A Framework for Mesh Segmentation and Annotation using ontologies

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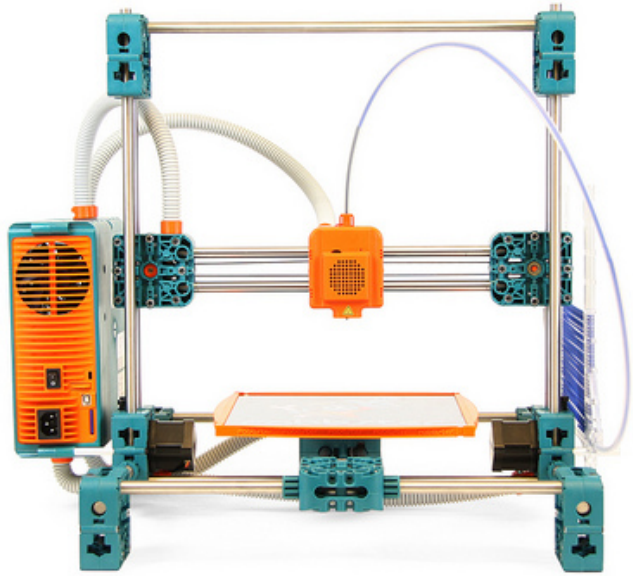
Segmentation and annotation

reconnaître ce que l'on regarde

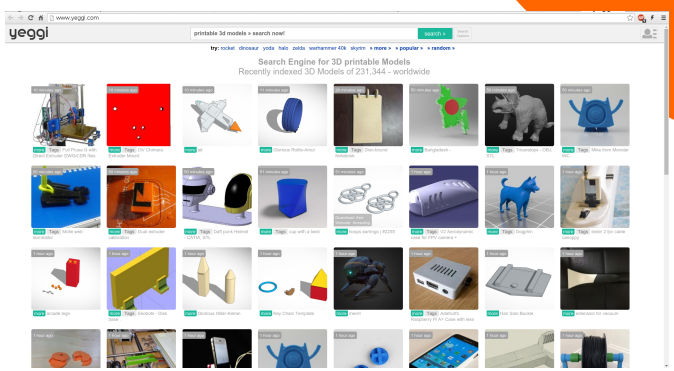
3D objects

Accumulation de données

3D scanners



3D printer

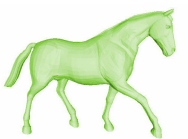


database

augmented reality,
virtual reality

Questions associated to 3D objects

Comment traiter ces données?

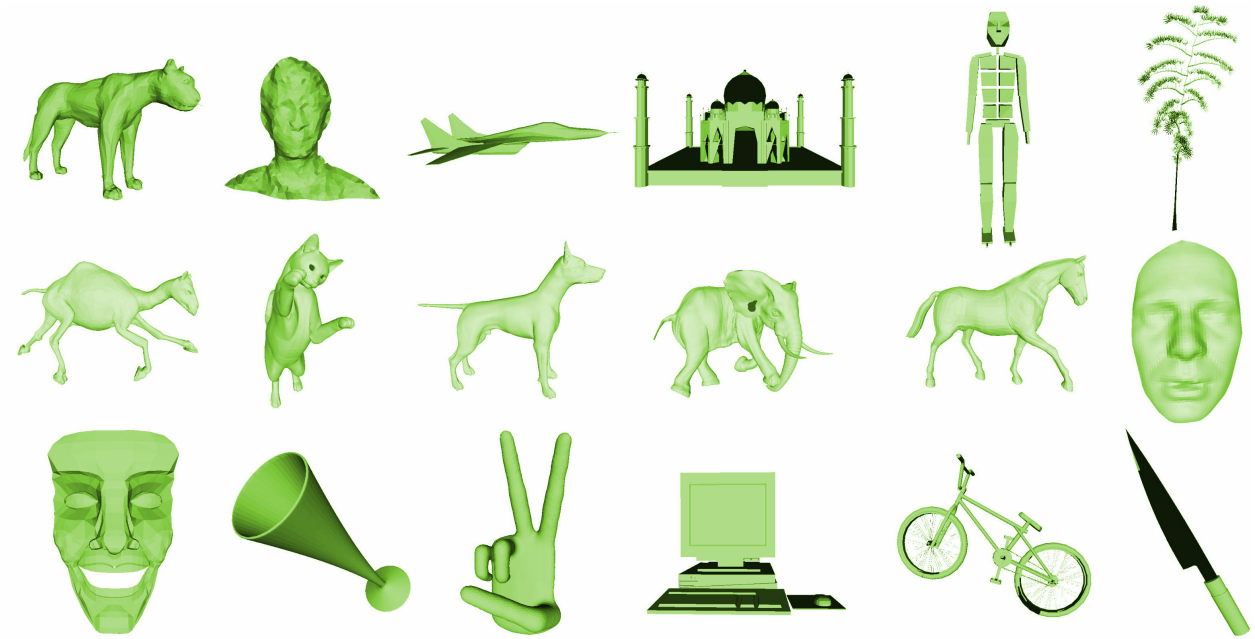


?

- Retrieval
- Recognition

Recognize 3D objects

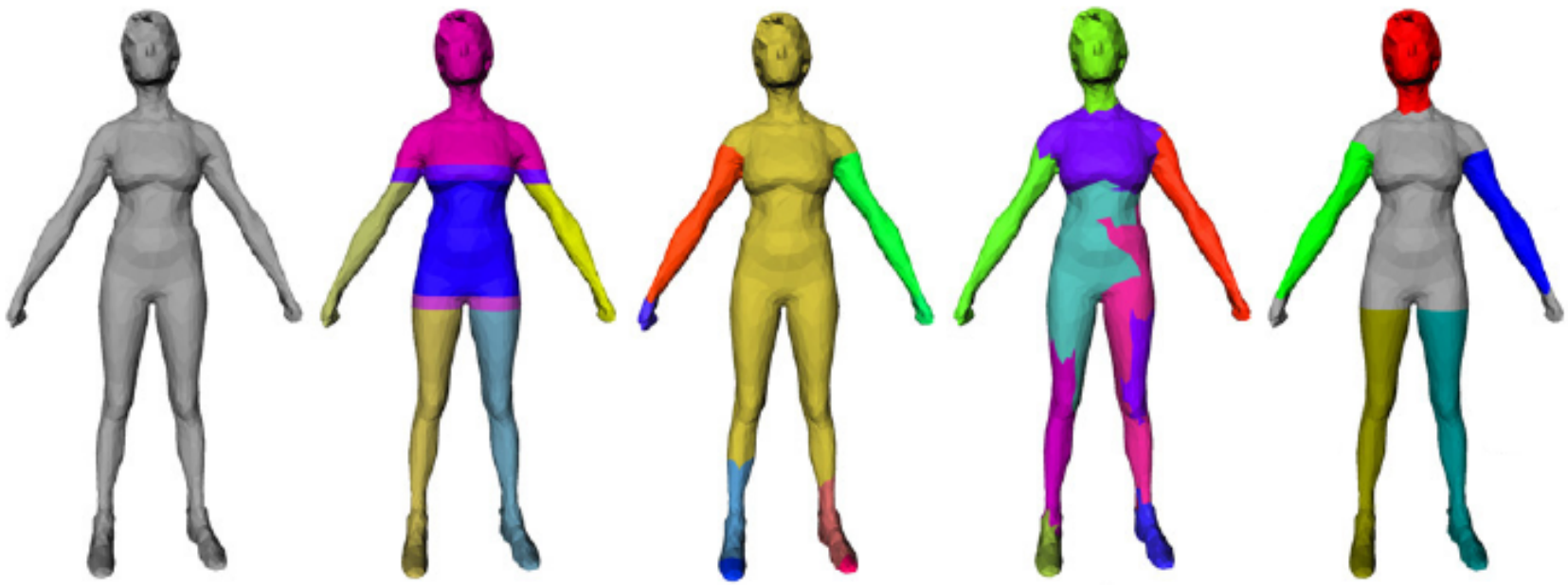
Éléments d'aide à la reconnaissance



- structure footage, humanoid, ...
- global shape svelte, wide, ...
- subpart shape flat, lying, convex, ...
- functionalities seat, handle, ...

Segmentation

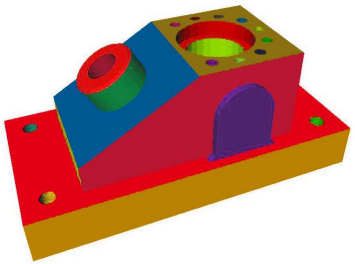
Décomposition en régions élémentaires



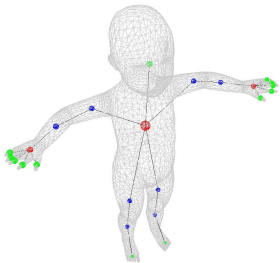
Classical ingredients for classification

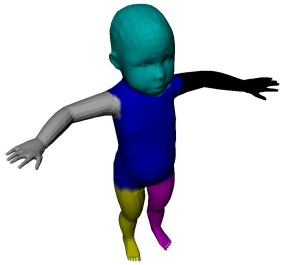
Ce qui existe

Identify **local structures**

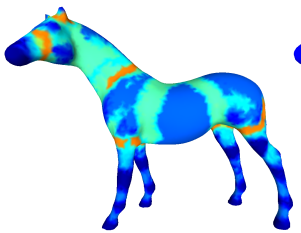


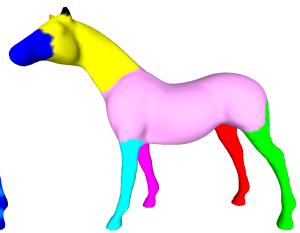
Identify **primitives**





Segmentation using **global structures** and geometry

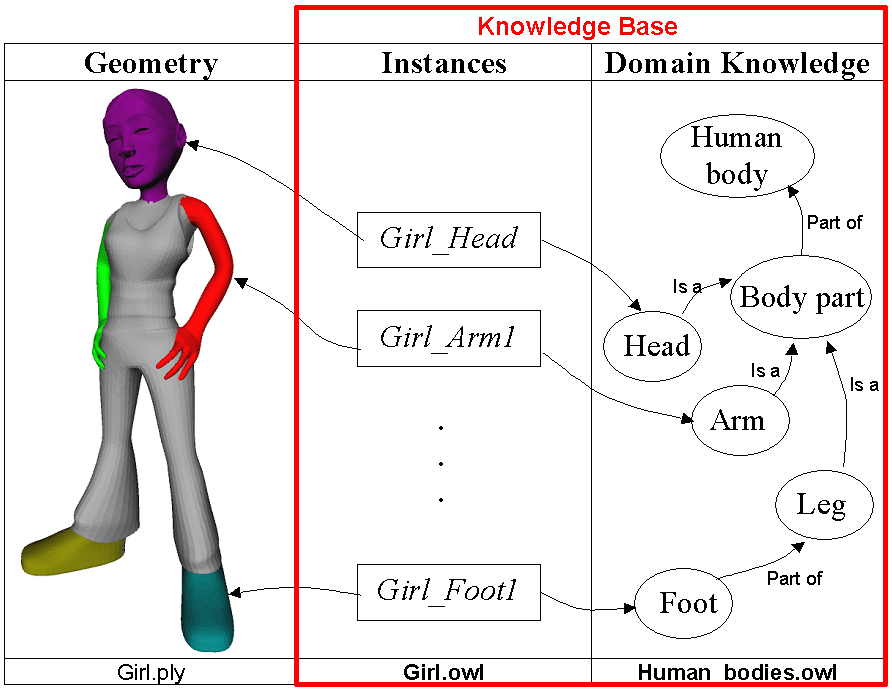




local feature descriptors and learning

Semantic is significant

Structurer les connaissances



Semantic allows:

- Impose **structure constraints**
- **Abstract** the recognized subparts
- Limit **possible deformations**
- Facilitate **search**

Semantic region

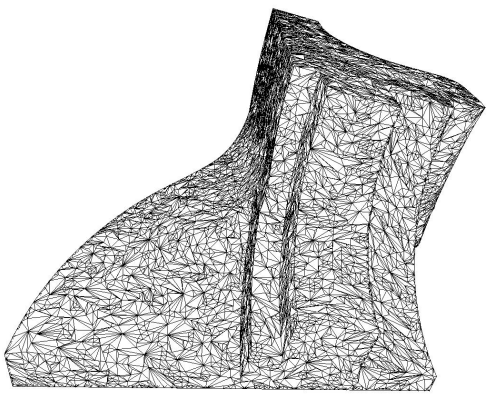
Geometric and expert characterization

Separate expert knowledges

Le traiteur de maillage et l'anatomiste

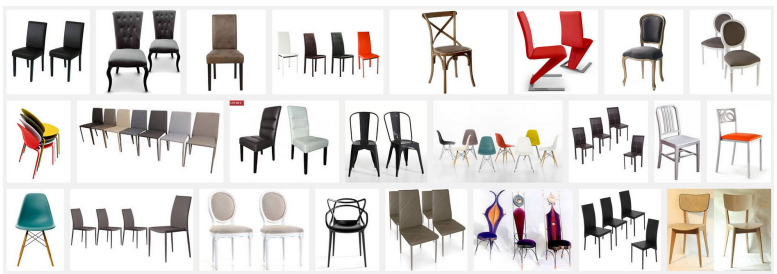
local, **global**, **structure** characterization:

- uniform *wrt* local property
- Smooth, curved region
- Connexions, branches, topology



Semantic to describe regions, de cohesion:

- arm, nut, backrest, ...
- Board, stick, ...
- Foot not connected to an head
- Bladder below uterus



Mimic human:

combine shape recognition and the use of context

Need of a generic framework

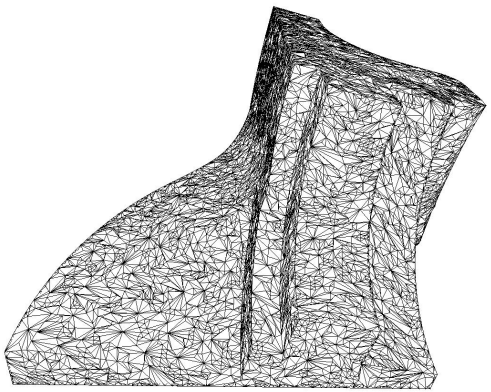
Recentrer l'expert sur son domaine

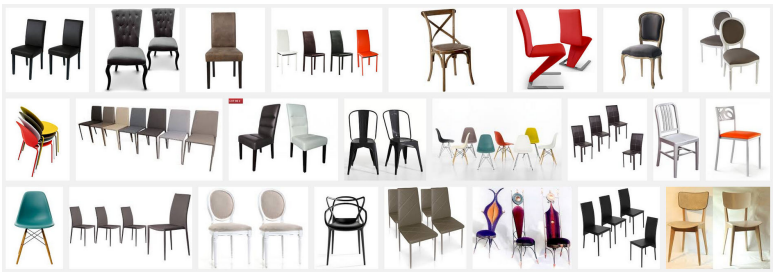
For the applicative domain expert:

- Provide a tool for **high level segmentation**
- **Independence** *wrt* algorithms

For the mesh processing scientist:

- **Categorize** the existing algorithms
- Identify **missing algorithms**
- **Split** mesh processing questions





Generic framework proposal

Structuration multi-niveaux

S_0 Characterization

- Generic ontology: color and geometry properties

Generic framework proposal

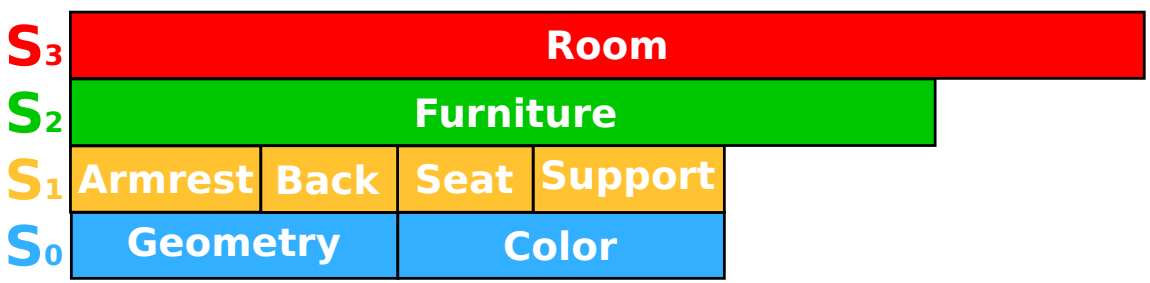
Structuration multi-niveaux

- S_0 Characterization
- S_1 Identification
  - Applicative context ontology (expert knowledge, semantic)
  - objects described in S_0
  - can be enumerated (*e.g.* #feet = #shapes × #colors)

Generic framework proposal

Structuration multi-niveaux

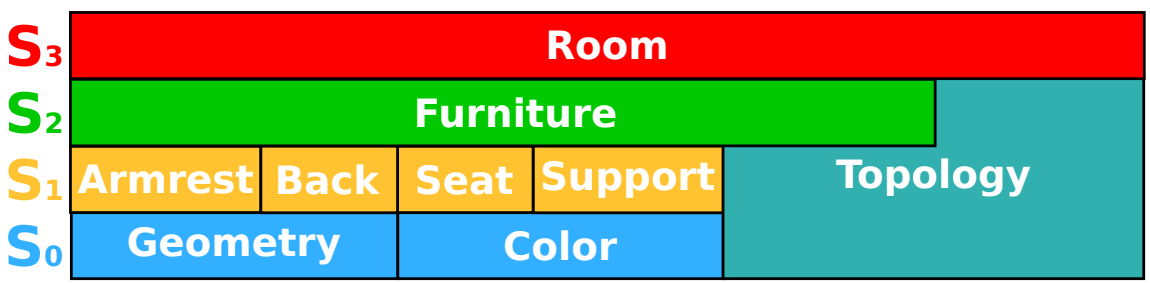
- S_0 Characterization
- S_1 Identification
- S_n Assembly
  - Applicative context ontology (expert knowledge, semantic)
  - combining S_{n-1} objects
  - can be enumerated (*e.g.* chair) or not (*e.g.* room)



Generic framework proposal

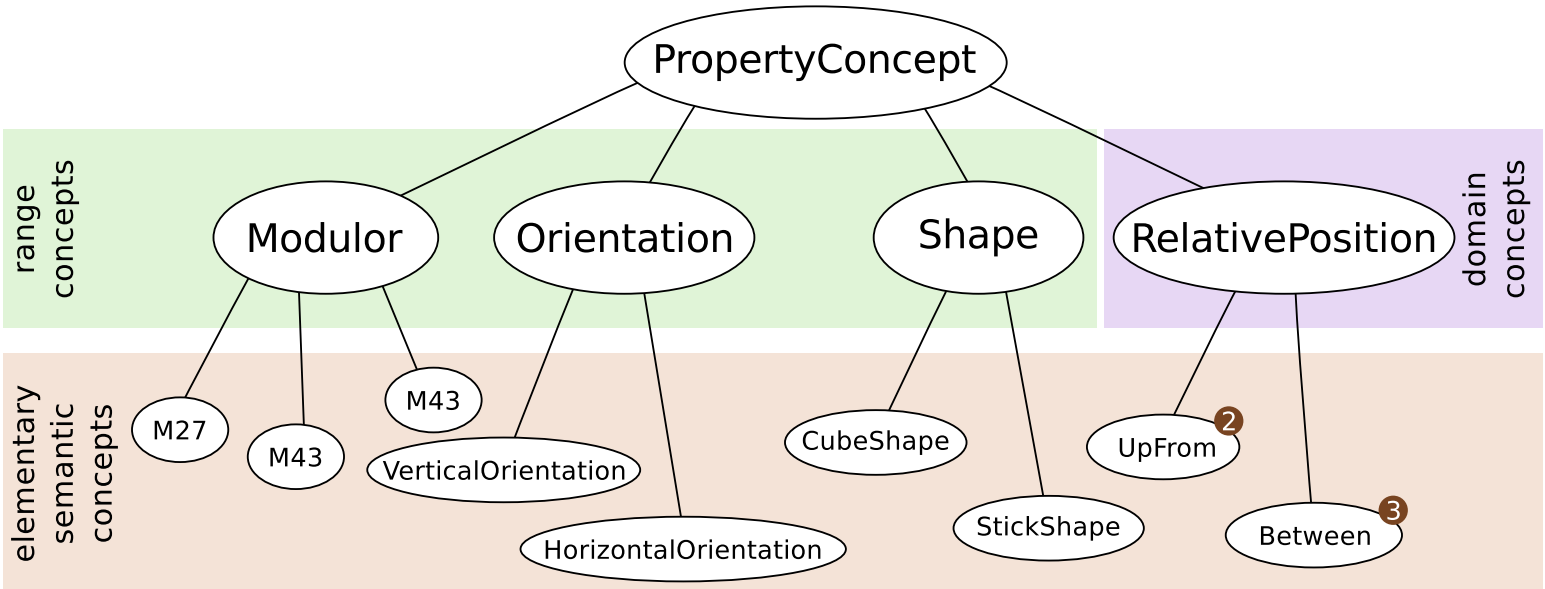
Structuration multi-niveaux

- S_0 Characterization
- S_1 Identification
- S_n Assembly
  - Topology
    - relationships between objects
    - can be used at each S_n layer

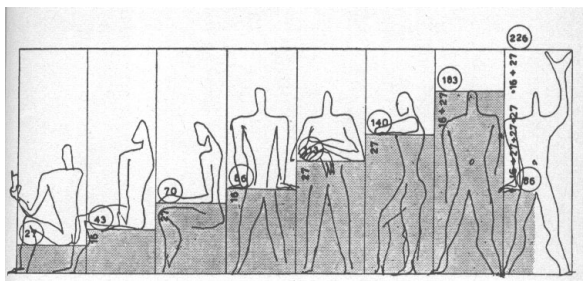


Elements to define S_0 layer

Les propriétés à associer aux régions

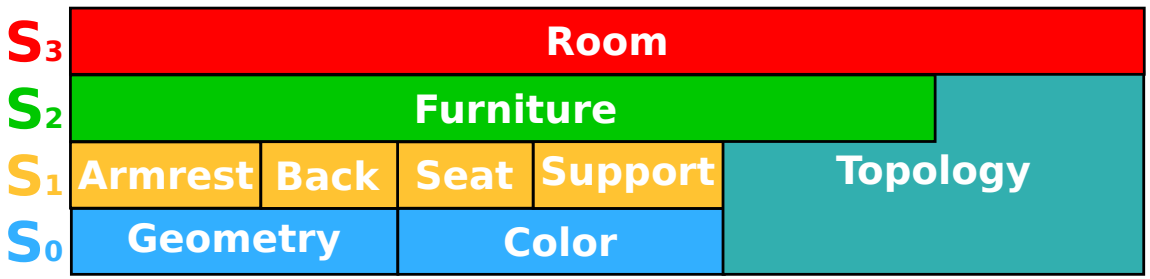


- Unary concepts geometry, color
- *n*-ary concepts topology, distance, relative location



Definition of next layers

Ce qu'exprimera l'expert



- Express links between layers using **equivalences**

  combining S_{n-1} concepts to describe S_n layer: *the leg of a chair is a vertical stick*

- Describe **possible and impossible configurations**

  define impossible configurations: *an headrest without backrest is impossible*

Segmentation driven by expert knowledge

piloter la segmentation par la sémantique

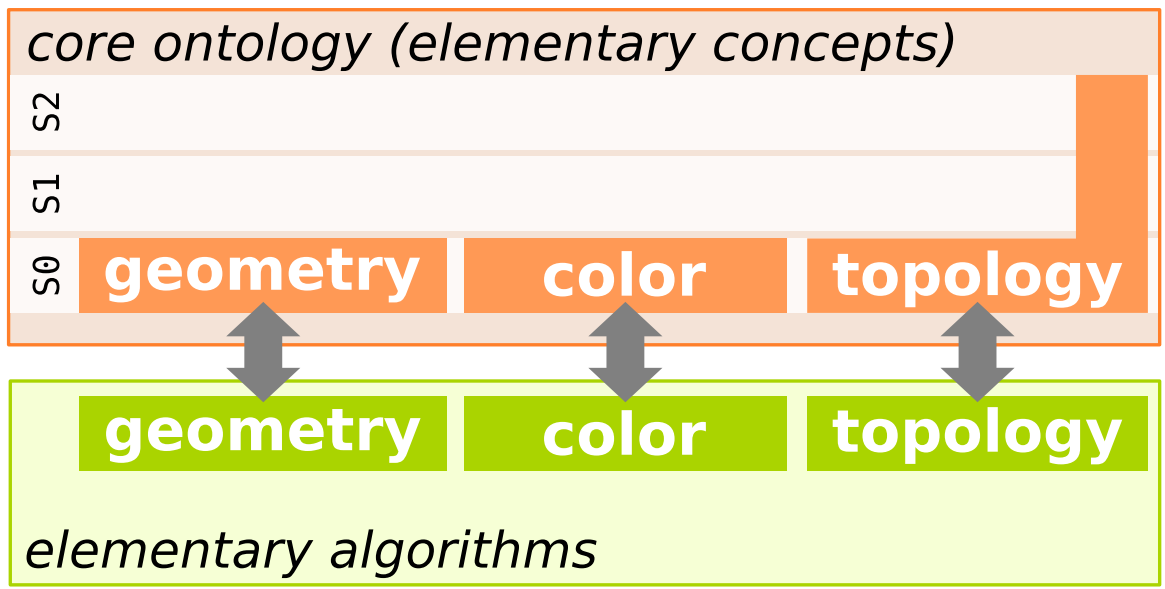
Introduction to elementary algorithms

Atomiser le savoir-faire des traiteurs de maillage

identify *an algorithm for each elementary concept*

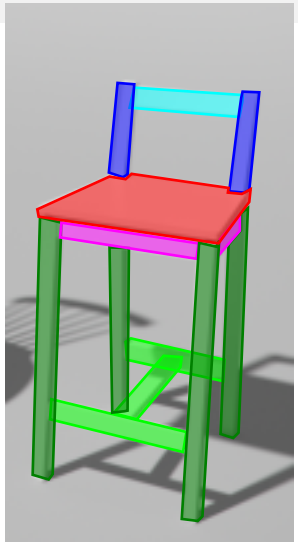
$\simeq$

categorize and filter existing algorithms +
identify missing algorithms



Type signature of elementary algorithms

Cataloguer ce que l'on peut faire



Distinguish between algorithms:

- search regions with a given property: *semantic find all*

  find all rectangle in region $\mathcal{A}$

- search regions with an n-ary property: *topological find all*

  find all regions between $\mathcal{A}$ and $\mathcal{B}$

- verify an unary property on a region: *semantic is a*

  is $\mathcal{A}$ a flat region?

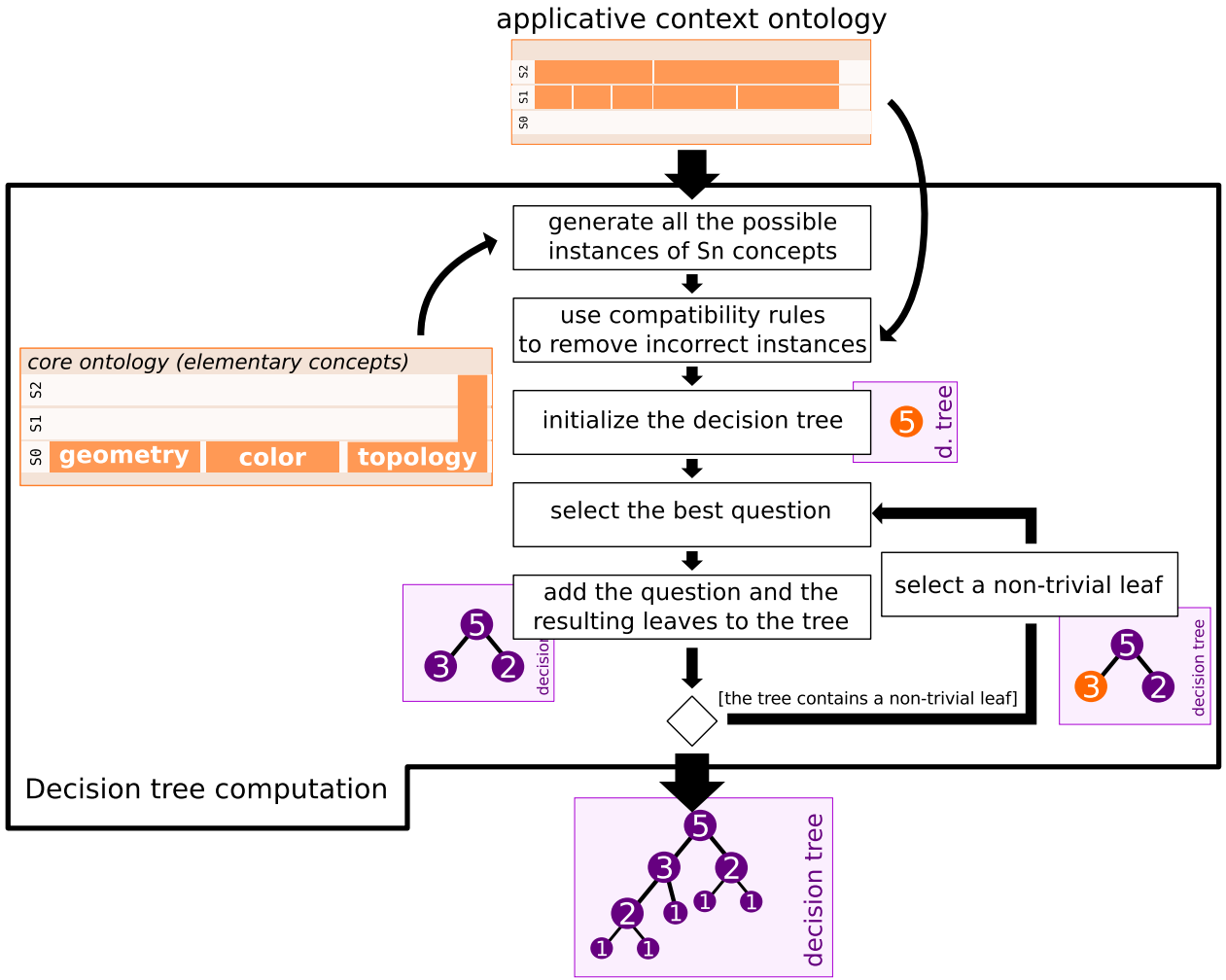
- verify an n-ary property between several regions: *topological is a*

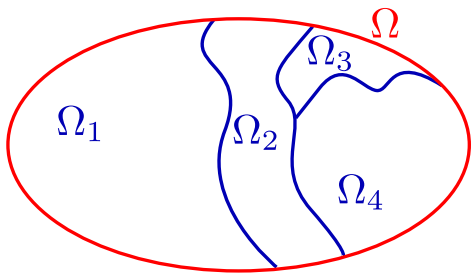
  are $\mathcal{A}$ and $\mathcal{B}$ connected?

Describing results using fuzzy maps

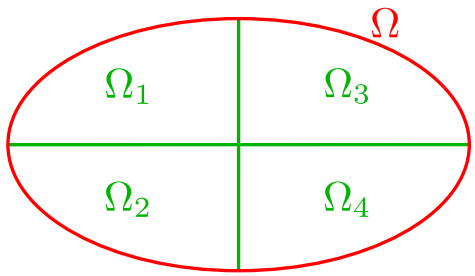
Decision tree generation

Pré-choisir les algorithmes





wrt algorithm 1

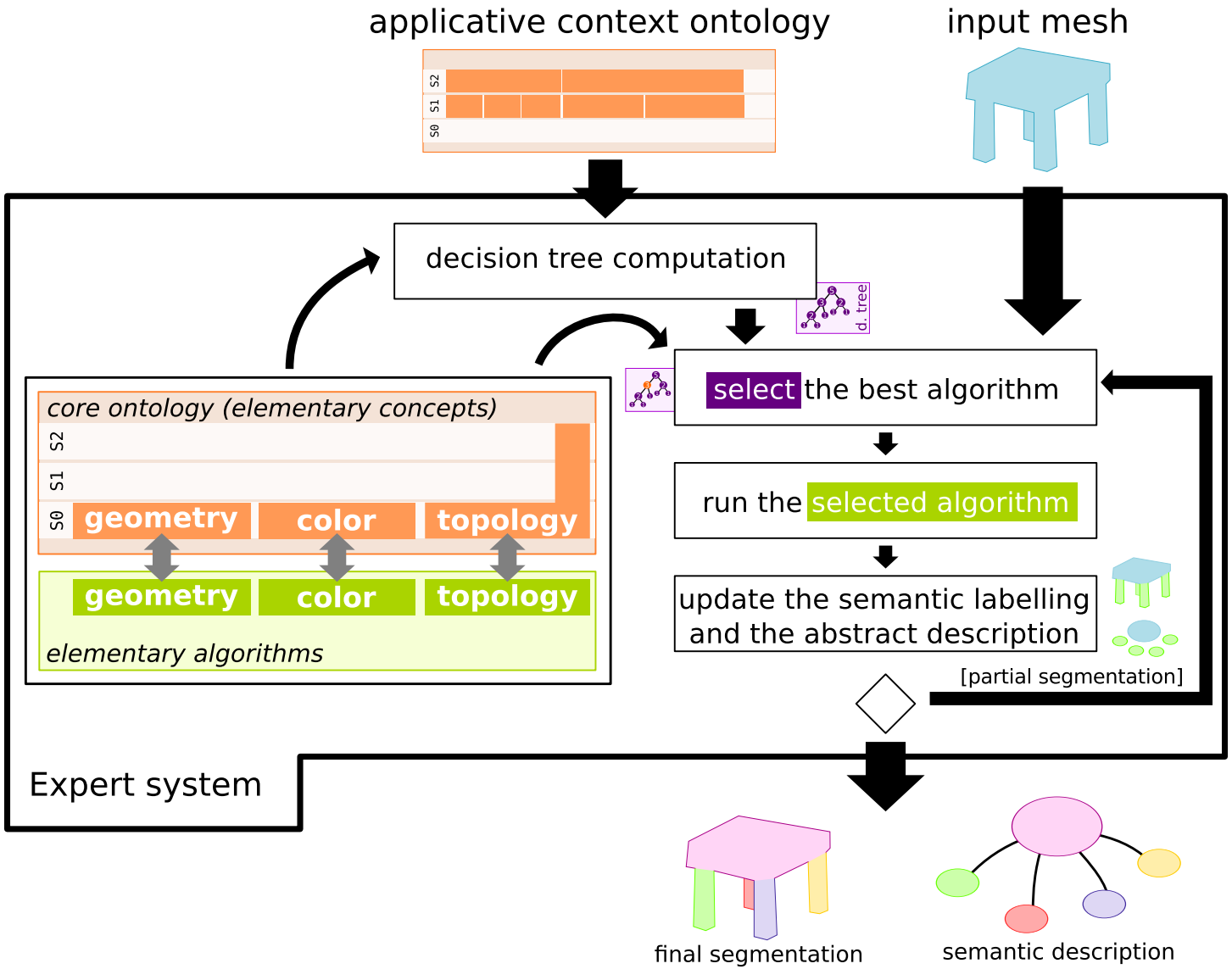


wrt algorithm 2

At each step choose the **most dichotomic algorithm** in the space of possible instances

Joint segmentation, labelling and identification

On passe à l'action

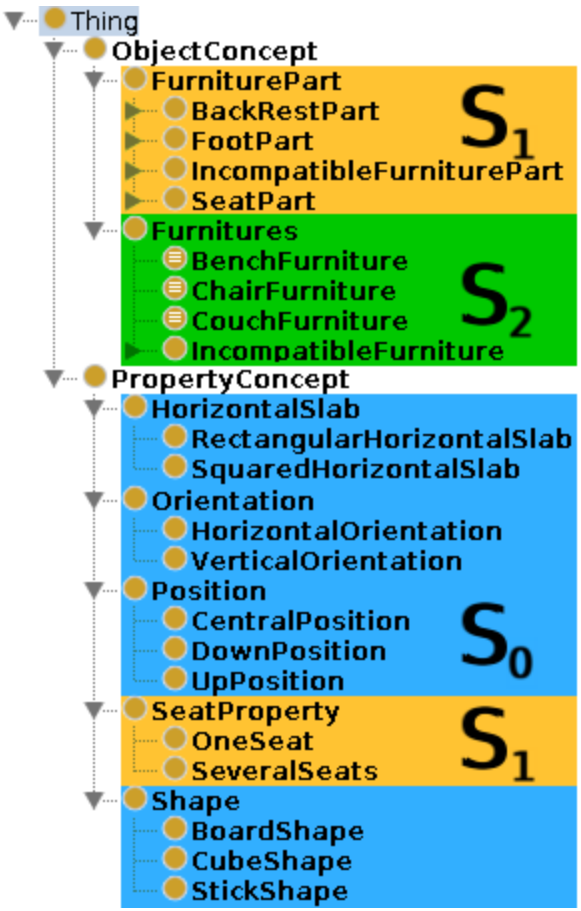


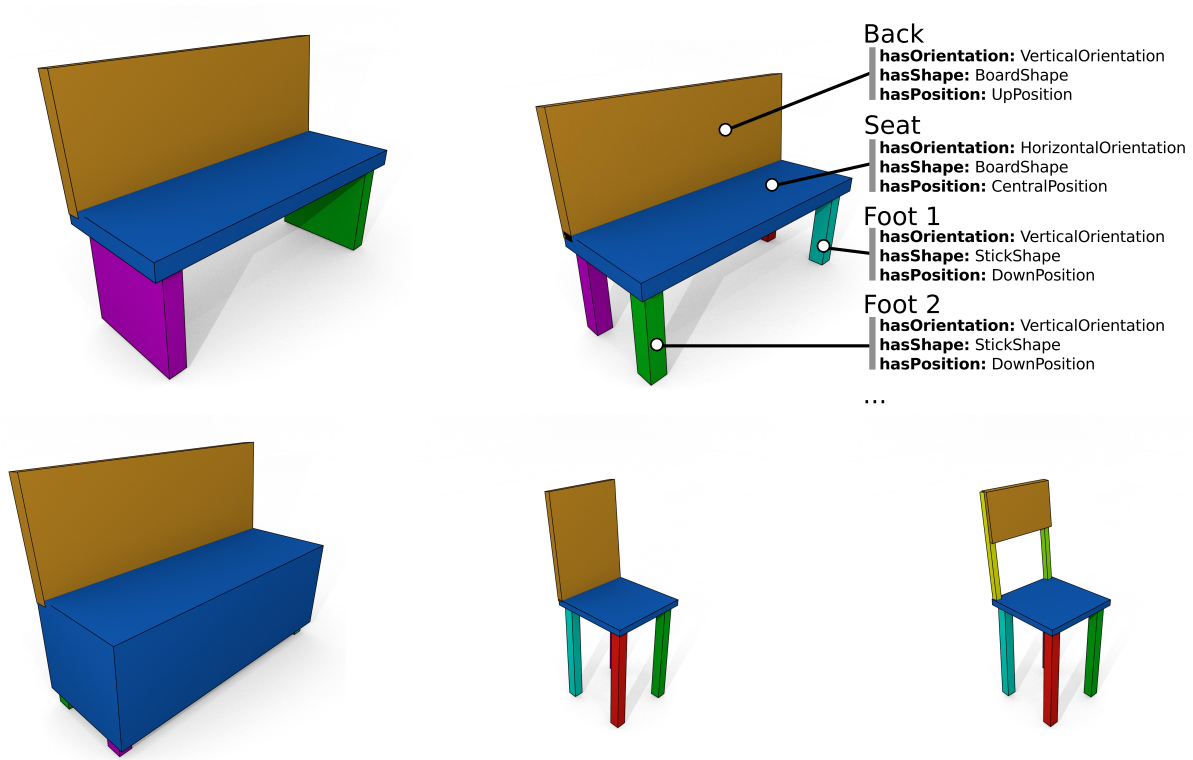
Experimental results

Results and perspectives

Proof of concept

Contexte applicatif du mobilier





A simple example

Quel est cet objet?

R0

R1

R2

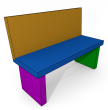
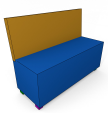
R3

R4

1. `SF OneSeat` in R0: false
2. `SF VerticalOrientation` in R0
   - R1: true
   - R2: true
   - R3: true
3. `SI DownPosition` R1: false
4. `SI DownPosition` R2: true
5. `SI DownPosition` R3: true
6. `SI StickShape` R2: false
7. `SI StickShape` R3: false
8. `SI DownPosition` R1: false
9. `SI BoardShape` R1: true
10. `SI BoardShape` R2: true
11. `SI BoardShape` R3: true
12. `SI BoardShape` R0 - {R1, R2, R3}
    - R4: true

First evaluation

Réduire la complexité

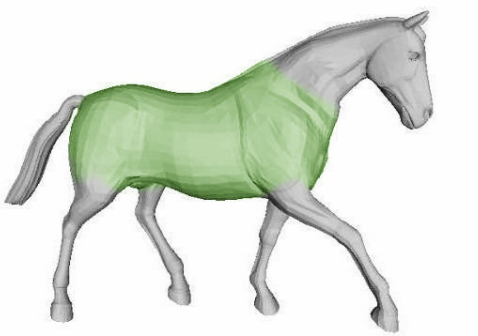
Object	#subparts	S. then I.		Naive S&I		our method	
		preprocessing		-		-	
		# SF	# SI	# SF	# SI	# SF	# SI
	4	0	21	9	0	2	10
	6	0	31	9	0	3	13
	6	0	31	9	0	3	14
	6	0	31	9	0	2	15
	8	0	41	9	0	2	19

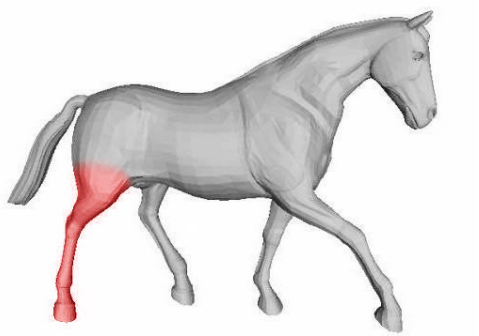
Number of steps required for a full segmentation

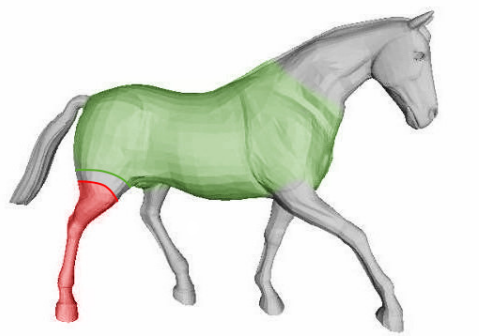
Perspectives

Parce que nos machines ne sont que des automates

- Implement elementary algorithms
- Describe more contexts with multi-layer ontologies
- Introduce fuzzy results:
  - Drive segmentation adjustment
  - Sort using semantic proximity







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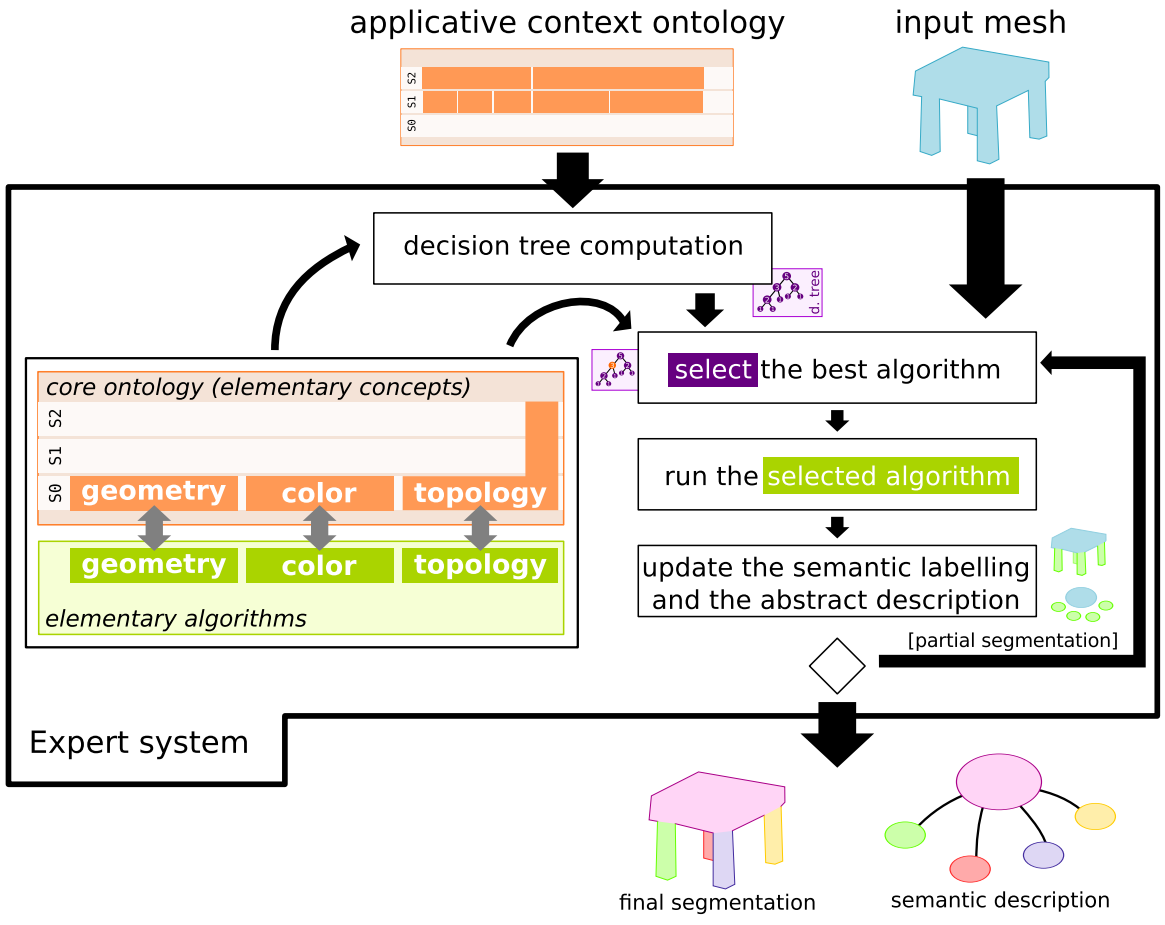

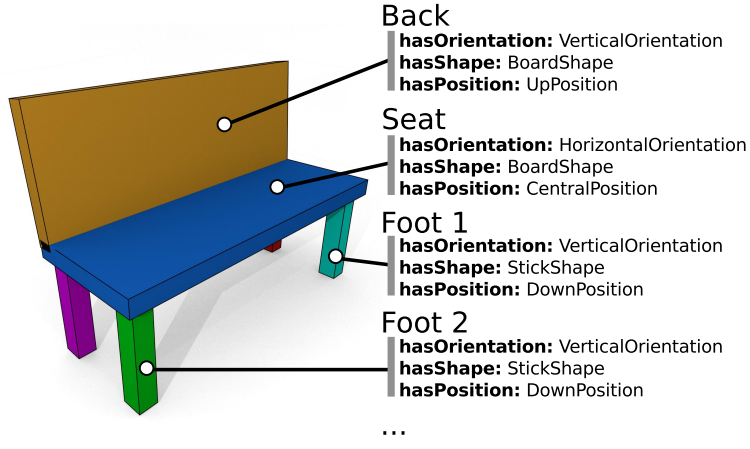

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