

Multi-Label Simple Points Definition for 3D Images Digital Deformable Model

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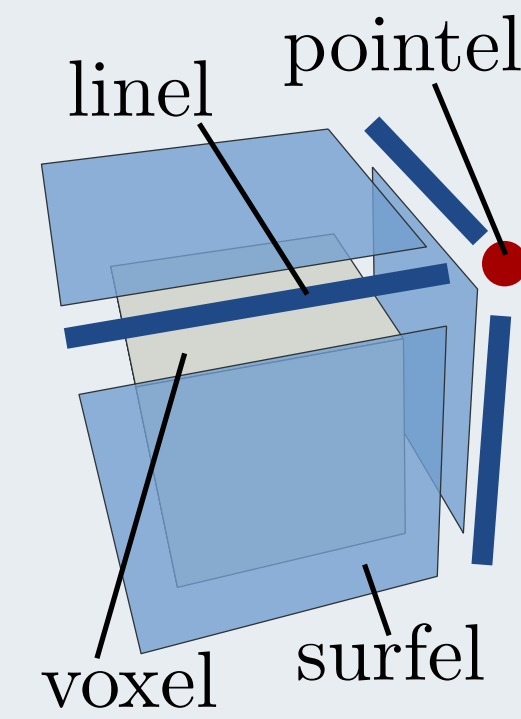
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Goal & Solution

Deformation of images without modifying topology of the partition:

- ▢ Definition of multi-label simple points:
 - use intervoxel elements to represent boundaries of the partition;
 - allow geometrical modification of faces;
 - forbid geometrical modification around edges and vertices.
- ▢ Deformation algorithm based on ML-Simple points.

Intervoxel



Notations

- ▢ Intervoxel elements in a matrix
- ▢ surfel *on* : between two different regions
- linels*(*v*) : linels incident to voxel *v*;
- sf*(*v*) : surfels *on* incident to voxel *v*;
- degree*(*l*) : #surfels *on* incident to line *l*;
- degree*(*l*, *v*) : #surfels *on* incident to line *l* ∈ *sf*(*v*).

Definition of ML-Simple Points

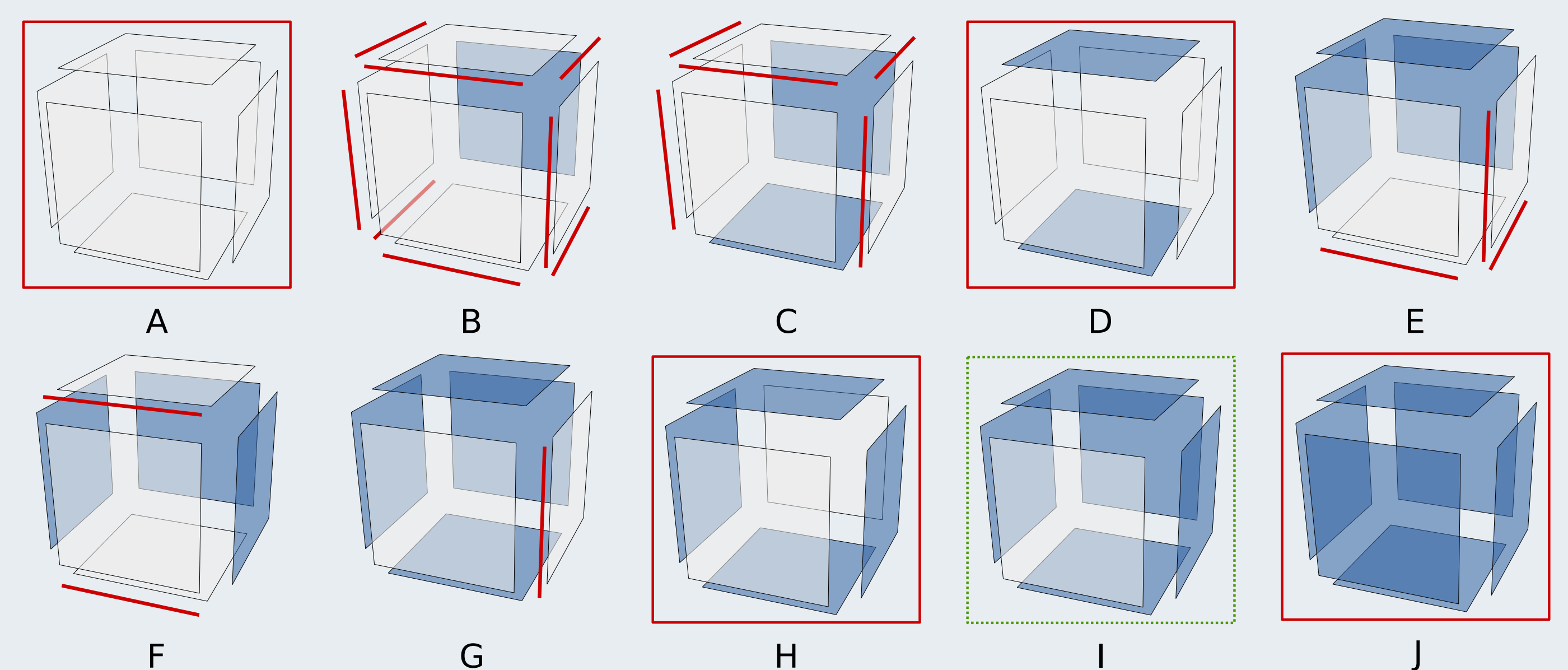
A voxel *v* is ML-Simple if:

1. $\forall l \in \text{linels}(v), \text{degree}(l) \in \{0, 2\}$;
2. the body of *sf*(*v*) is homeomorphic to a 2-disk;
3. $\forall l \in \text{linels}(v), \text{degree}(l, v) = 0 \Rightarrow \text{degree}(l) = 0$.

Main Properties

- ▢ $v \in R$ is a ML-Simple point $\Rightarrow v$ is a simple point for *R*.
- ▢ v is a ML-Simple point \Leftrightarrow topology of the image partition is invariant by swapping *v*.

3D Cases



Energies

Surface Energy : Naive Area Estimator

- ▢ based on the number of surfels of the surface;

Surface Energy : Discrete Area Estimator

- ▢ based on a discrete estimation of the surface:
 - use a discrete plane recognition algorithm;
 - give for each surfel an estimation of its contribution to the surface area.
- ▢ example of the contribution of surfels to the total area:

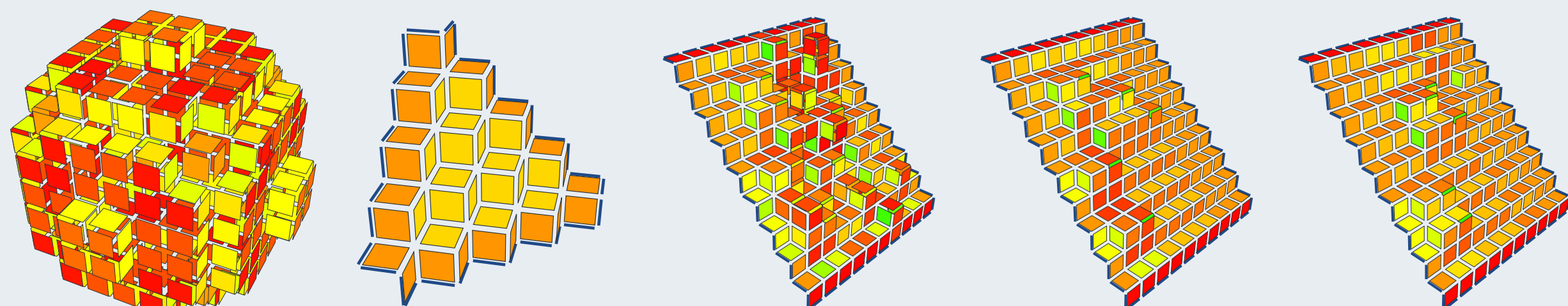


Image Energy

- ▢ based on voxel intensity:
 - use the Mean Square Error of regions.

Detection algorithm

Algorithm 1: Test if a voxel *v* is a ML-Simple point

Result: *true* iff *v* is a ML-Simple point.

```

foreach l ∈ linels(v) do
    if l is on then return false;
    if both surfels incident to l and v are off then
        if at least one surfel incident to l and not to v is on then
            return false;
if configuration of surfels is A, D, H, J then return false;
return true;
    
```

Conclusion

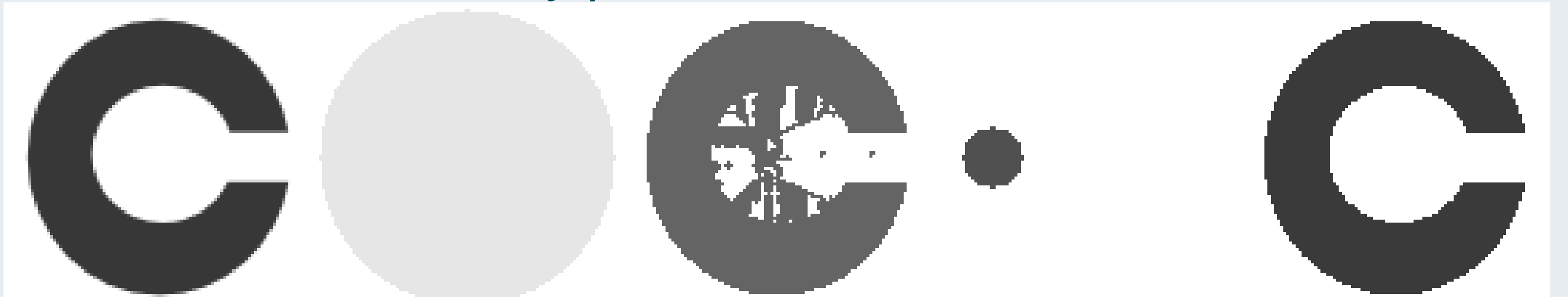
- ▢ definition of ML-Simple points:
 - with a simple local detection algorithm
- ▢ generic approach using topological maps:
 - energies can be defined using any information about regions and partition boundaries.
- ▢ works in arbitrary image partitions:
 - binary partitions or multi-label partitions;
 - with or without surface intersections.

Perspectives

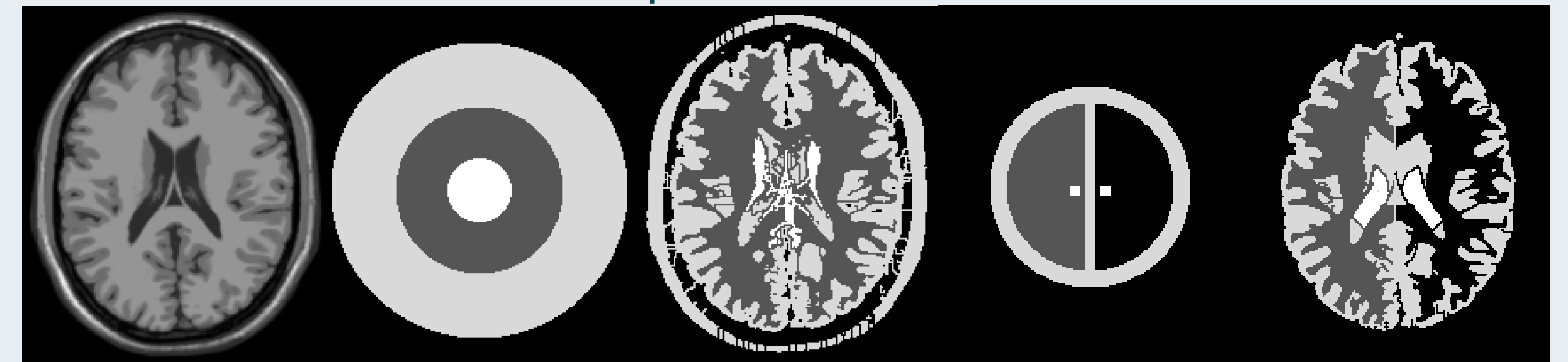
- ▢ allow deformation of surface intersection (edges, vertices);
- ▢ allow some topological changes while restraining other (eg. allow new cavities but forbid new tunnels);
- ▢ propose a definition of 2D ML-Simple points;
- ▢ use different energies.

Experiments

- ▢ Deformation of a binary partition



- ▢ Deformation in multi-label partition without surface intersections



- ▢ Deformation in multi-label partition with surface intersections

