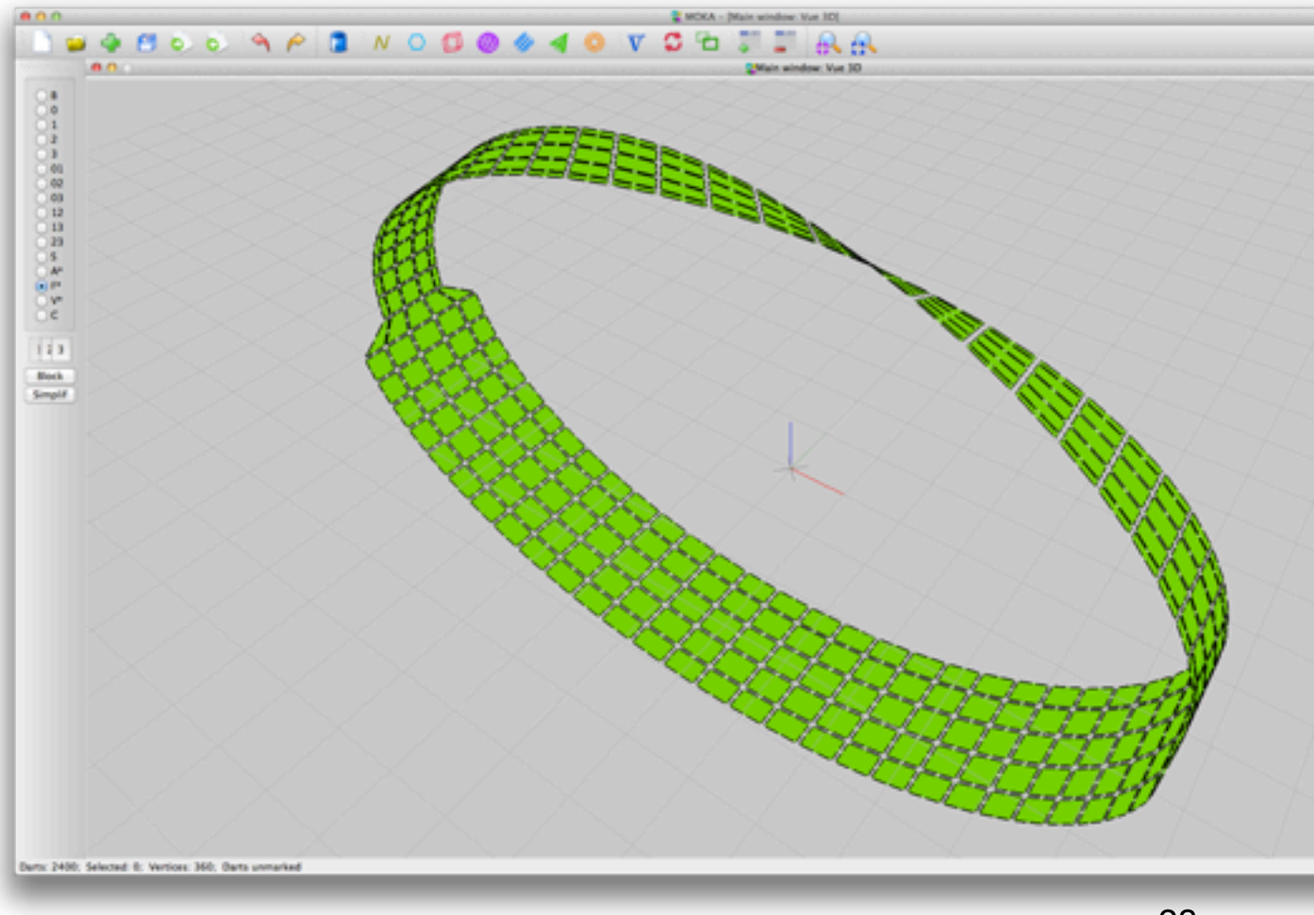
- Mathematically strong models that work on any data and can be extended

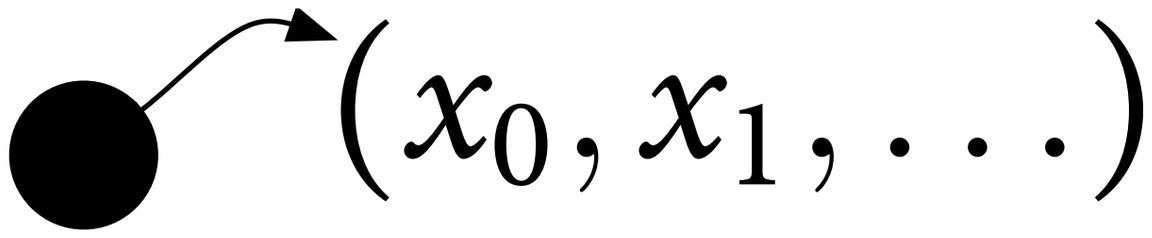


Flickr

Technical

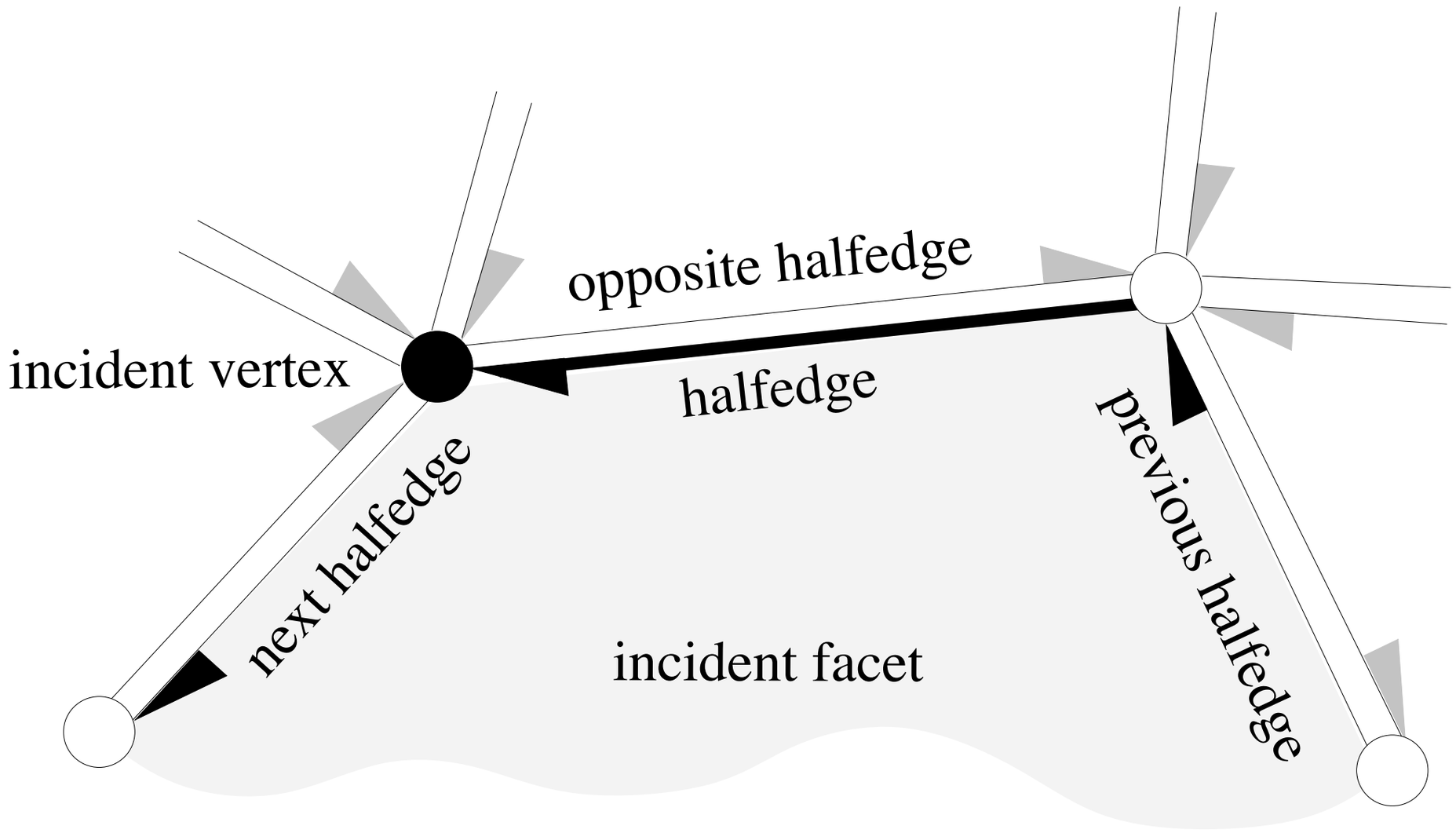
- Ongoing research on higher dimensional models, structures and algorithms





What is a dimension?

Point



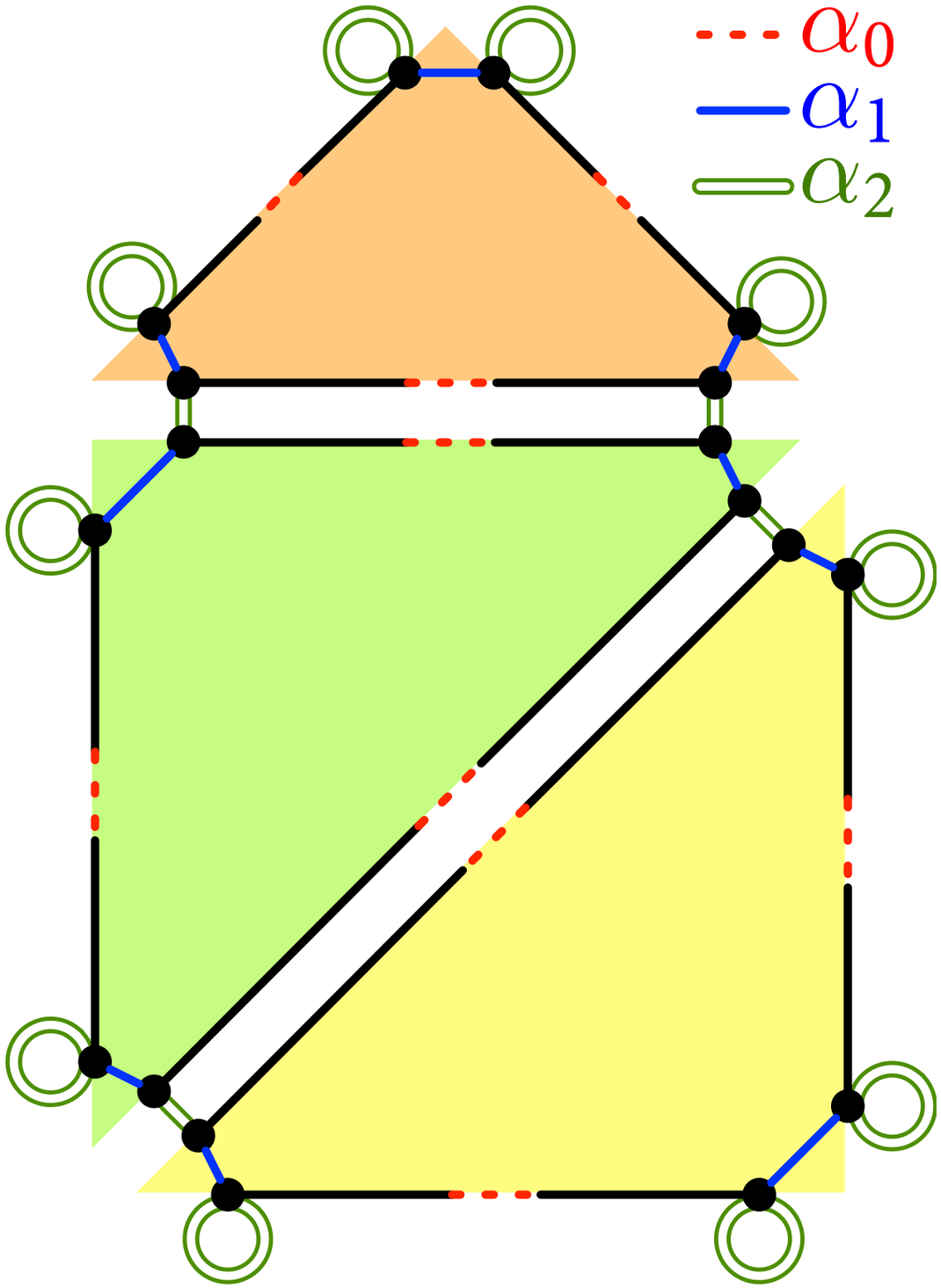
Kettner (1998)

What is a dimension?

Half-edge

Dimension

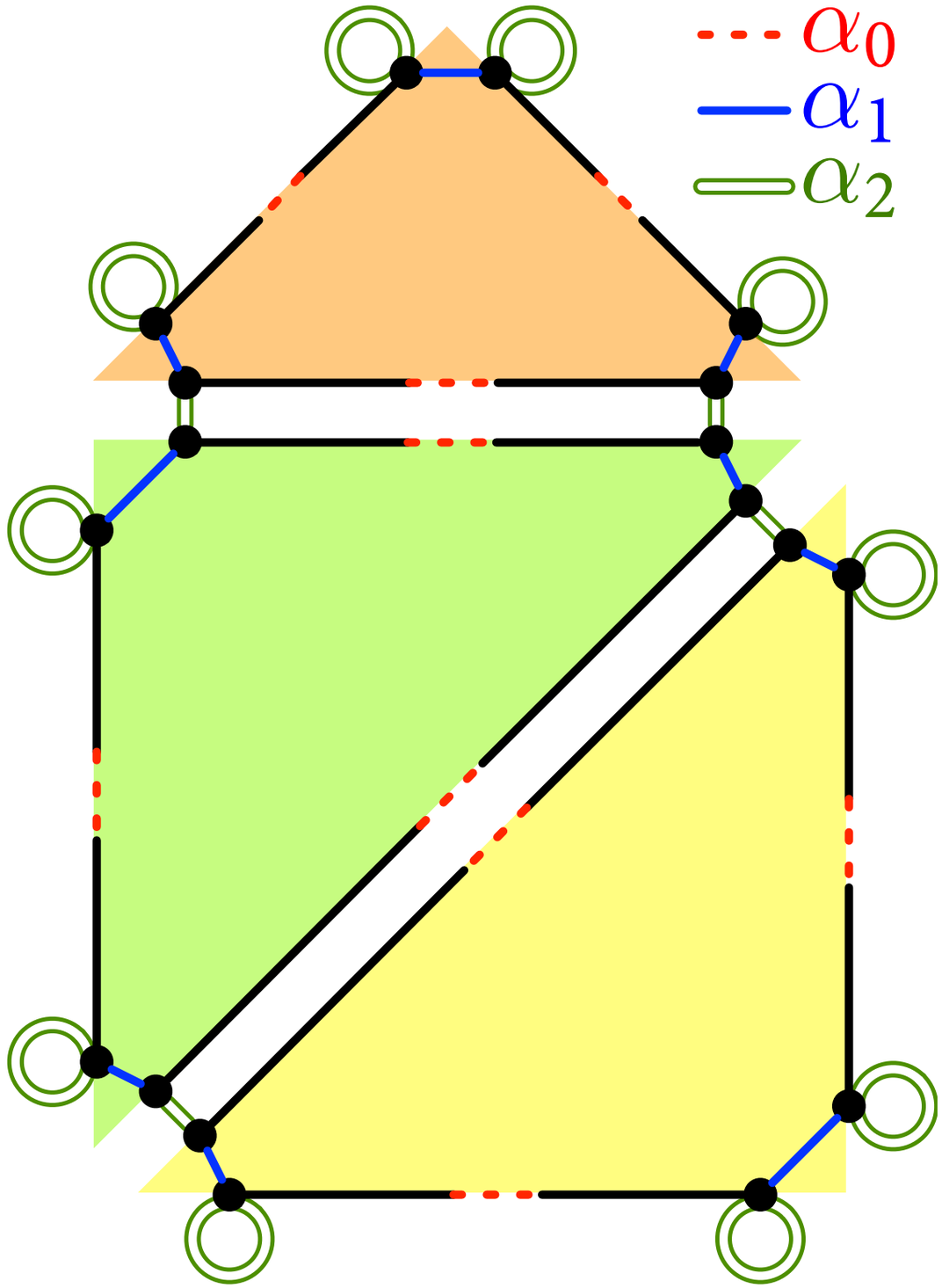
Topological/combinatorial vs. embedding/geometry



Dimension

Topological/combinatorial vs. embedding/geometry

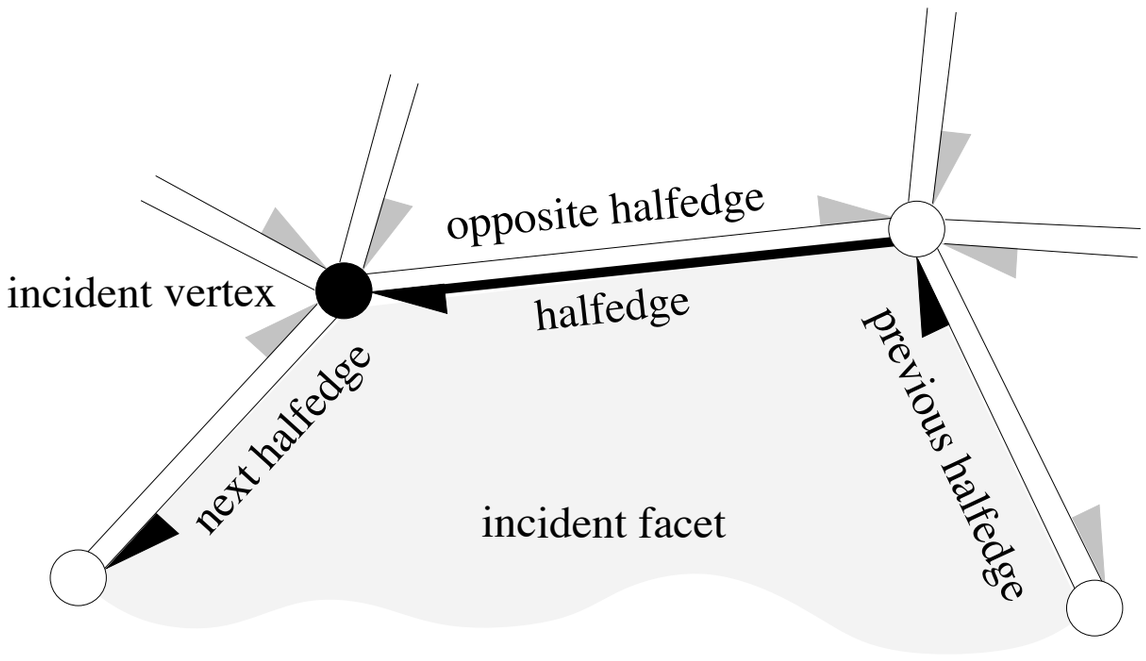
Geometric modellers vs. computational geometers



Dimension of an object

- The dimension of an object is given by the **minimum** dimension of a combinatorial model that is able to store it.

- The dimension of a set of spatial objects is given by the **minimum** dimension of a combinatorial model that is able to store **all** of these objects, **and** the topological relationships between them.

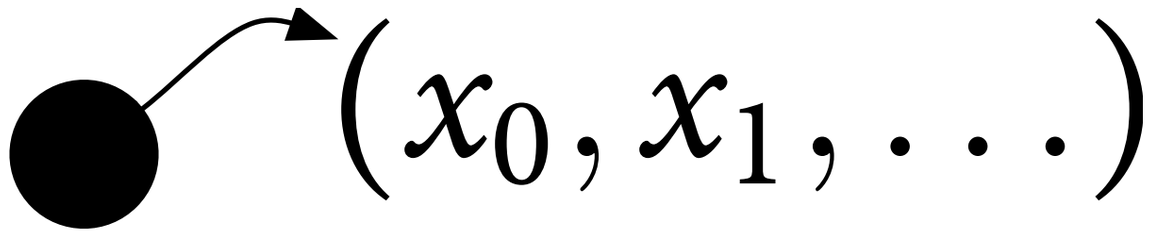


Kettner (1998)

Dimension of the space

- The dimension of the space is given by the minimum number of linearly independent axes in which the objects are embedded.

- In R^d, it is *d.*

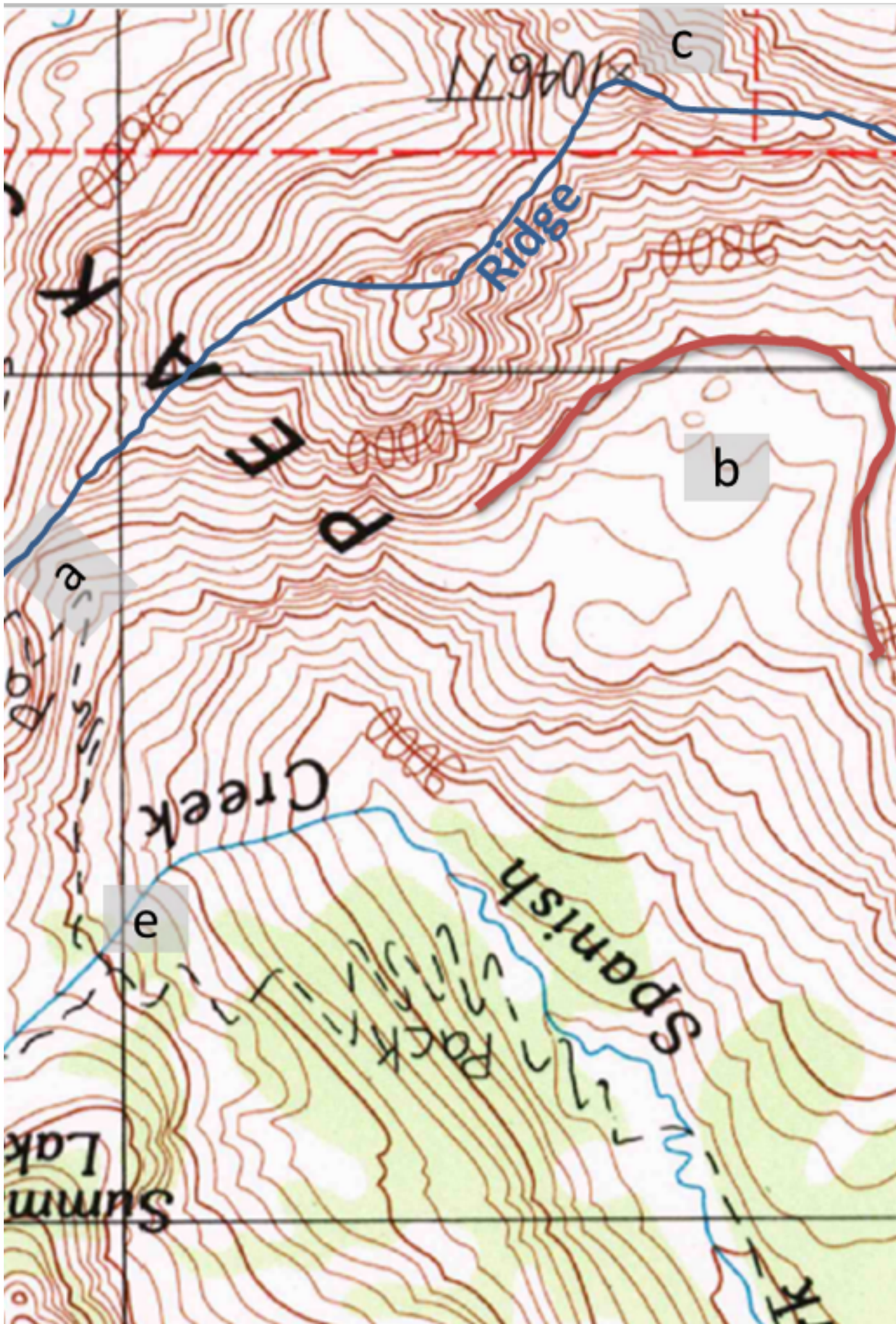


Dimension reduction

Why?

Dimension reduction

Why?

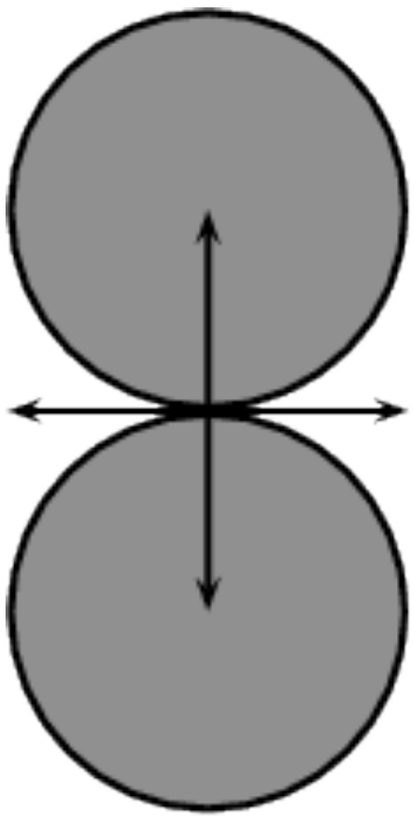


USGS

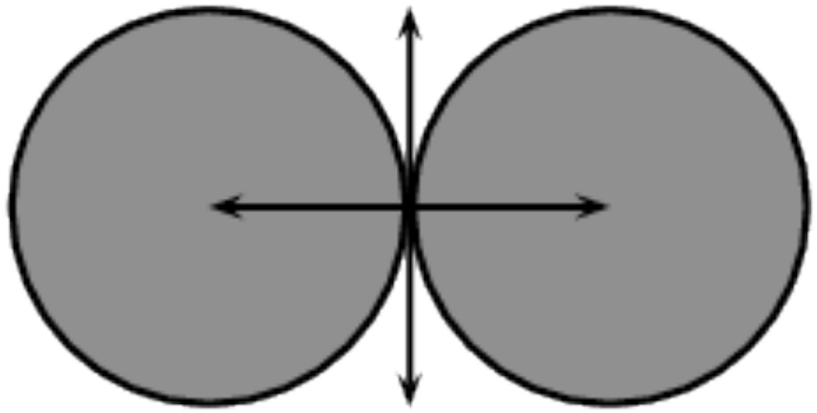
Dimension reduction

Extracting **meaningful** 2D/3D (intuitively undestandable) data

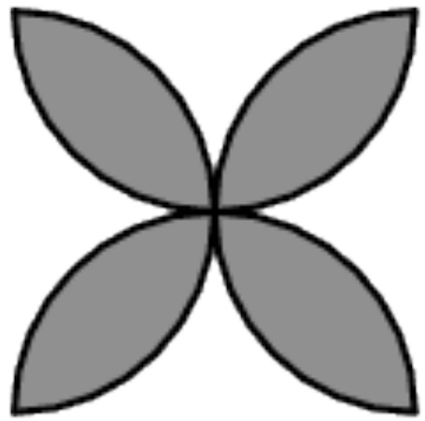
Intersection



A



B



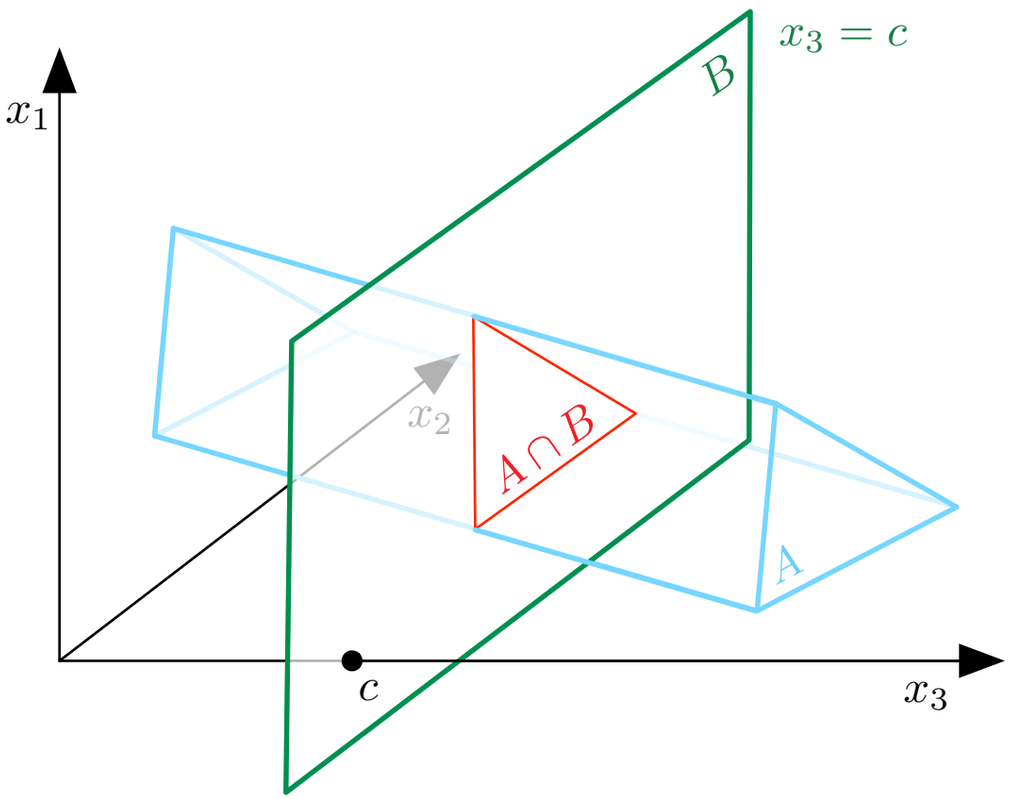
intersection(A, B)

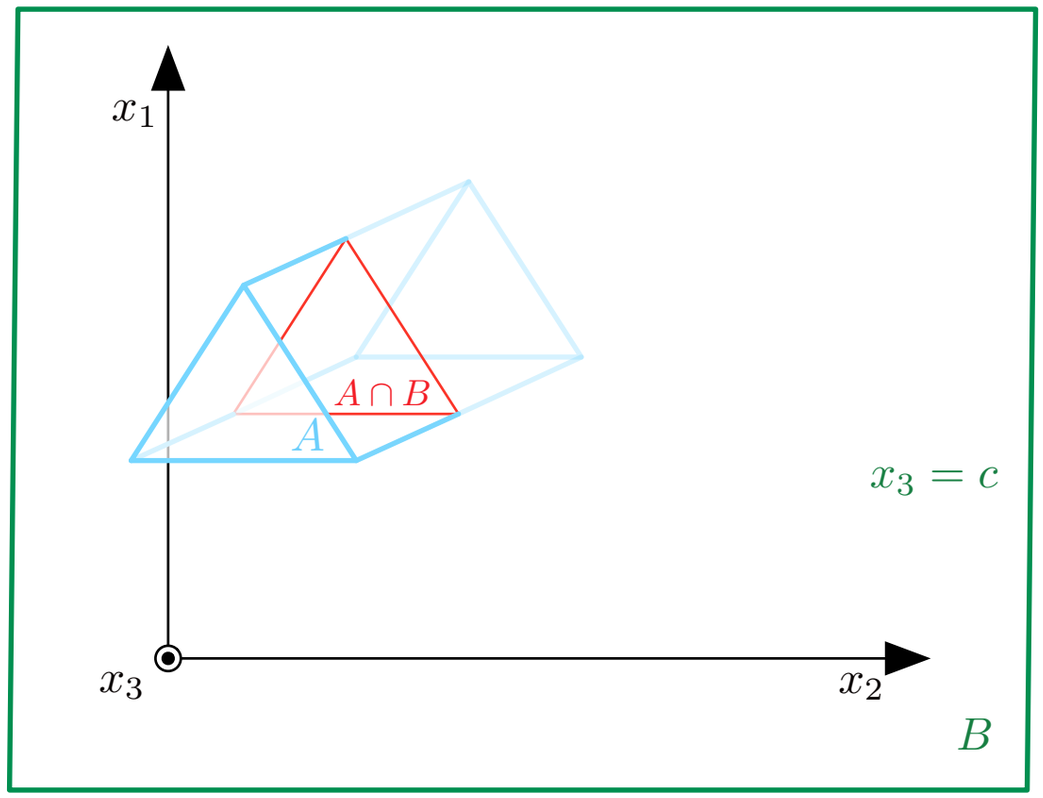
Intersection

- General case
- Computationally expensive: at least $O(n^{d-1})$
- Very hard to implement!
- Robustness/numerical errors
- Depends on underlying data structure

Introducing slicing

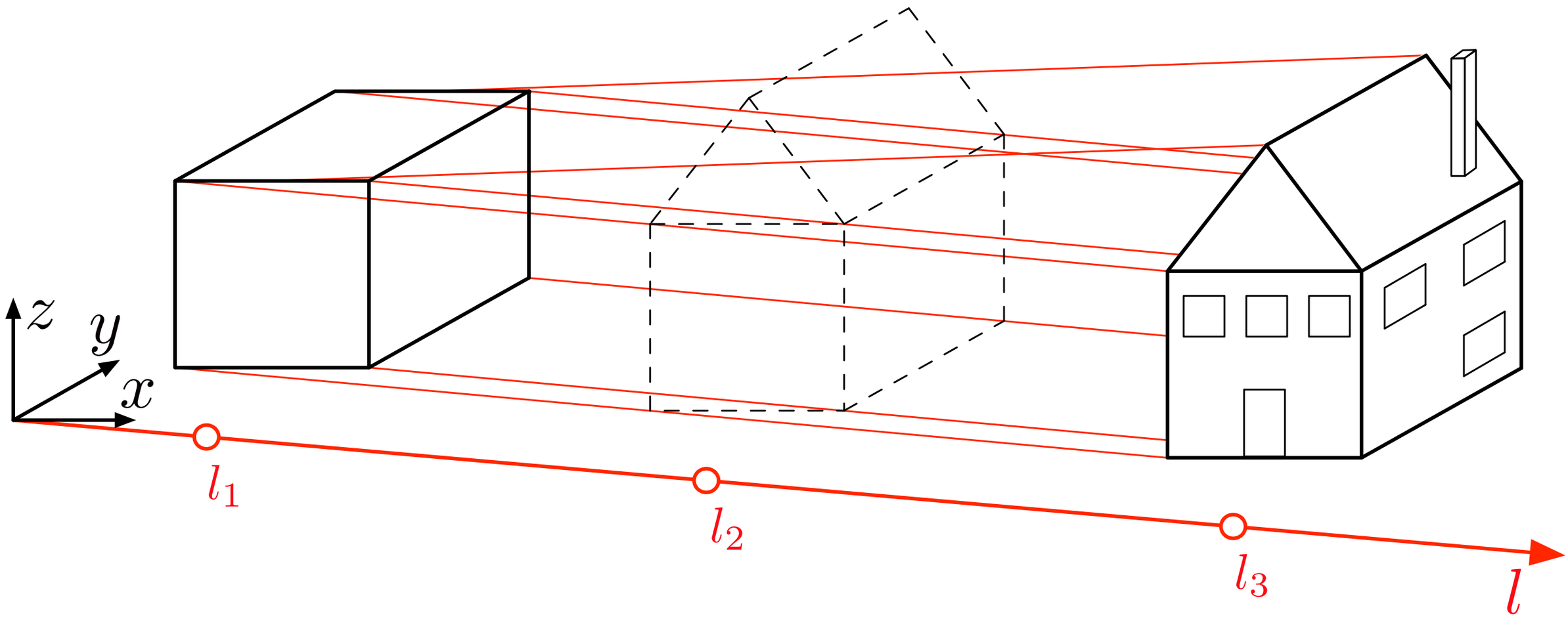
- Start simple and build towards more complex cases
- A specific case of intersection:
  - a higher dimensional object, generally consisting of a spatially indexed and large data set
  - is intersected with another lower-dimensional object, which is often simple, half-open, box-shaped, and parallel to an axis





Slicing

3D to 2D



Slicing

4D to 3D

5D project

3D space

\+ Scale

\+ Time

= 5D modelling

Current and future work

- Algorithms to construct n-d datasets
- Exploiting the full power of additional informations
- Work toward more complex cases

Thank you.

g.a.k.arroyoohori@tudelft.nl

TU Delft Delft University of Technology