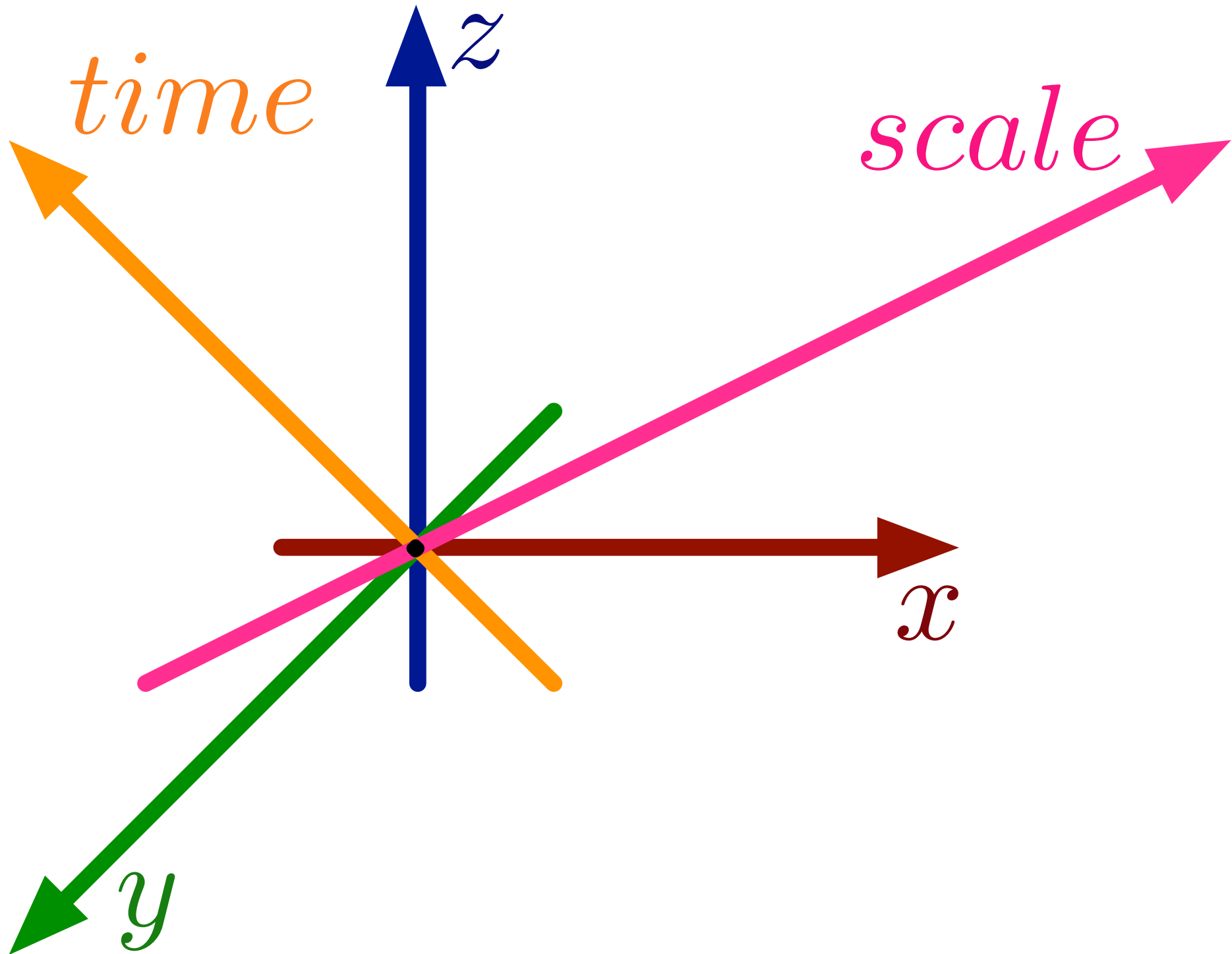


# Storing a 3D City Model, its Levels of Detail and the Correspondences between Objects as a 4D Combinatorial Map

**Ken Arroyo Ohori**, Hugo Ledoux and Jantien Stoter  
ISPRS WG II/2 Workshop  
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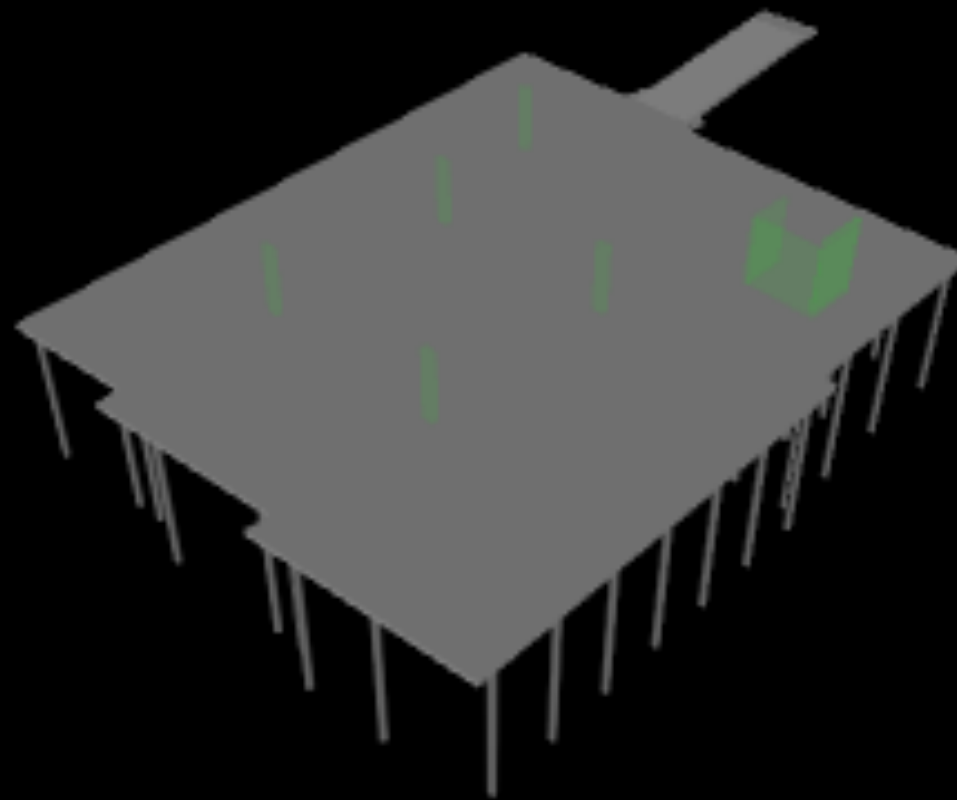
Motivation

# $n$ D integration



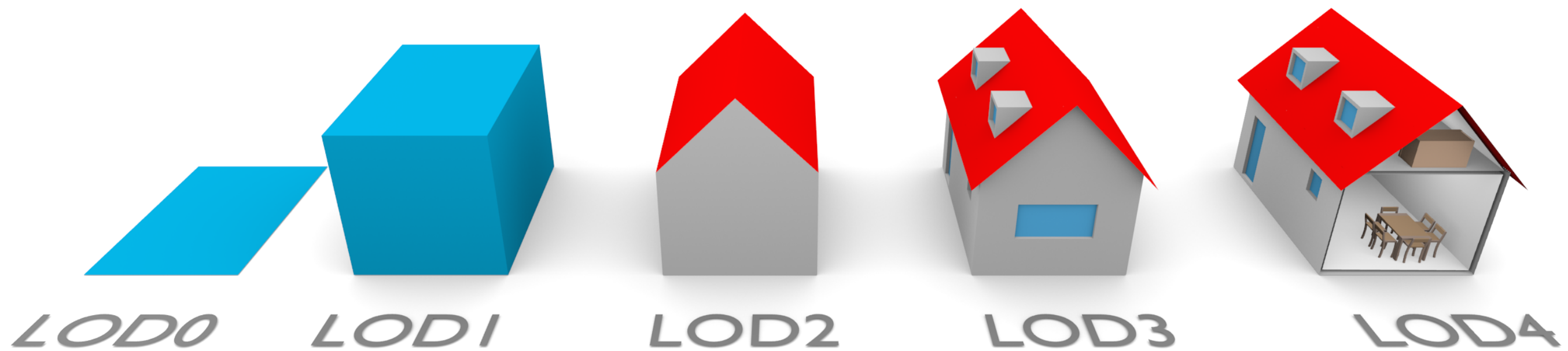
# 3D+time

zaterdag 11:02:24 4-9-2010 Day=18 Week=3



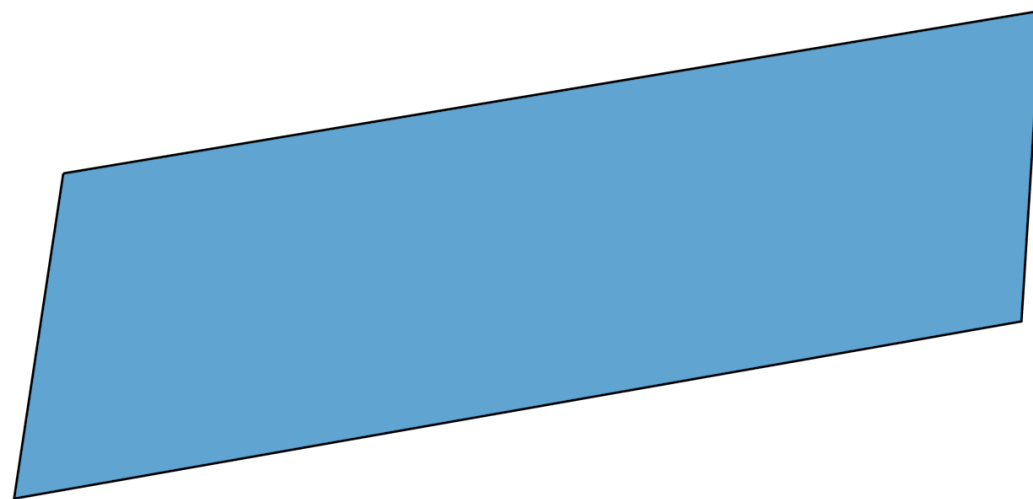


# Here: 3D+scale

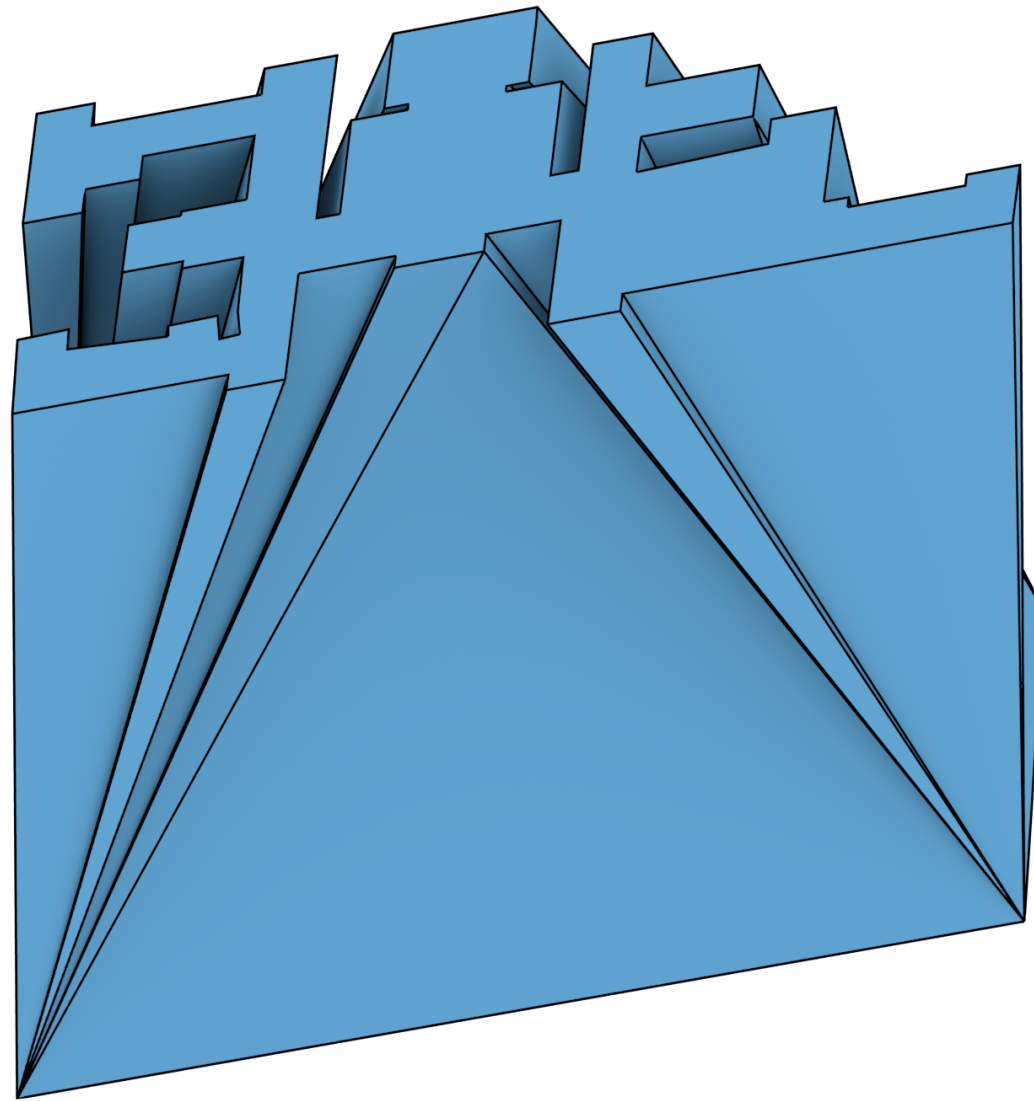


Aim

志望



# Aim

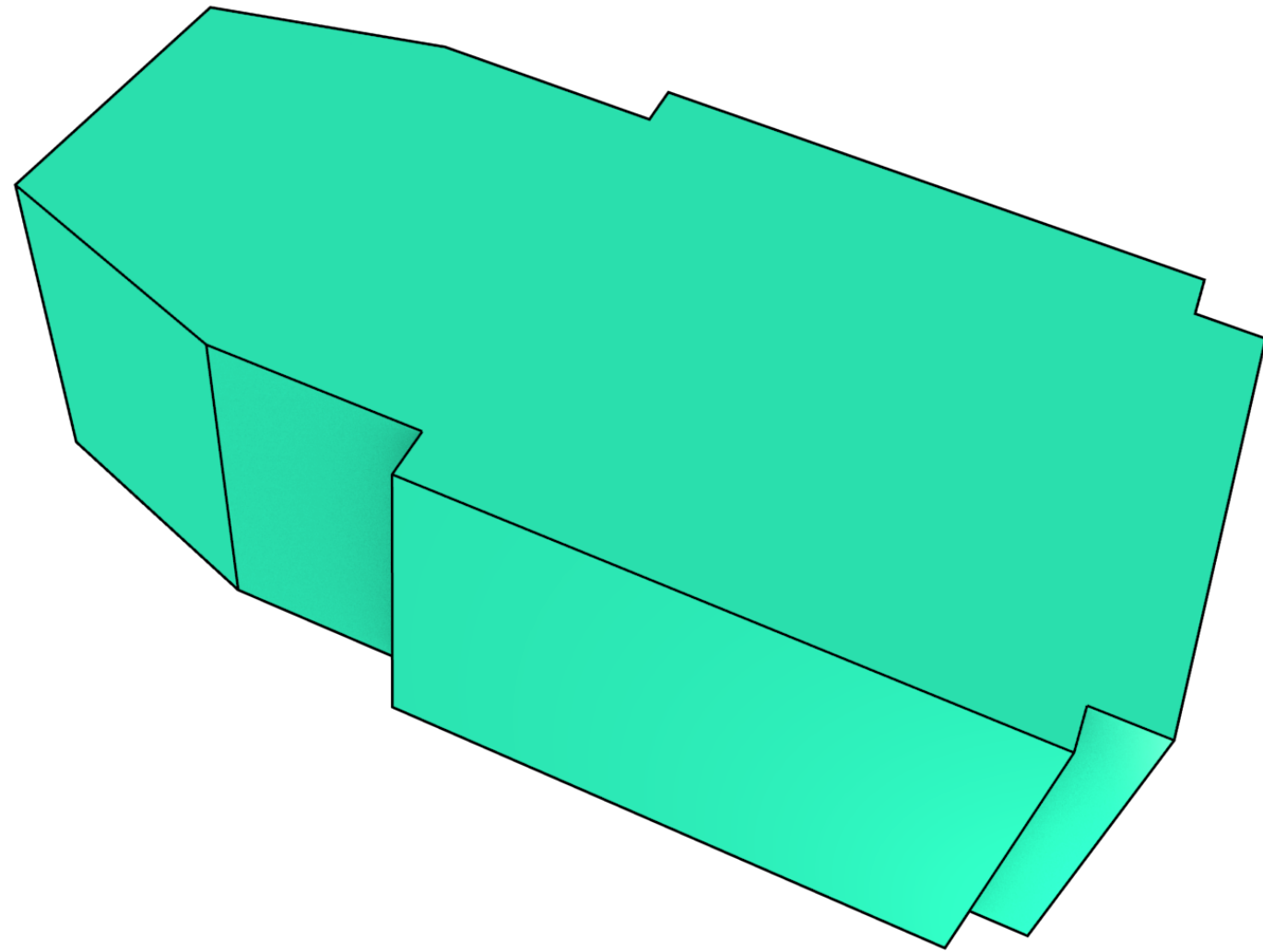
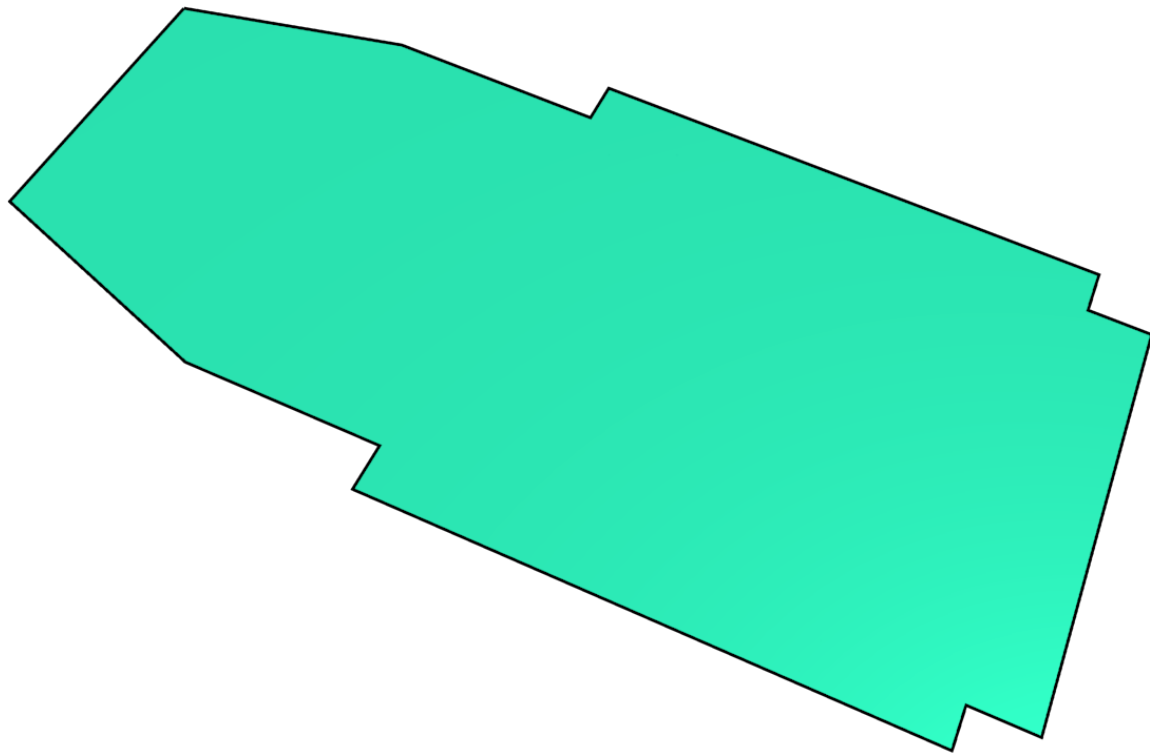


# Advantages

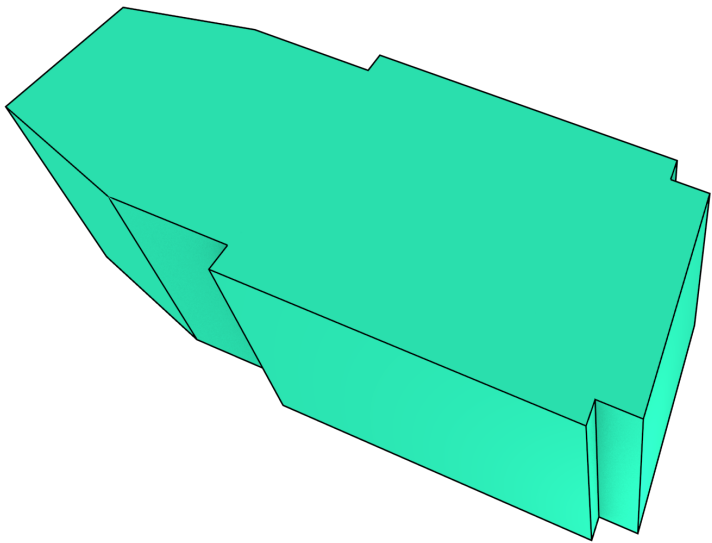
- Forming a clean 4D topological space partition
- Storing relationships between any group of related objects, of any dimension
- Attaching semantic information to objects of any dimension or to the relationships between them

Examples: simple nD  
operations

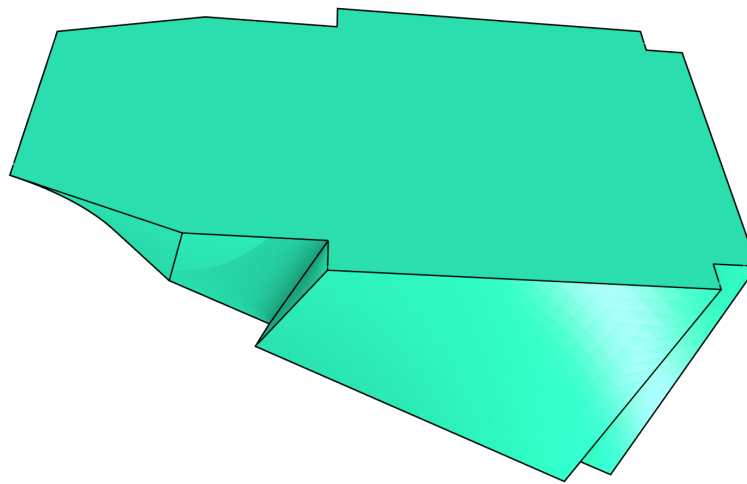
# Extrusion: no change



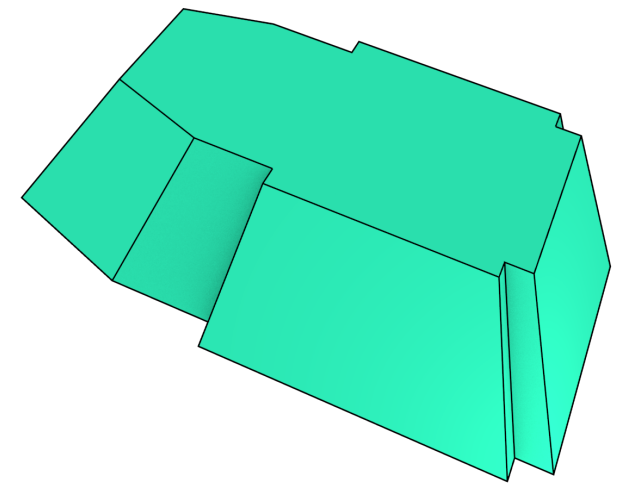
# Transformations



Translation

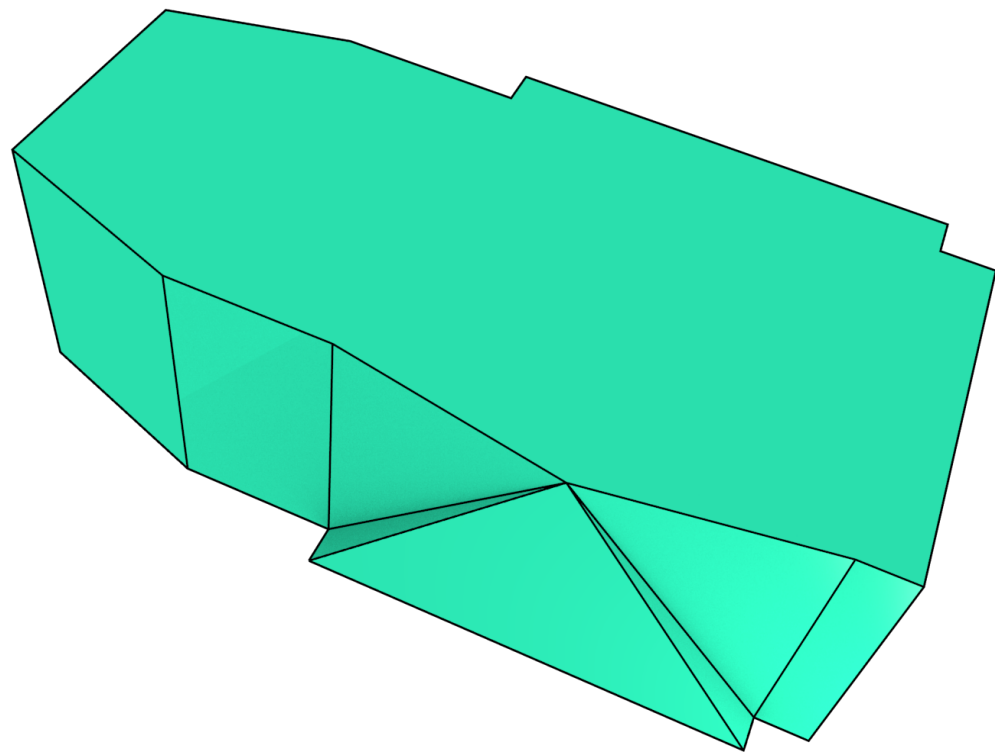


Rotation

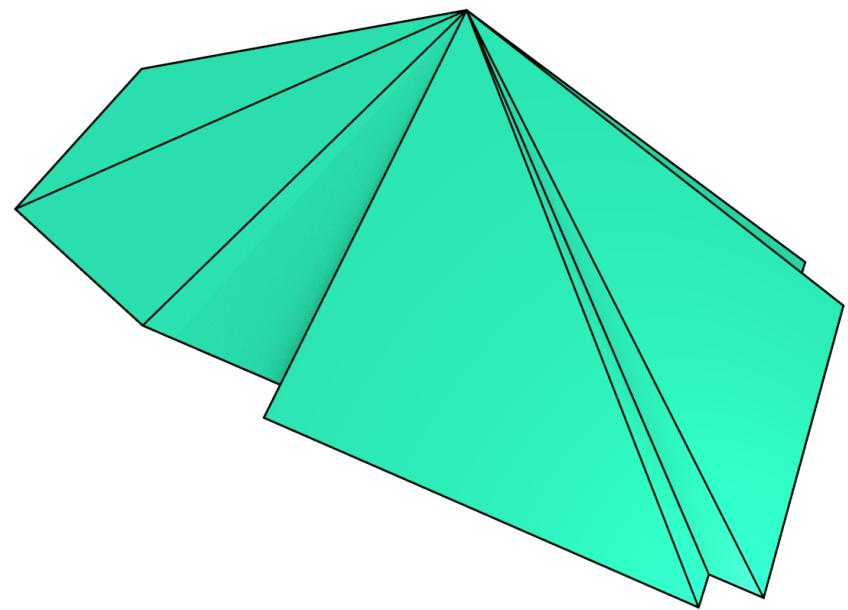


Scale

# Collapse



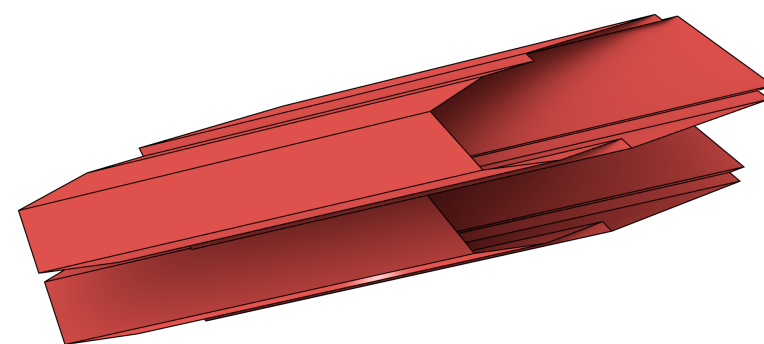
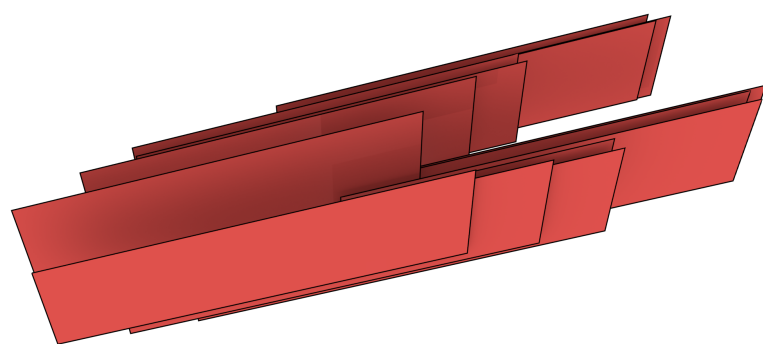
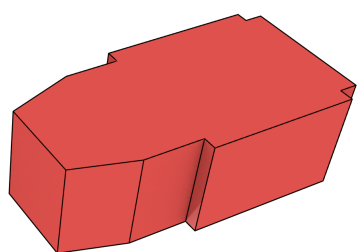
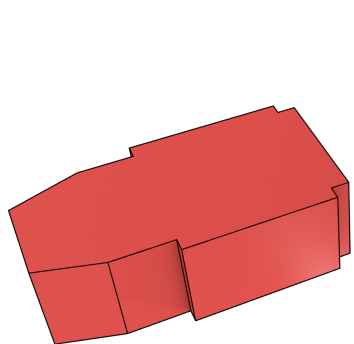
Edge



Face



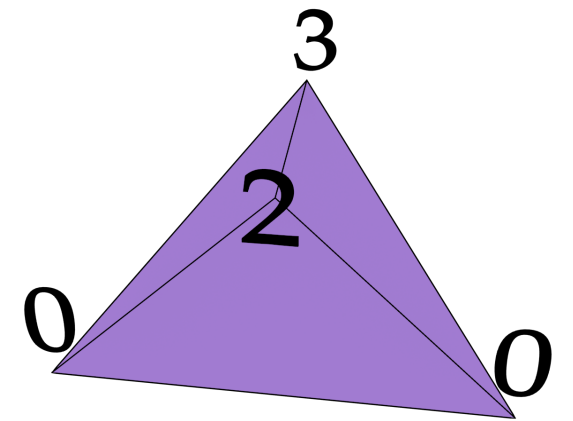
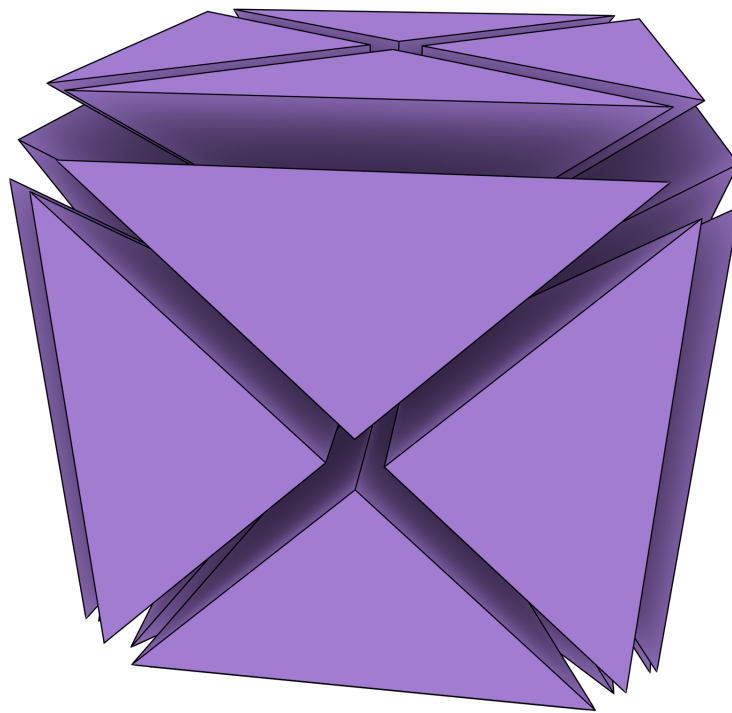
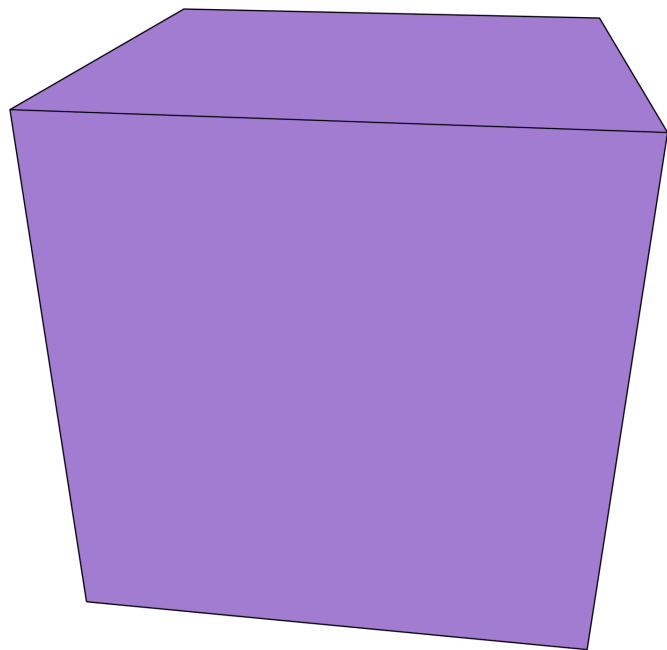
# 4D example



# Storage as combinatorial maps



# 3D combinatorial maps



```

typedef CGAL::Dart<d, Refs> Dart;
typedef typename Refs::size_type size_type;
static const size_type NB_MARKS = Refs::NB_MARKS;
int id;

```

```

Dart_with_id() : Dart() {
    id = -1;
}

```

```

Dart_with_id(int id) : Dart() {
    this->id = id;
}

```

```

Dart_with_id(const Dart& adart) : Dart(adart) {
    id = -1;
}

```

```

};

```

```

template <unsigned int d>

```

```

struct Linear_cell_complex_items_with_id {

```

```

    template <class LCC>

```

```

    struct Dart_wrapper {

```

```

        typedef CGAL::Cell_attribute_with_point<LCC, int> Point_attribute_with_id;

```

```

        typedef CGAL::Cell_attribute<LCC, int> Attribute_with_id;

```

```

        template <unsigned int attributes_to_add, class Result = CGAL::cpp11::tuple<> >

```

```

        struct Linear_cell_complex_items_with_id_attributes;

```

```

        template <class ... Result>

```

```

        struct Linear_cell_complex_items_with_id_attributes<0, CGAL::cpp11::tuple<Result ...> > {

```

```

            typedef CGAL::cpp11::tuple<Point_attribute_with_id, Result ...> tuple;

```

```

        };

```

```

        template <unsigned int attributes_to_add, class ... Result>

```

```

        struct Linear_cell_complex_items_with_id_attributes<attributes_to_add, CGAL::cpp11::tuple<Result ...> > {

```

```

            typedef typename Linear_cell_complex_items_with_id_attributes<attributes_to_add-1,

```

```

                CGAL::cpp11::tuple<Attribute_with_id, Result ...> ::tuple tuple;

```

```

        };

```

```

        typedef Dart_with_id<d, LCC> Dart;

```

```

        typedef typename Linear_cell_complex_items_with_id_attributes<d>::tuple Attributes;

```

```

    };

```

```

};

```

# Implementation:

# CGAL

# Read more

- **Storing a 3D city model, its levels of detail and the correspondences between objects as a 4D combinatorial map.** Ken Arroyo Ohori, Hugo Ledoux and Jantien Stoter. *Proceedings of the ISPRS WG II/2 Workshop*, October 2015.
- **Modelling a 3D city model and its levels of detail as a true 4D model.** Ken Arroyo Ohori, Hugo Ledoux, Filip Biljecki and Jantien Stoter. *ISPRS International Journal of Geo-Information* 4(3), September 2015, pp. 1055–1075. ISSN: 2220–9964.

# Thank you!

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