Manifold Dual Contouring

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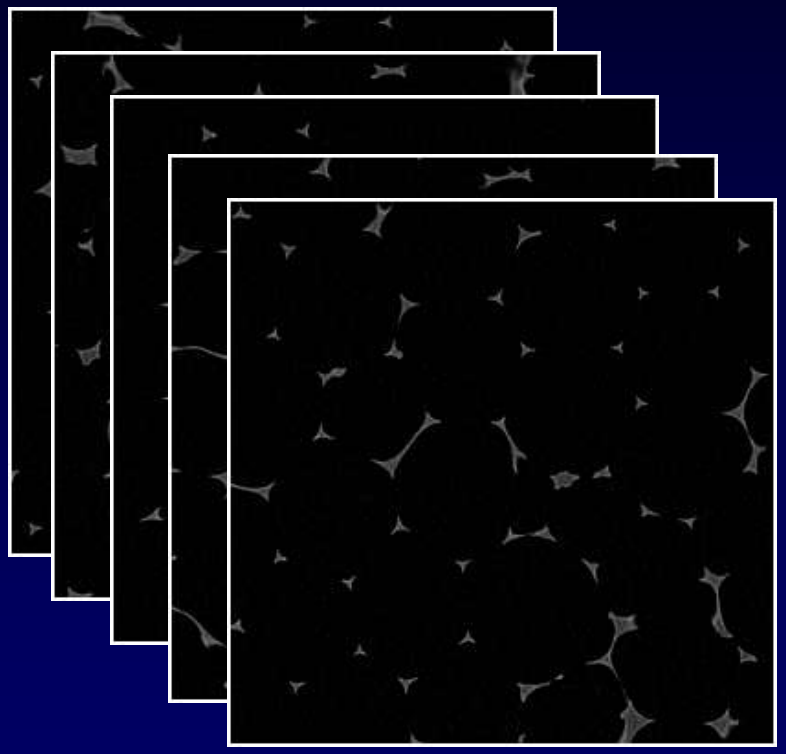
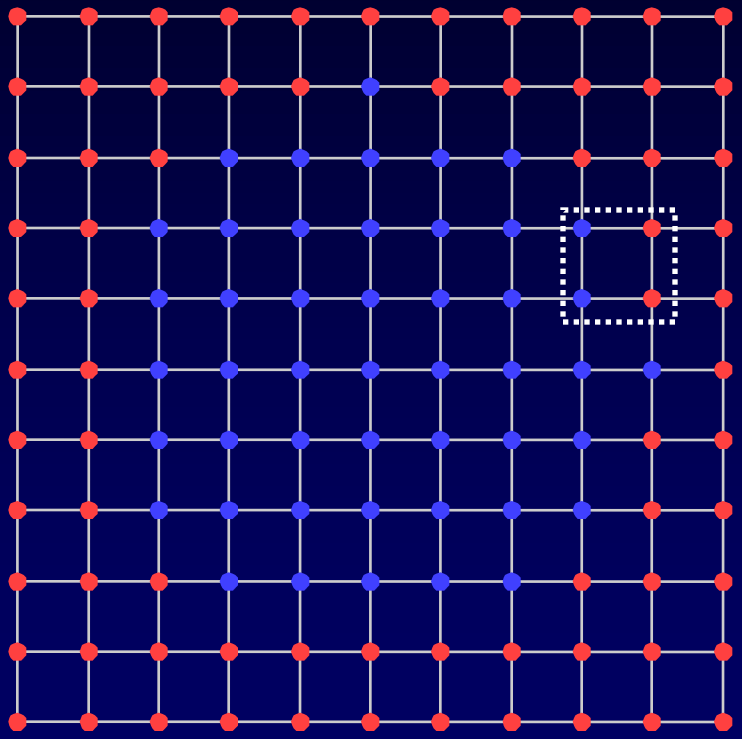
Implicit Modeling

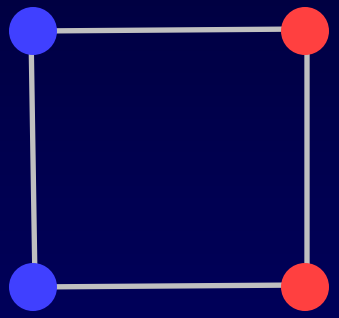


$$f(x) = 0$$

Dual Contouring

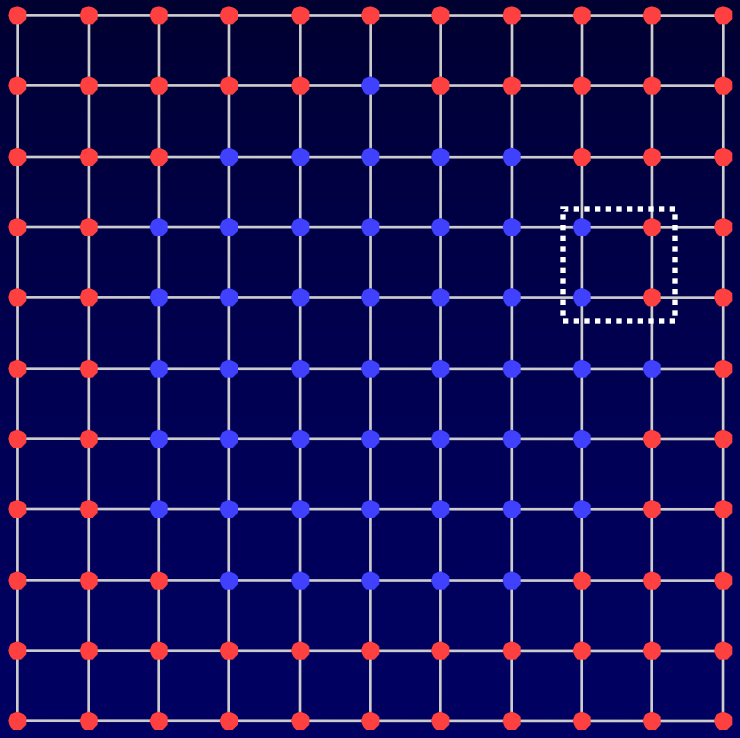
[Ju et al 2002]

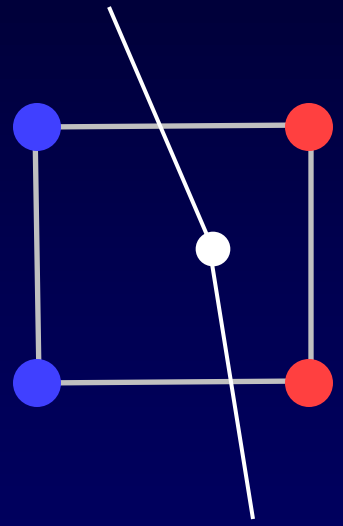




Dual Contouring

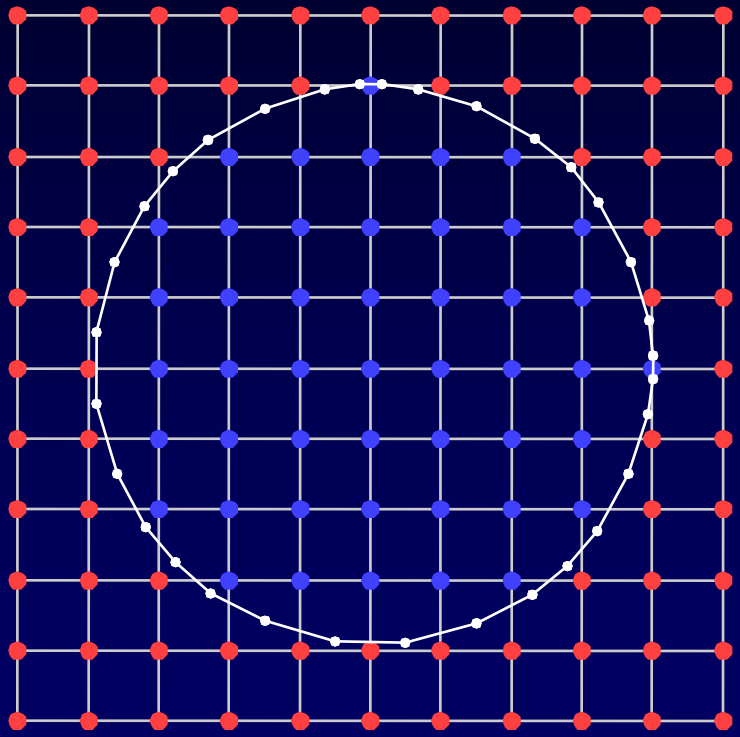
[Ju et al 2002]

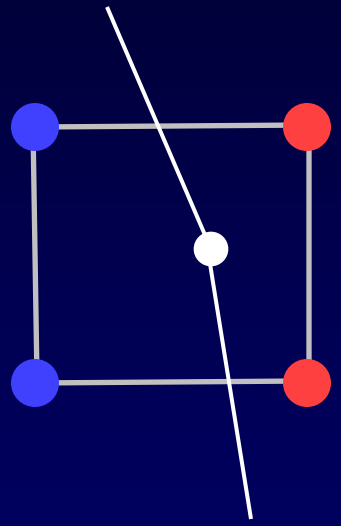




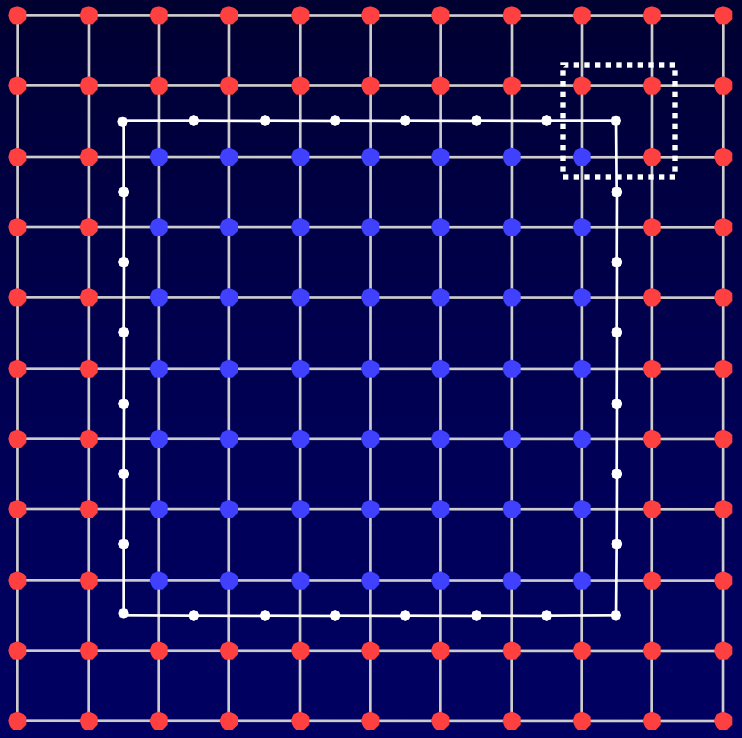
Dual Contouring

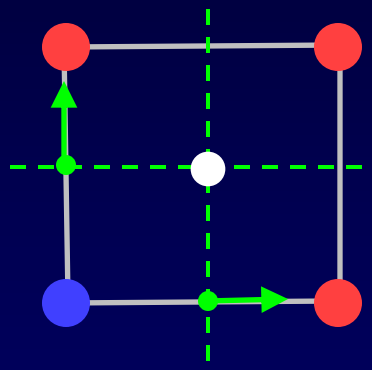
[Ju et al 2002]





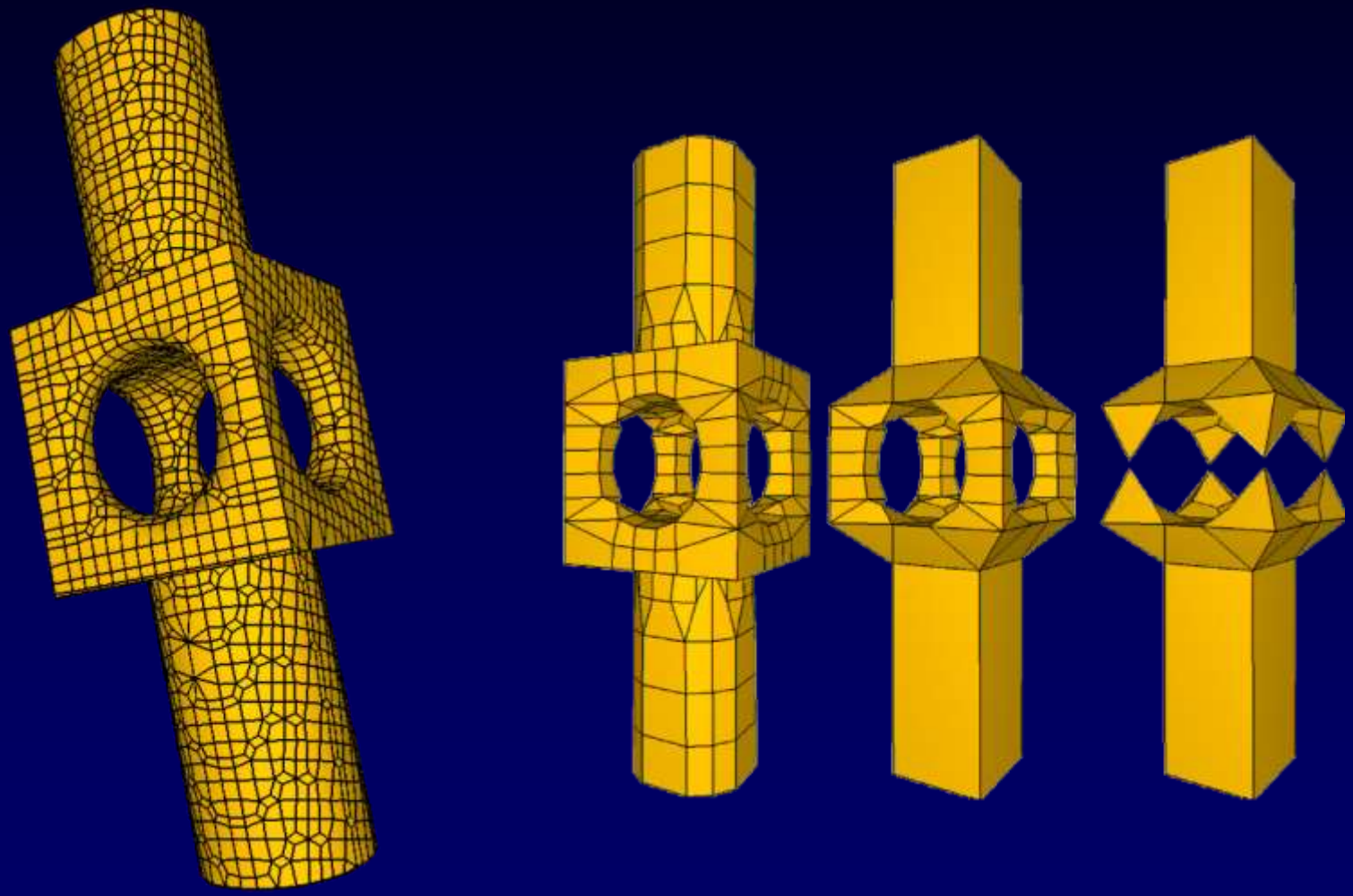
Sharp Features





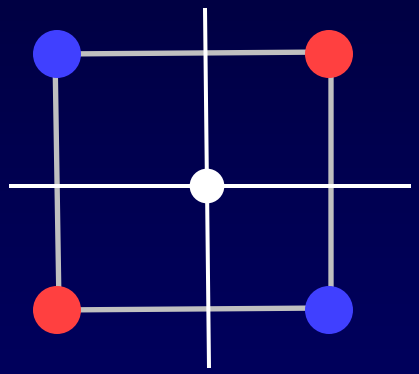
[Garland, Heckbert 1998]

Adaptive Surface Extraction

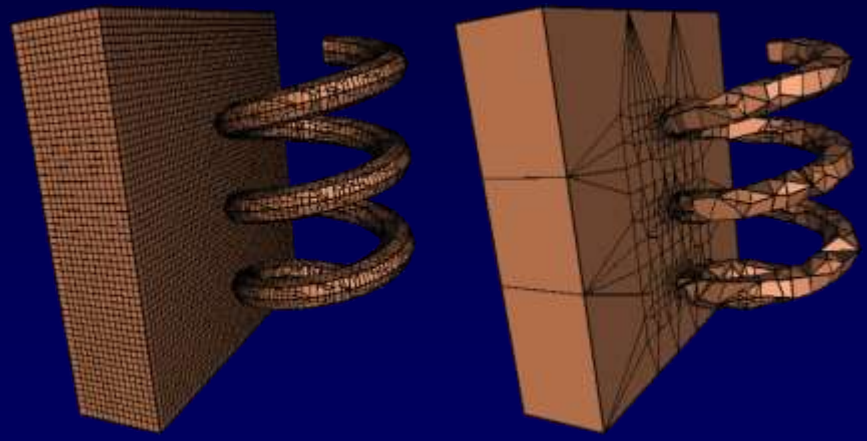


Problems with Dual Contouring

Non-Manifold Geometry



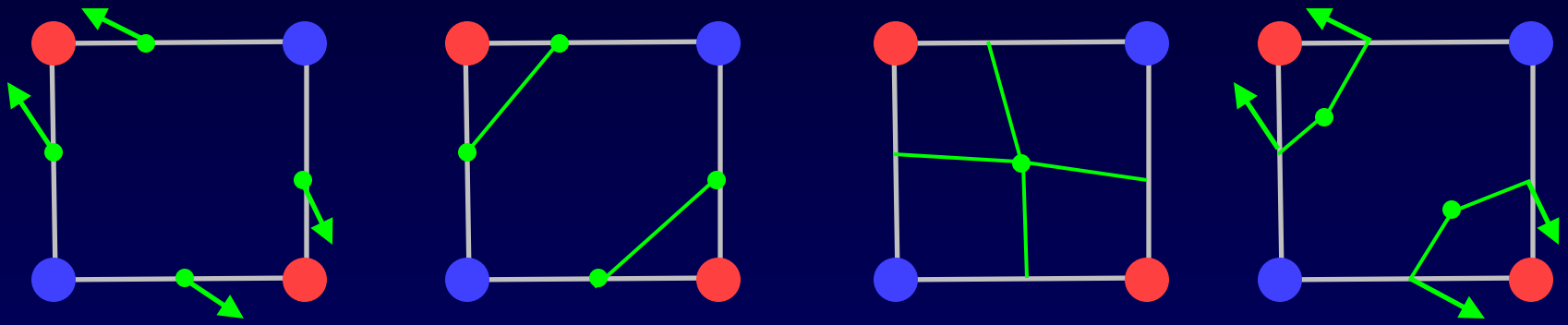
Conservative Topology Test



Previous Work

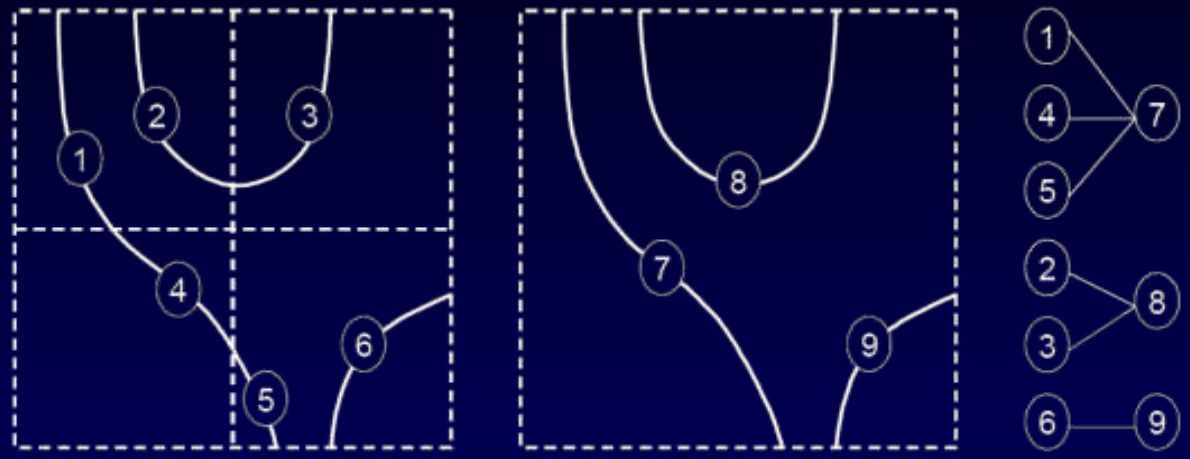
- DC with multiple surface components
  - [Varadhan et al 2003], [Ashida et al 2003], [Zhang et al 2004], [Nielson 2004], [Schaefer et al 2004]
- Vertex Clustering
  - [Rossignac et al 1993], [Low et al 1997], [Luebke 1997], [Lindstrom 2000], [Brodsky et al 2000], [Shaffer et al 2001], [Kanaya et al 2005]
- Topology-Preserving Contour Simplification
  - [Cohen et al 1996], [Ju et al 2002], [Lewiner et al 2004]

Manifold Assumption

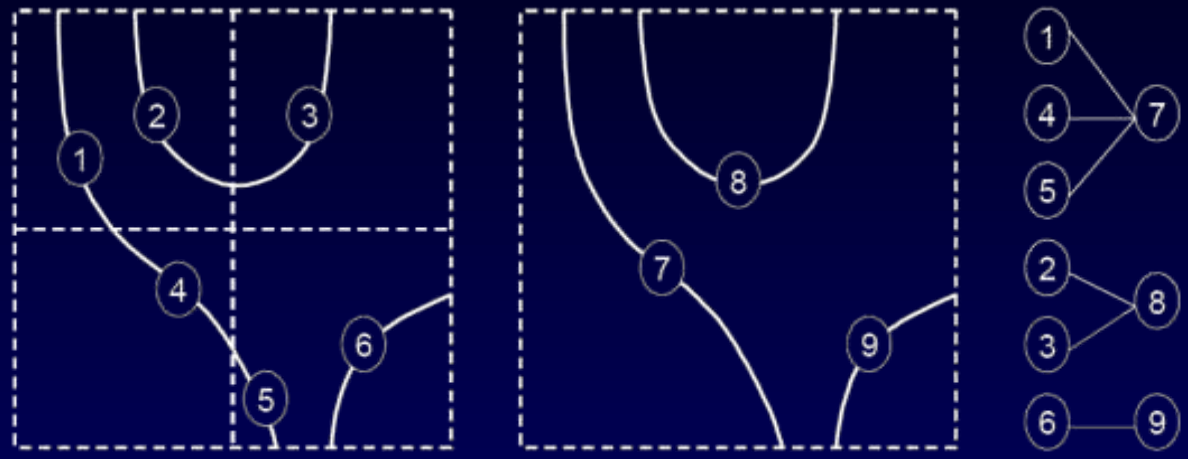


Original Data MC DC DMC

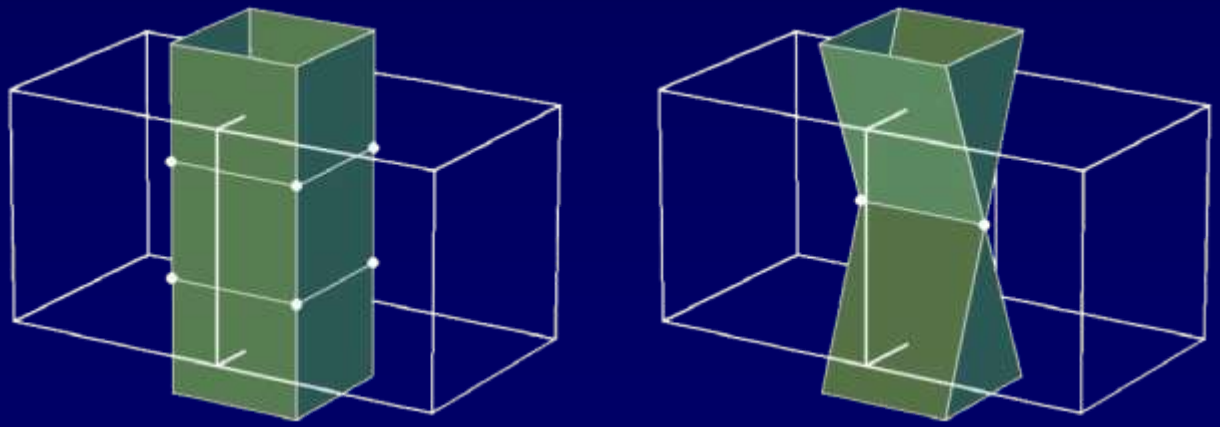
Vertex Clustering



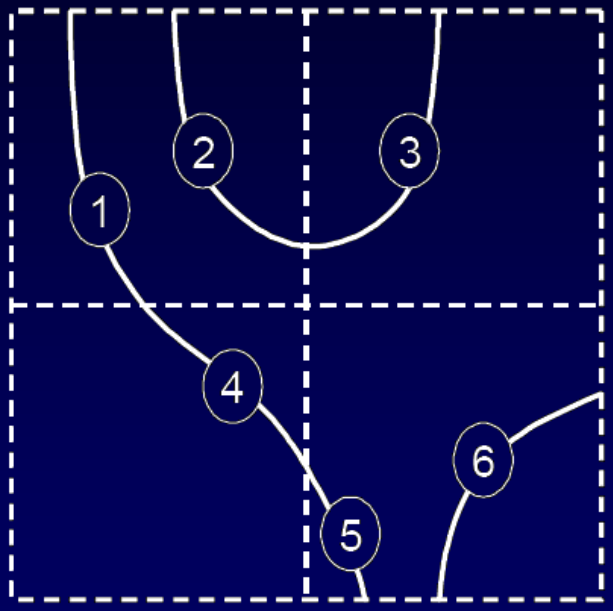
Vertex Clustering



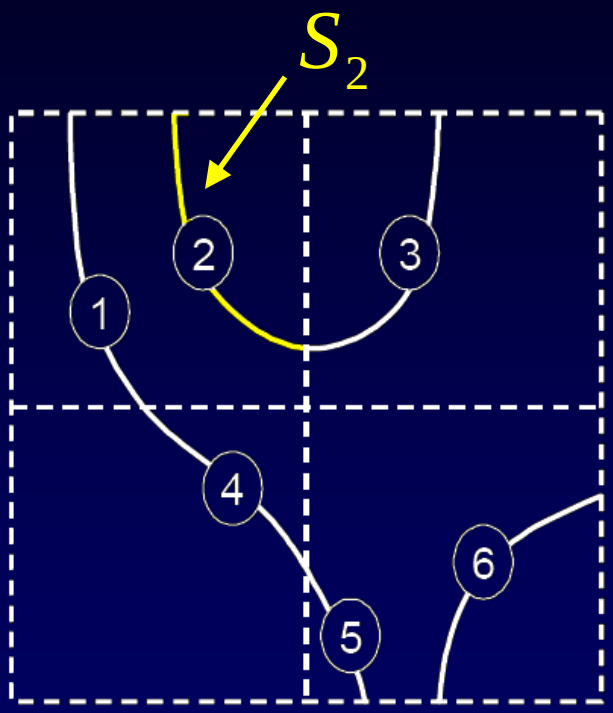
Not sufficient to prevent non-manifold geometry!



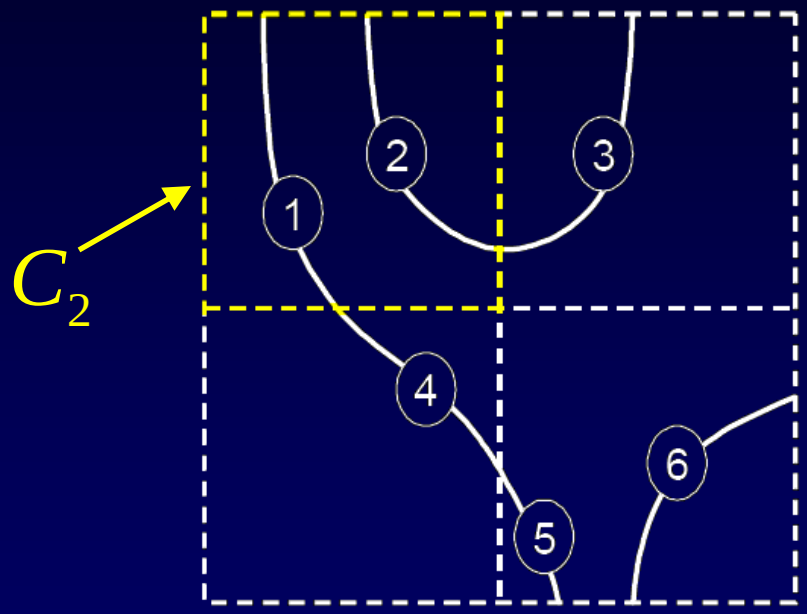
Topological Safety



Topological Safety



Topological Safety



Topological Safety

- A surface is a 2-manifold, if for every vertex
  - The number of intersections of S_v with the edges of each face of C_v is either 0 or 2
  - S_v is equivalent to a disk with a single, connected boundary

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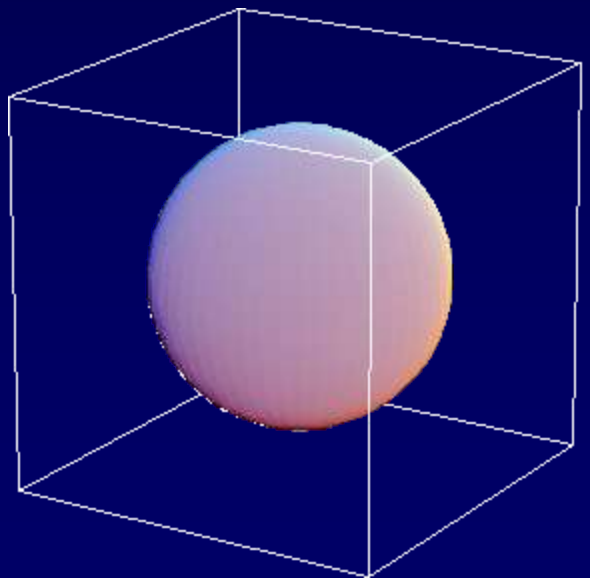
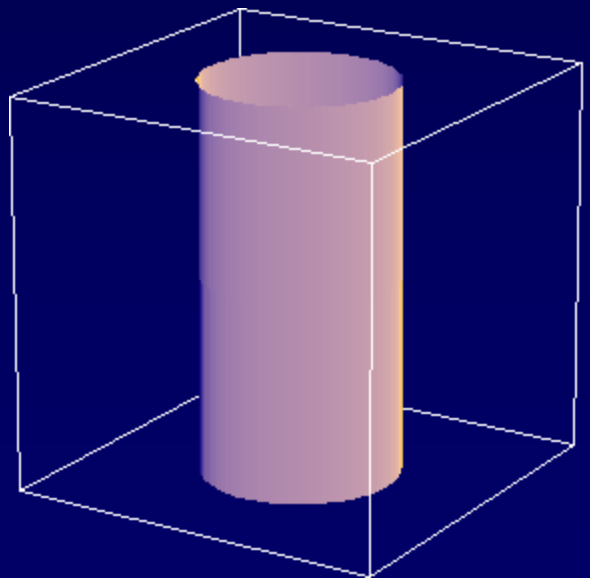
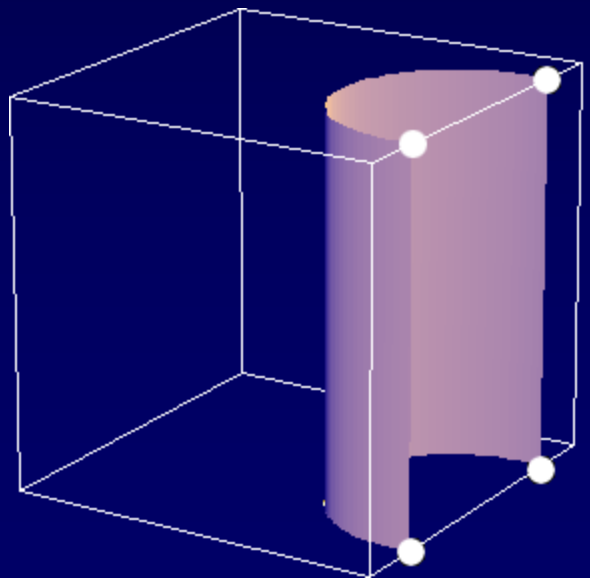
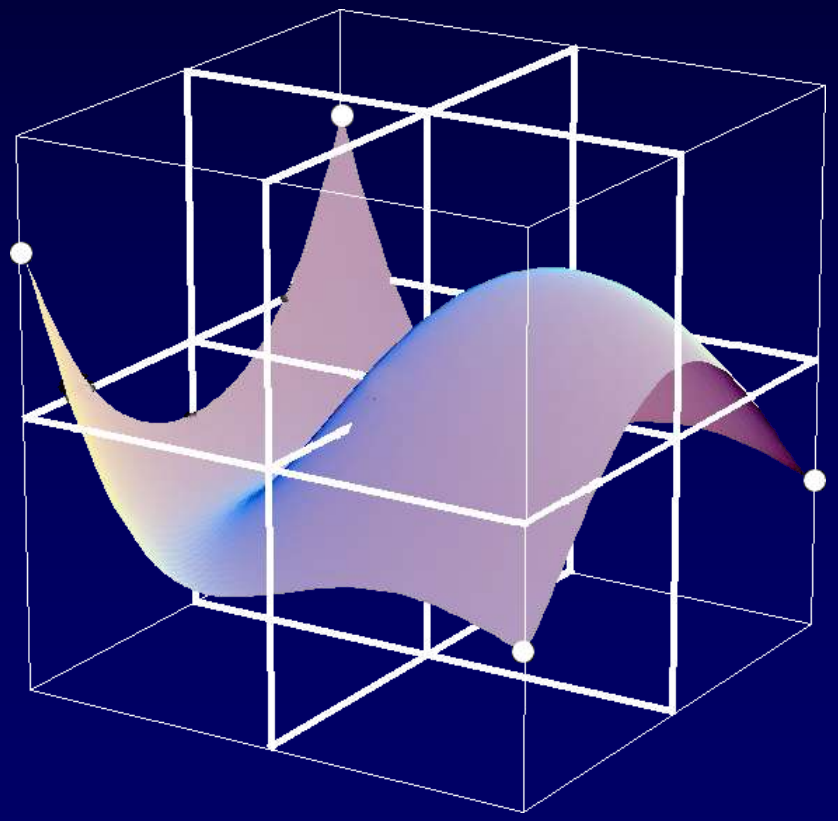




Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$

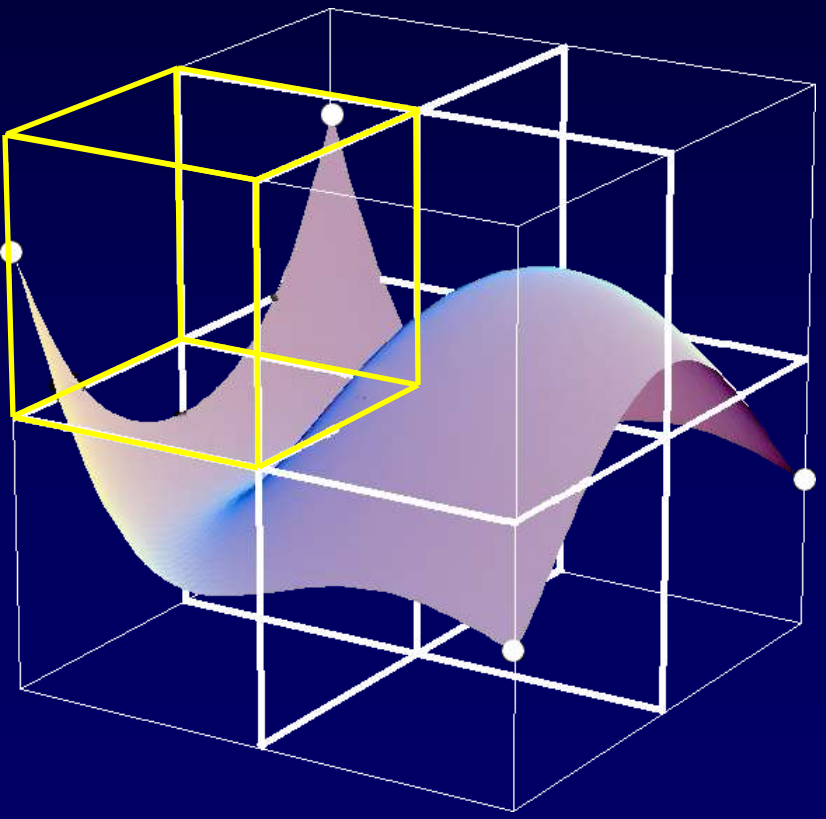


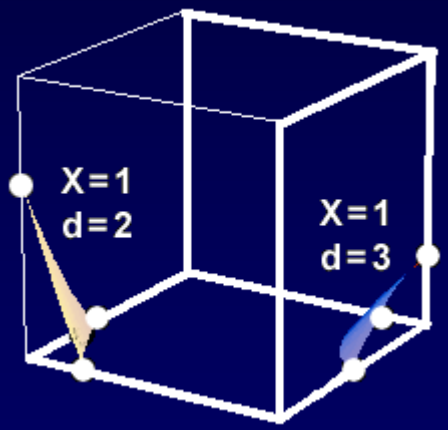
$$\sum_k \chi\left(S_{v_k}\right) = 0$$

$$\sum_k e\left(S_{v_k}\right) = 0$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$



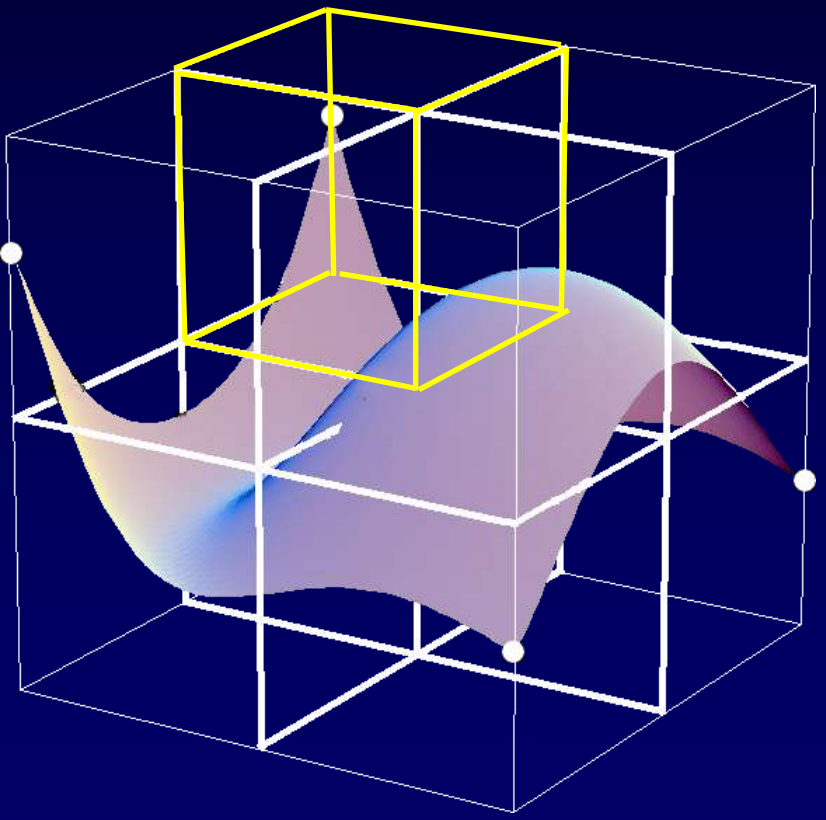


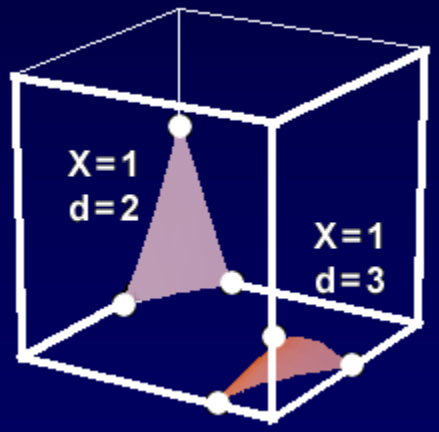
$$\sum_k \chi\left(S_{v_k}\right) = 2$$

$$\sum_k e\left(S_{v_k}\right) = 5$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi(S_{v_k}) - \frac{e(S_{v_k})}{4}$$



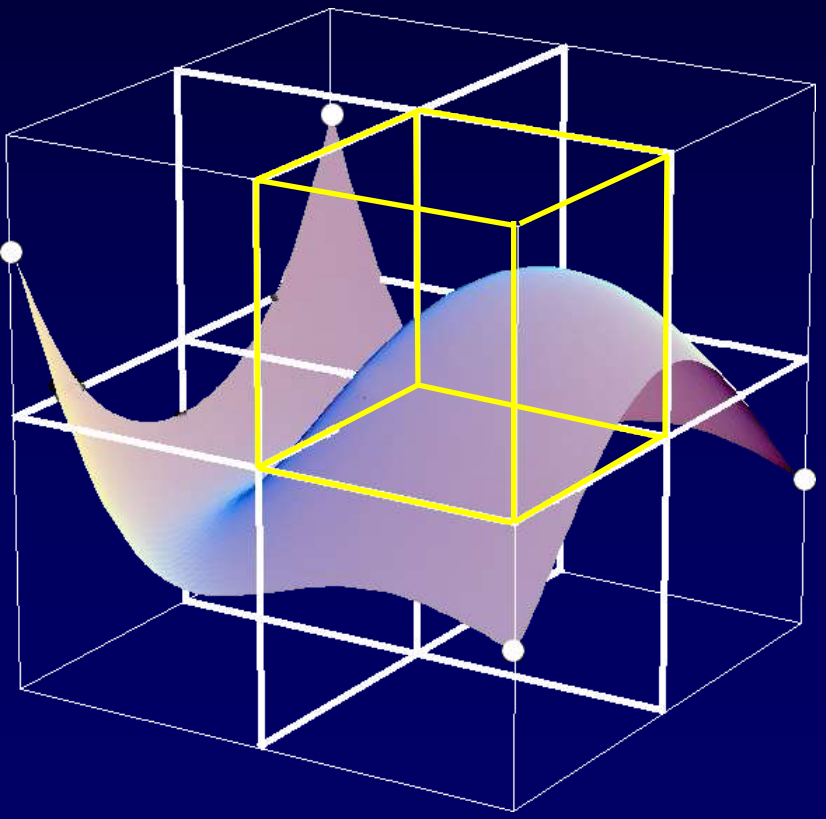


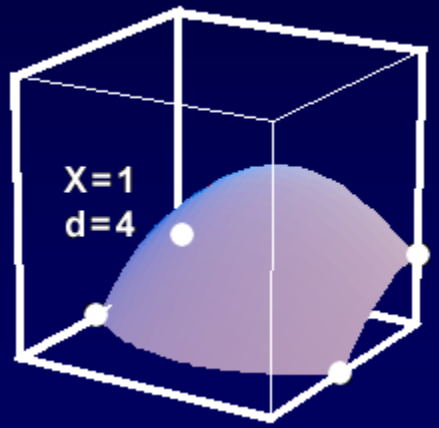
$$\sum_k \chi(S_{v_k}) = 4$$

$$\sum_k e(S_{v_k}) = 10$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi(S_{v_k}) - \frac{e(S_{v_k})}{4}$$



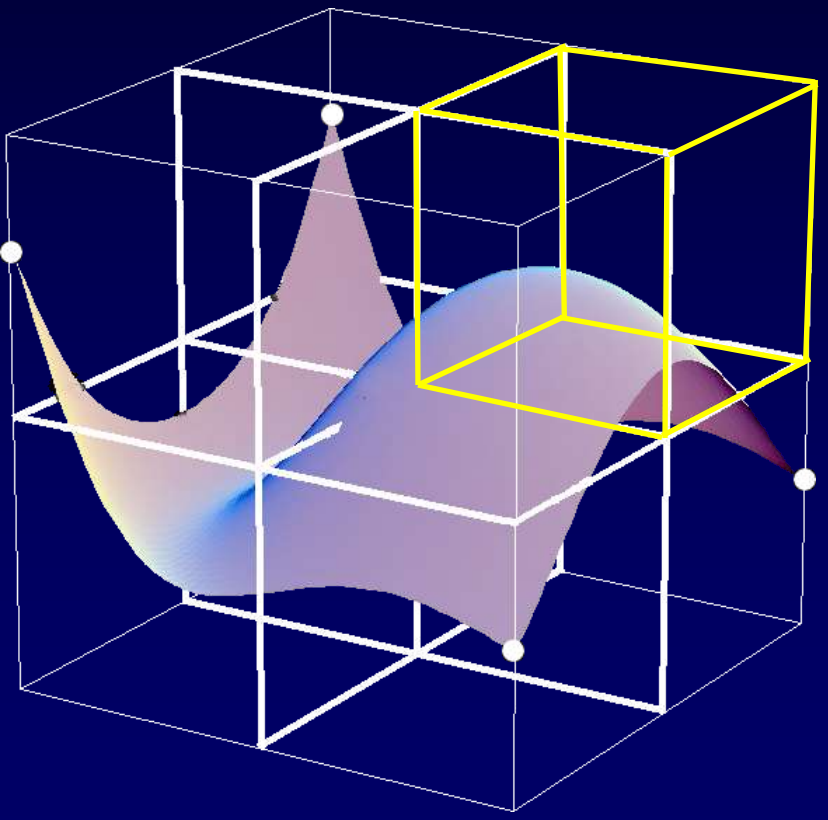


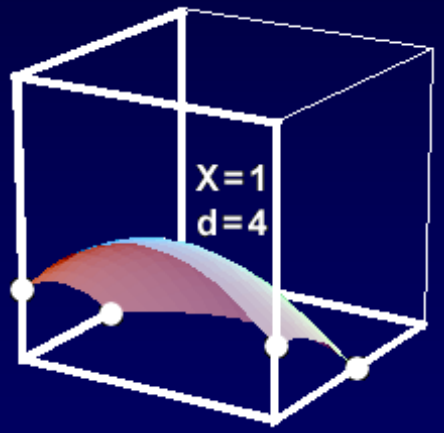
$$\sum_k \chi(S_{v_k}) = 5$$

$$\sum_k e(S_{v_k}) = 14$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$



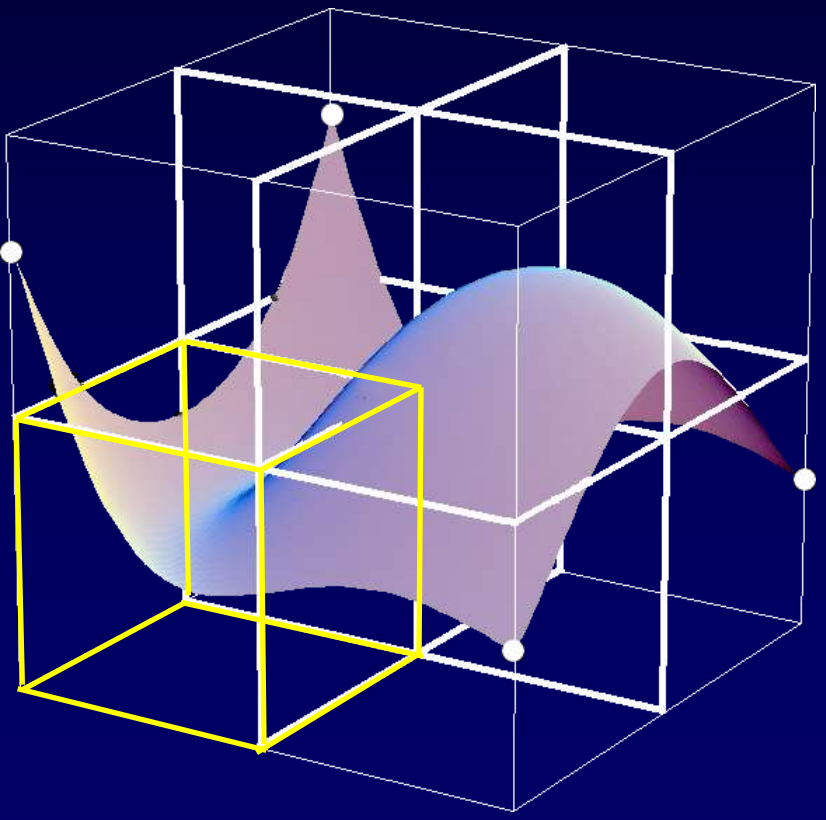


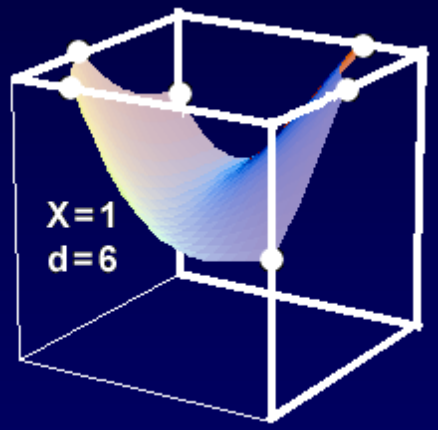
$$\sum_k \chi\left(S_{v_k}\right) = 6$$

$$\sum_k e\left(S_{v_k}\right) = 18$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$



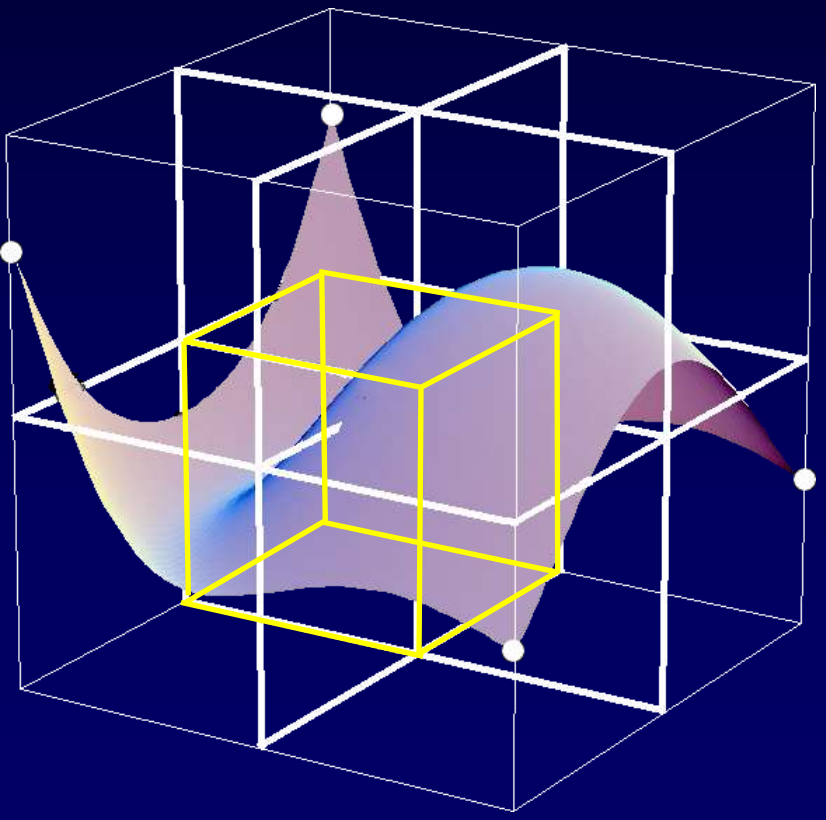


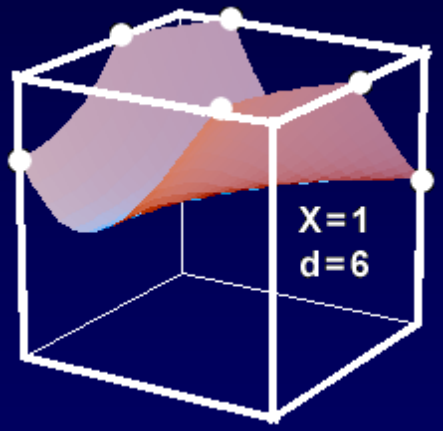
$$\sum_k \chi\left(S_{v_k}\right) = 7$$

$$\sum_k e\left(S_{v_k}\right) = 24$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$



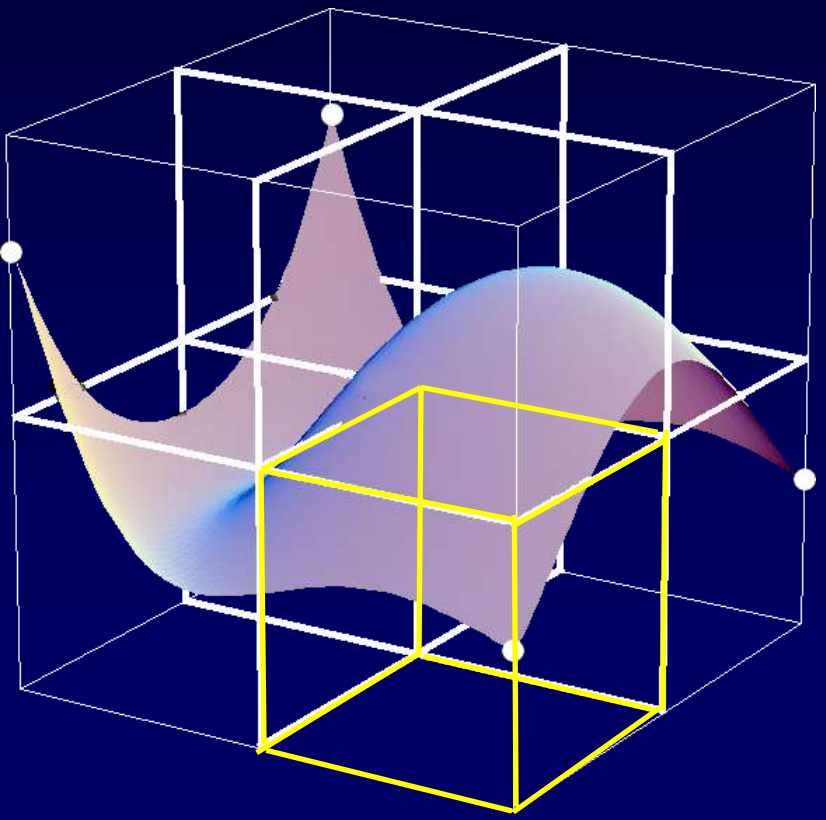


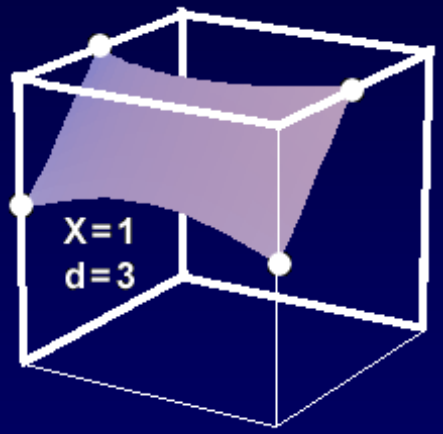
$$\sum_k \chi\left(S_{v_k}\right) = 8$$

$$\sum_k e\left(S_{v_k}\right) = 30$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$



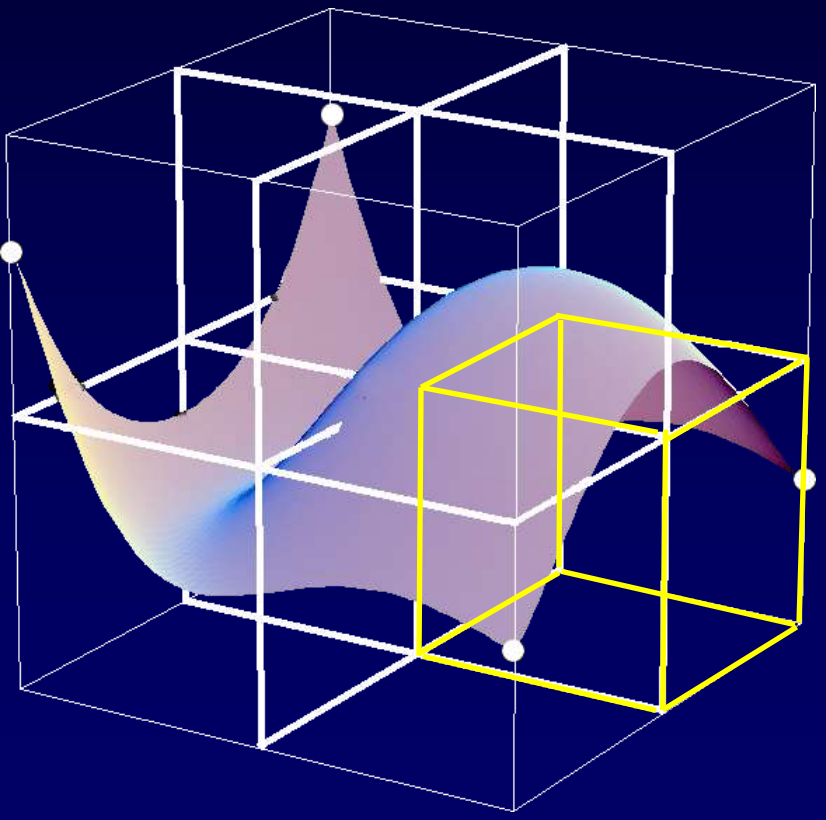


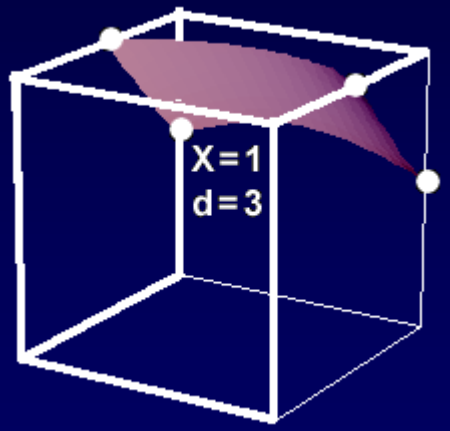
$$\sum_k \chi\left(S_{v_k}\right) = 9$$

$$\sum_k e\left(S_{v_k}\right) = 33$$

Recursive Safety Computation

$$\chi(S_v) = \sum_k \chi\left(S_{v_k}\right) - \frac{e\left(S_{v_k}\right)}{4}$$

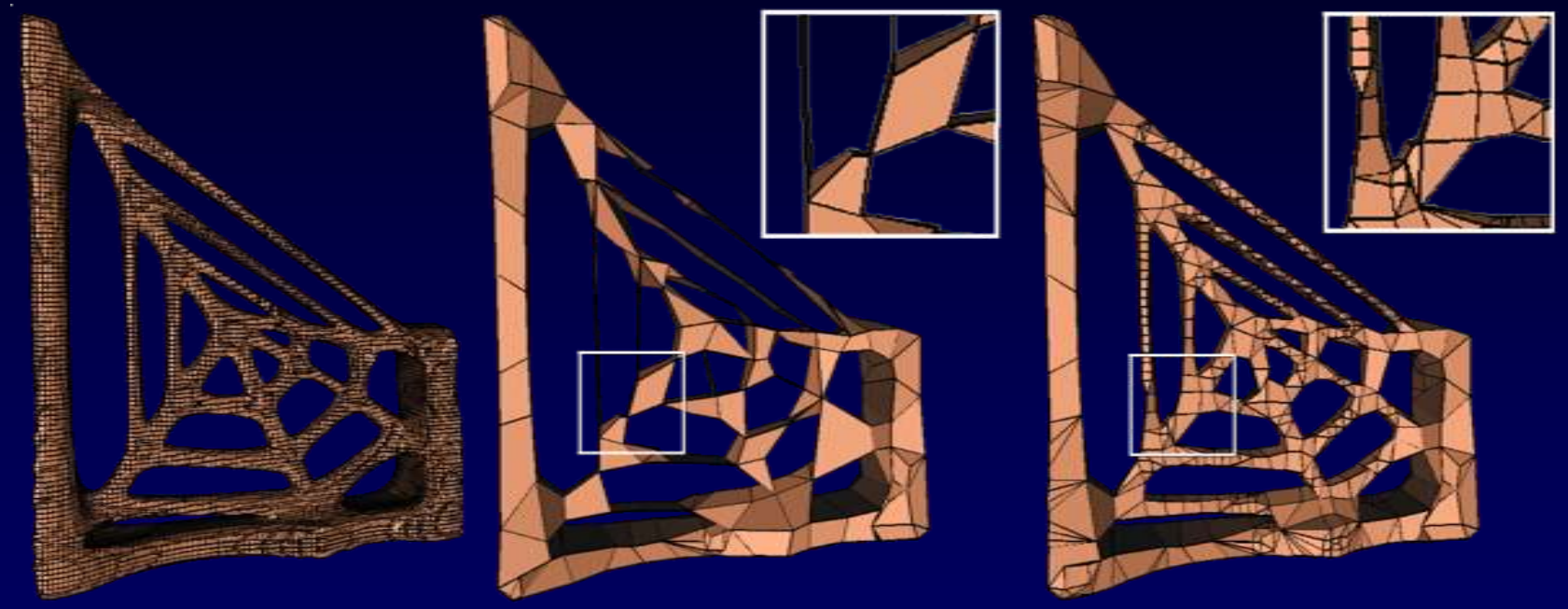




$$\sum_k \chi\left(S_{v_k}\right) = 10$$

$$\sum_k e\left(S_{v_k}\right) = 36$$

Results



Uncollapsed

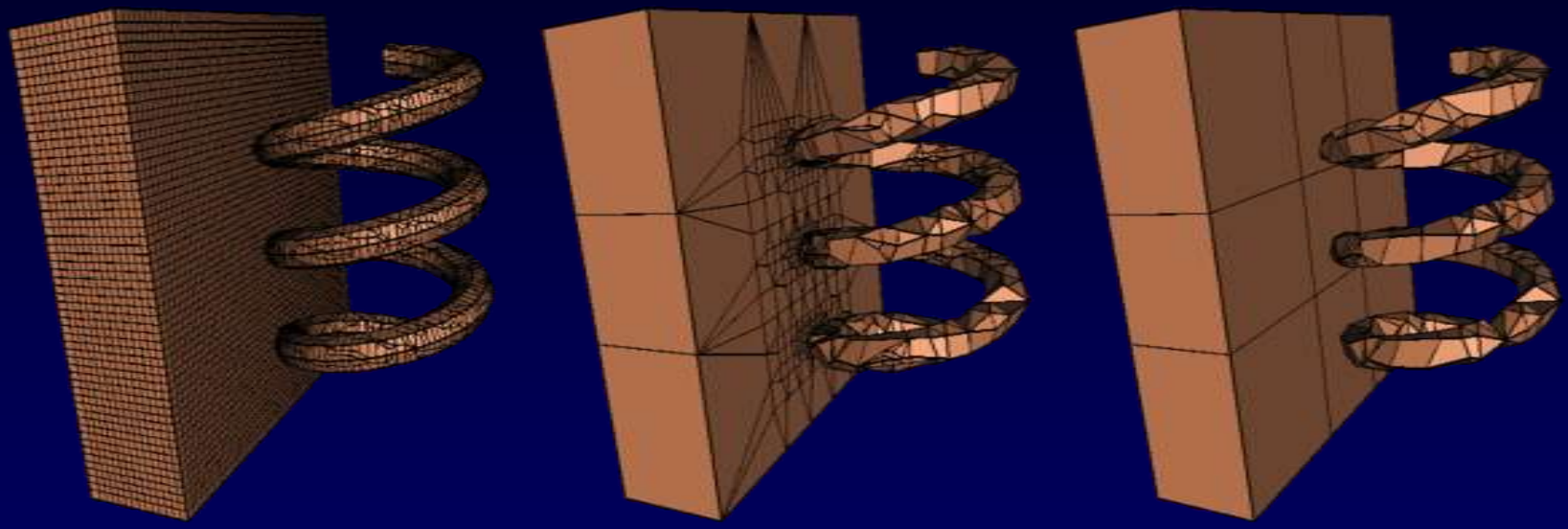
Only Vertex Clustering

Manifold Safety Test

Results

476184 142570 62134 14335 2738 78

Comparison



Original Shape

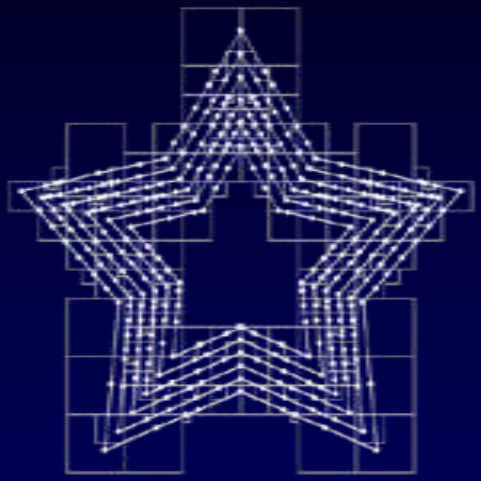
Dual Contouring

Our Method

Comparison

Original Shape

Dual Contouring



Extended
Dual Contouring

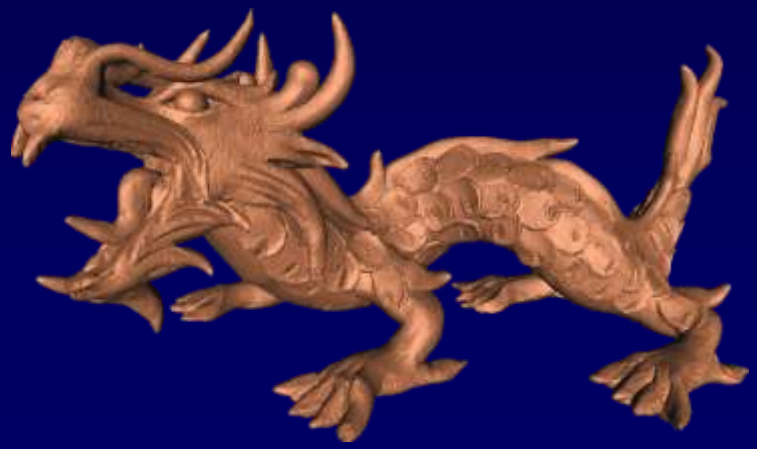
Our Method

Performance

	Octree Depth	Base Polys	Clustering w/o Manifold Test	Clustering w/ Manifold Test	Poly Generation	Simplified Polys
Spring	6	28740	0.254	0.259	0.06	1042
Spider Web	7	44784	0.459	0.465	0.10	3672
Queen	9	476184	5.58	5.76	1.12	78
Dragon	9	611476	6.65	6.71	1.42	9944
Thai Statue	9	878368	10.89	10.99	2.01	30002

Conclusions

- Vertex clustering algorithm that allows multiple components per cell in DC
- Simple, recursive test for vertex clustering that guarantees manifold geometry



100%

3.3%