MODELING WITH BLOCKS

Luc Leblanc, Jocelyn Houle, Pierre Poulin

Dept. I.R.O.
Université de Montréal

CGI

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CONTEXT

- Object modeling has different requirements according to
  - surface properties
  - topological constraints
  - modeling process itself
- Applications can vary from high-precision CAD to 3D sculpting

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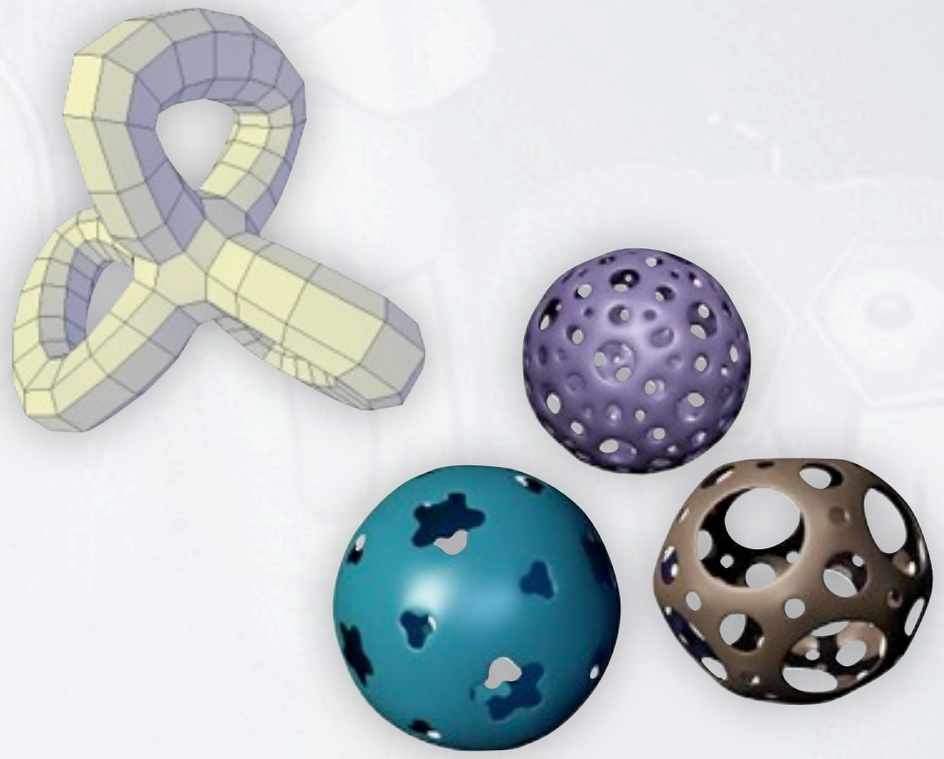

from Akleman et al.

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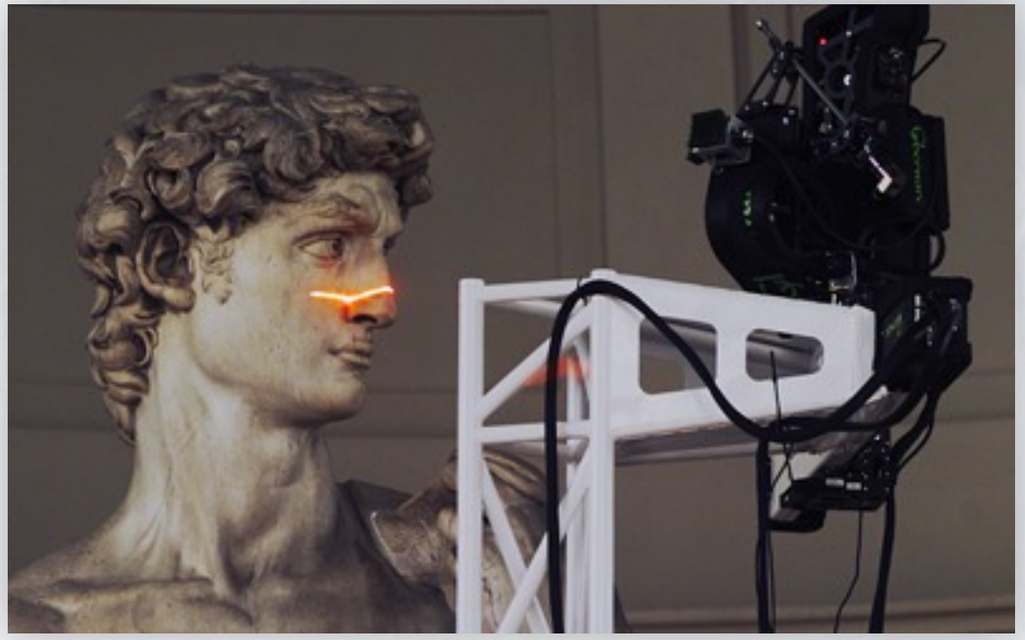

from the The Digital Michelangelo Project

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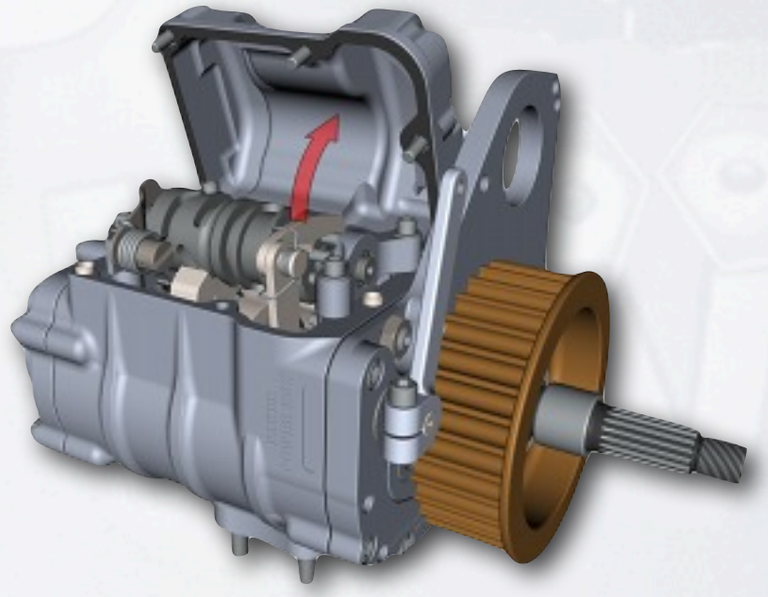

from solidworks

CONTEXT

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from 3d-coat

GOALS

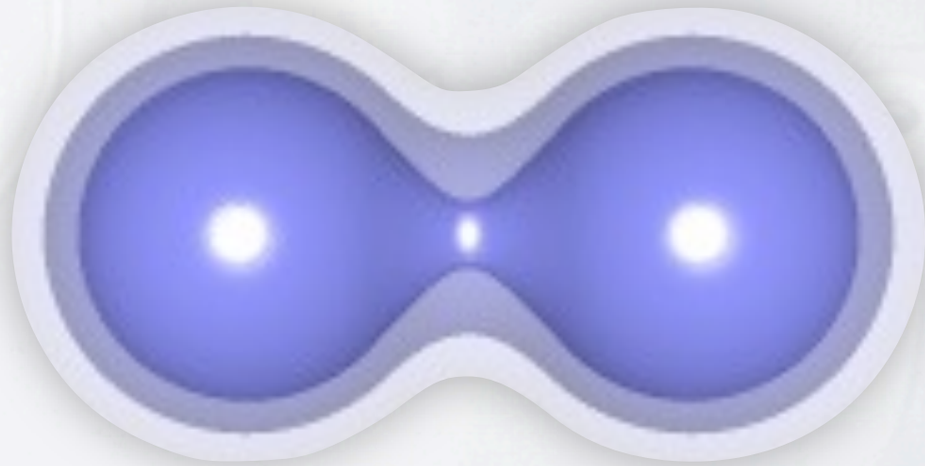
- Procedural modeling
  - simple topology specification
  - volumetric definition
  - surface parameterization
  - surface control

INSPIRATIONS

- Implicit surfaces
- ZSpheres
- Polycube maps

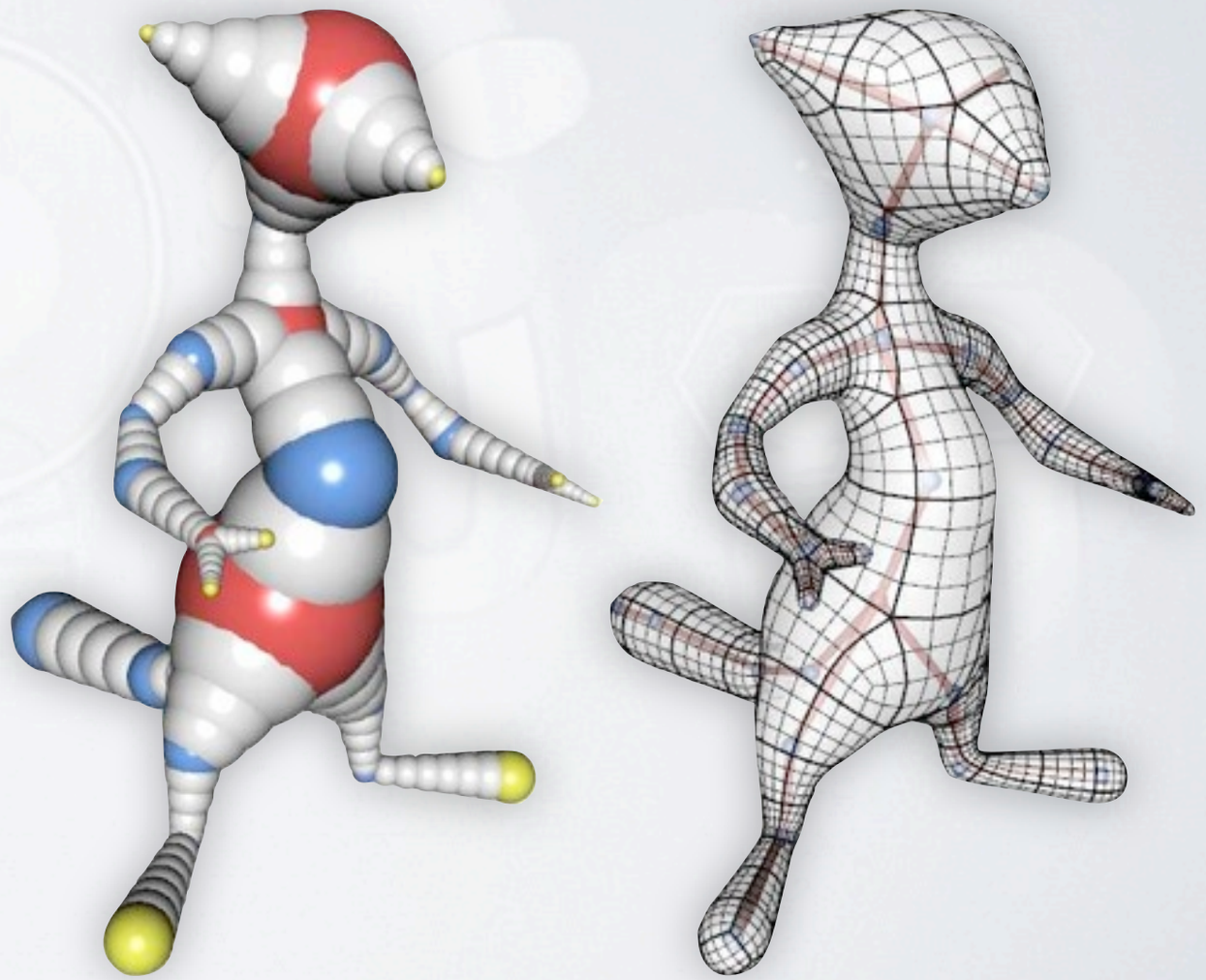
RELATED WORK

- Implicit surfaces and F-Rep
  - Iso-surface of a field defined by simple primitives
  - ✓ easy topology specification
  - ✓ volumetric definition
  - ✗ complicated quality mesh extraction
  - ✗ complex surface parameterization



RELATED WORK

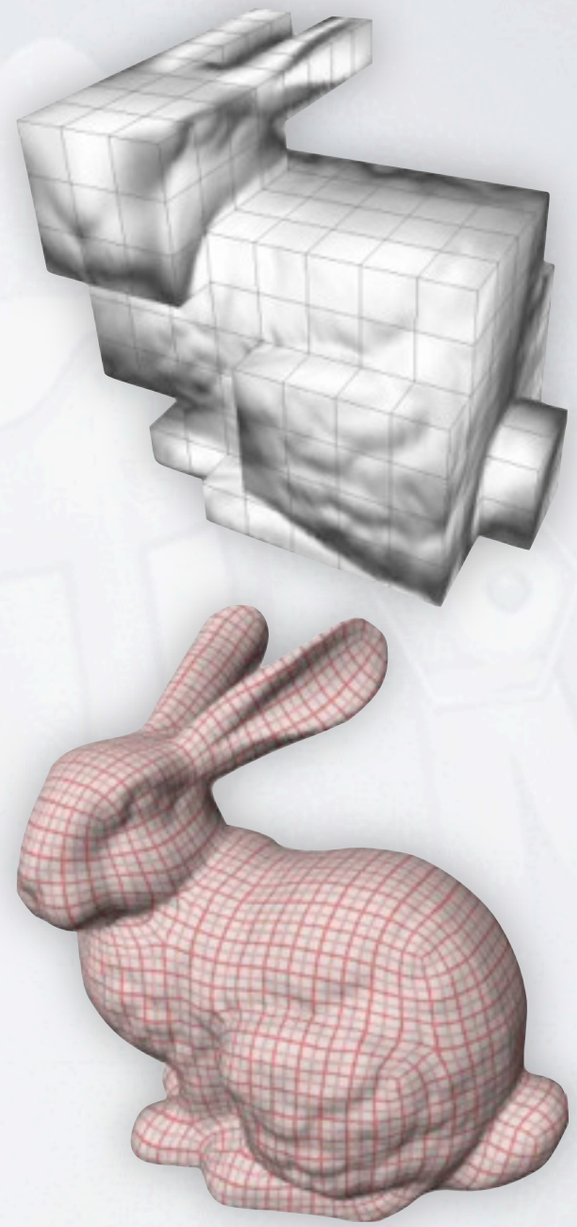
- ZSpheres (zbrush), B-mesh
  - subdivision mesh enclosing a tree of spheres
  - ✓ surface parameterization
  - ✓ volumetric definition
  - ✓ appropriate for organic objects
  - ✗ more difficult for industrial objects with sharp edges



from Ji et al.

RELATED WORK

- Polycube maps
  - displacement map applied on surfaces of a set of aligned connected cubes
  - ✓ efficient representation for different topologies
  - ✗ not used as a modeling primitive

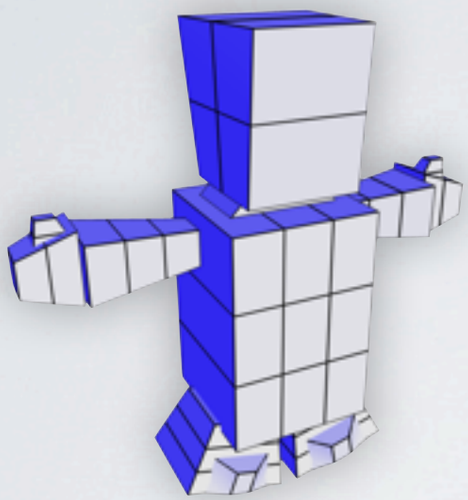


from Tarini et al.

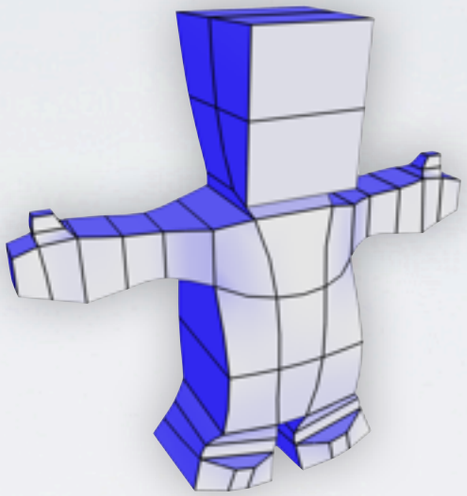
OUR BLOCKS

- Inspired by last three previous work
- Similarities
  - block as a cube of polycube, with parameterization on individual exterior face
  - blocks assembled as zspheres and implicit surfaces
  - subdivision surfaces of exterior faces

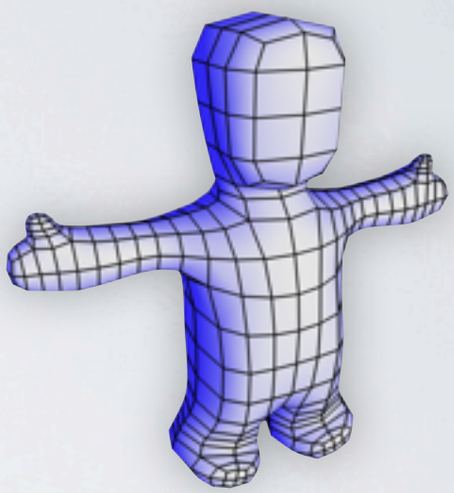
MODELING PIPELINE



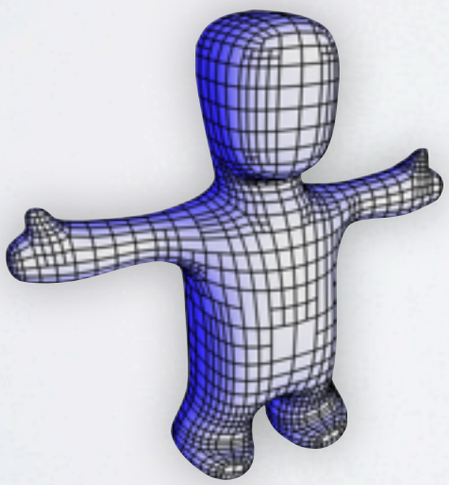
Place blocks



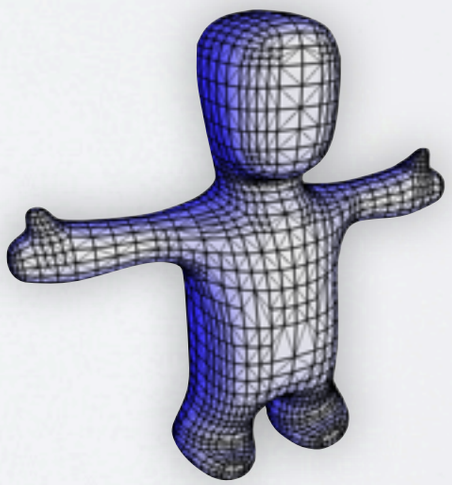
Connect blocks



Control Mesh

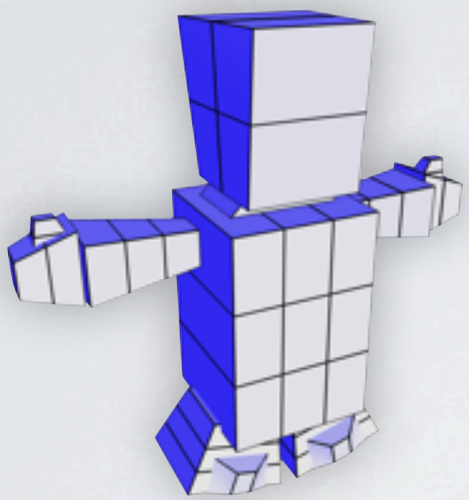


Subdivision of patches

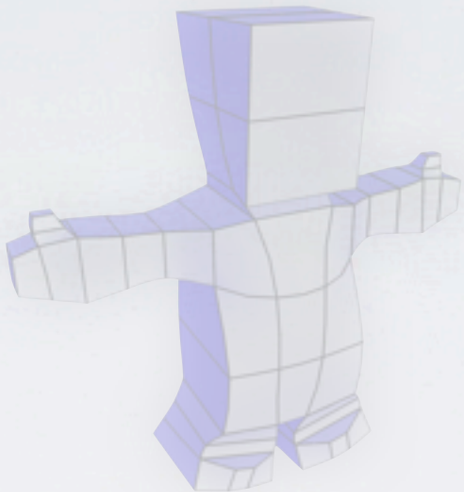


Final triangle mesh

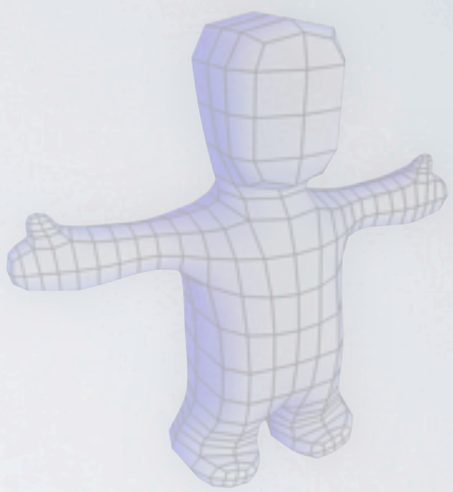
MODELING PIPELINE



Place blocks



Connect blocks



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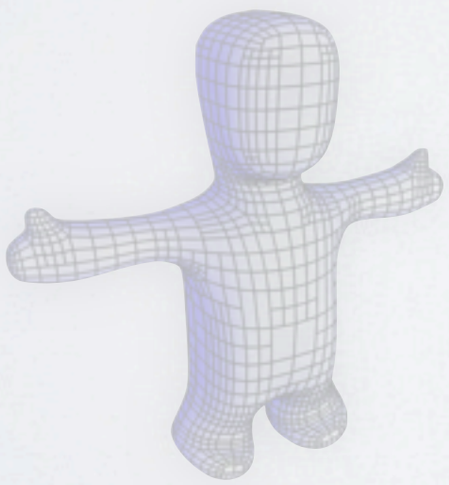

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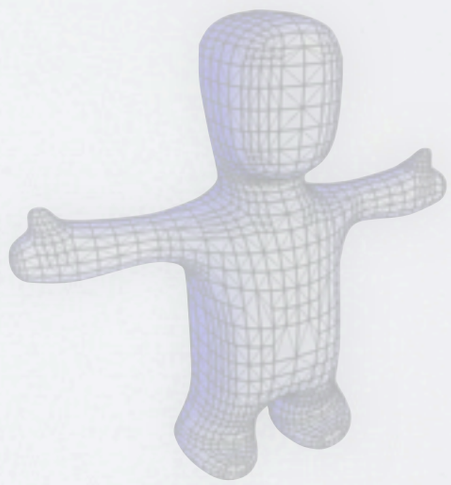
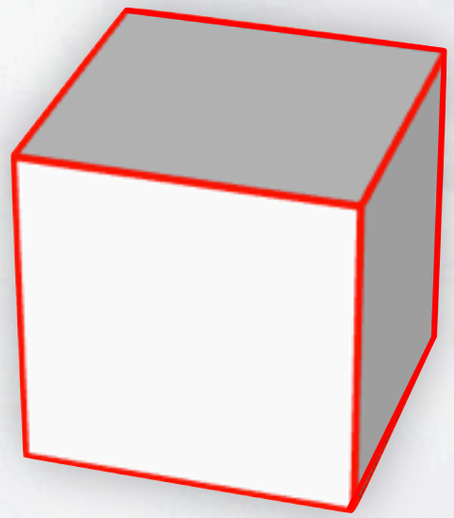


Final triangle mesh

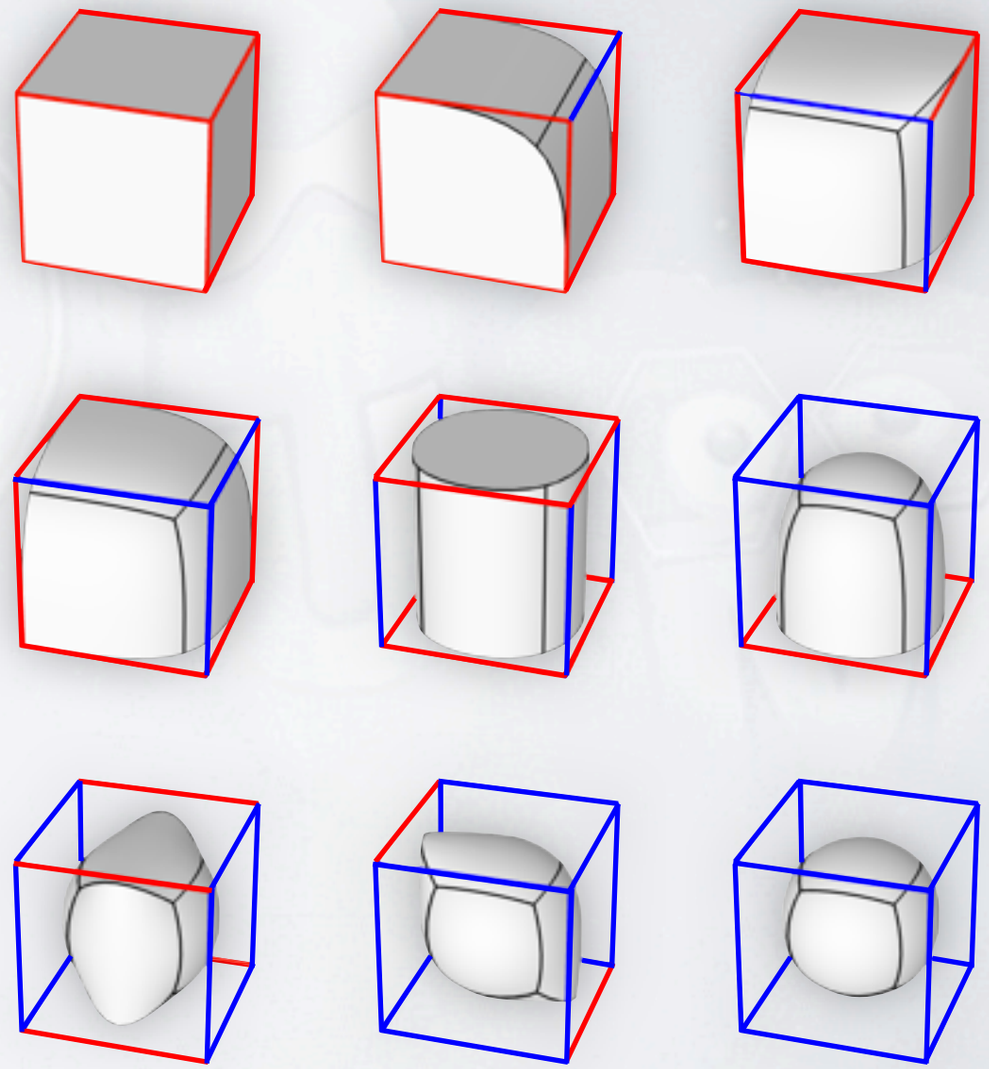
A BLOCK

- Cuboid: 8 vertices, 6 faces
- No restrictions imposed on the vertices
  - except that they should generate a valid continuous interior (not verified)



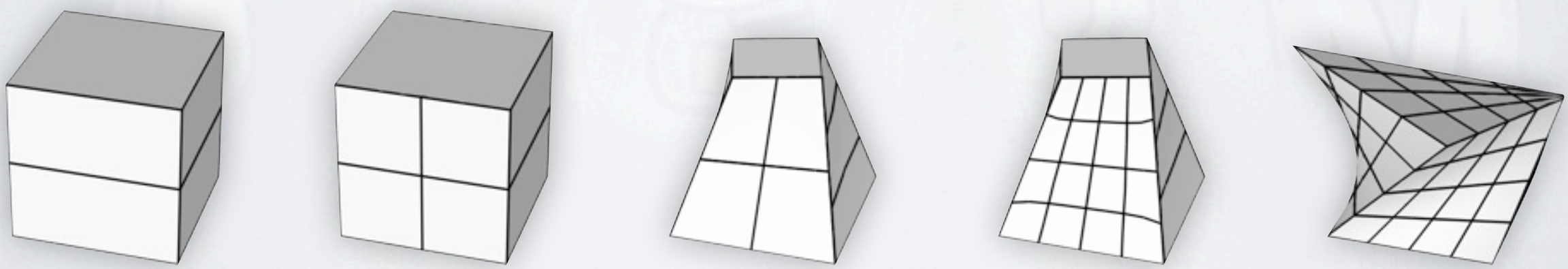
A BLOCK

- Each edge is smooth or sharp

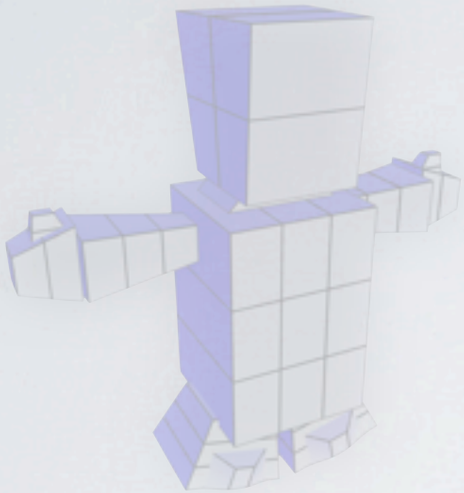


A FACE OF A BLOCK

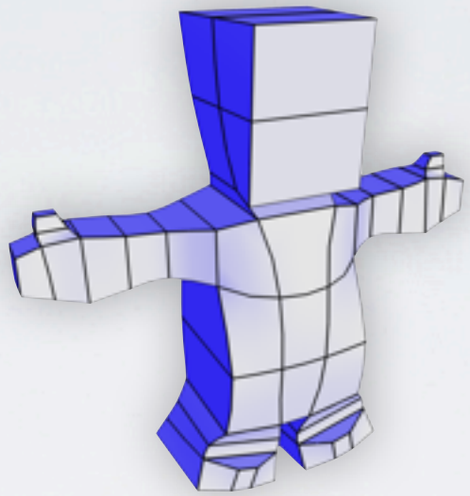
- Each face is a bilinear patch subdivided in a grid of sub-faces
- Each sub-face is a quad (not necessarily planar)
- Catmull-Clark subdivision of sub-faces



MODELING PIPELINE



Place blocks



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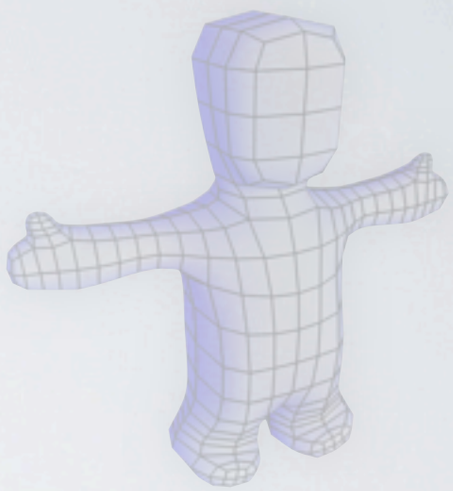

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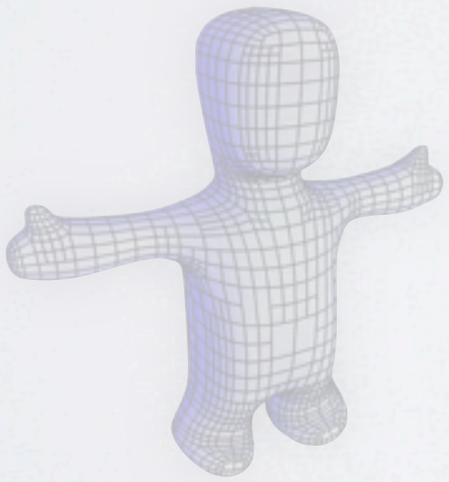

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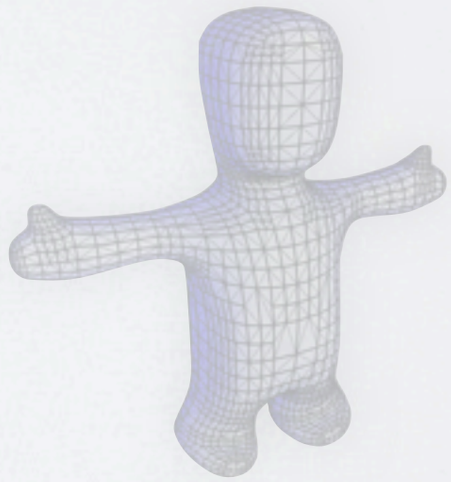


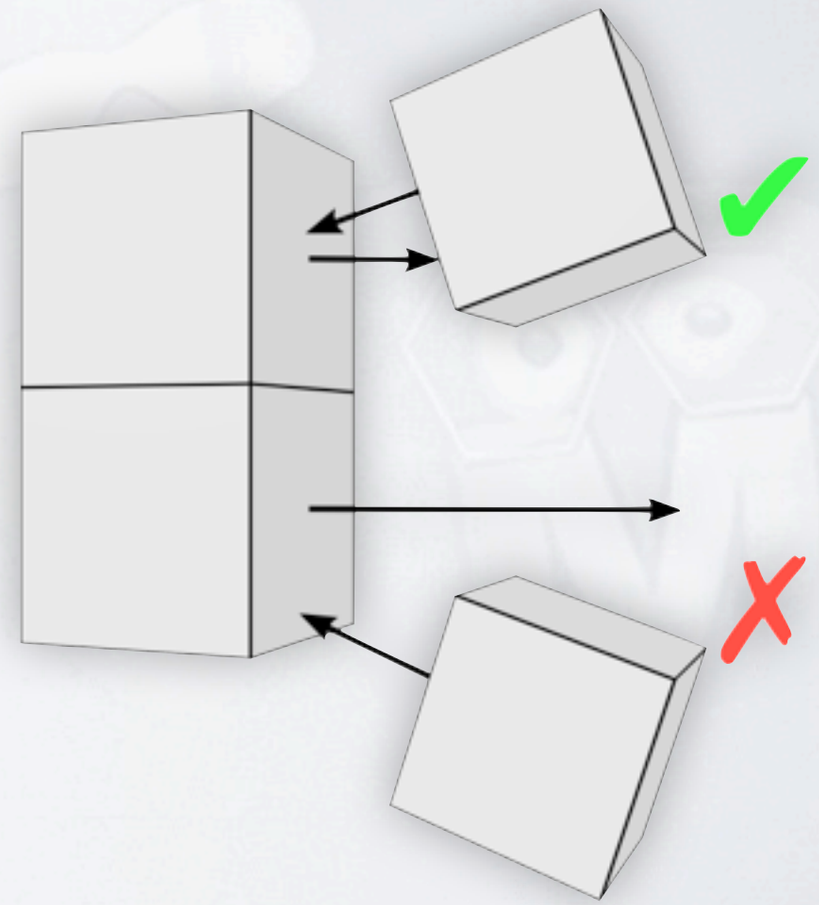
Final triangle mesh

CONNECTING BLOCKS

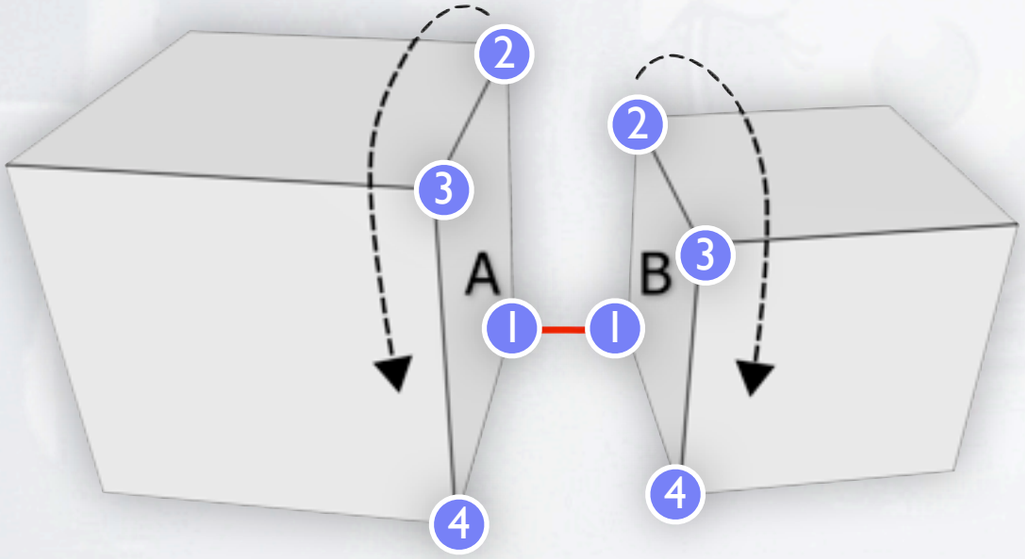
- BlobTree-like merging group IDs
- Maximum of one connection between two blocks
- Relative distance (sub)face-(sub)face
- Connected vertices computed as averaged position

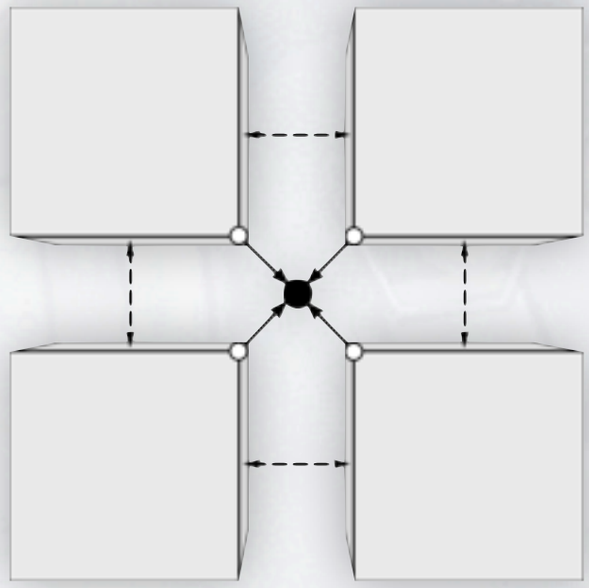
CONNECTING SUB-FACES

- Ray casting from every sub-faces center
- Validate connection between two sub-faces
  - Belong to different blocks
  - Group ID is valid
  - Distance within a threshold
  - Mutually closest



CONNECTING VERTICES





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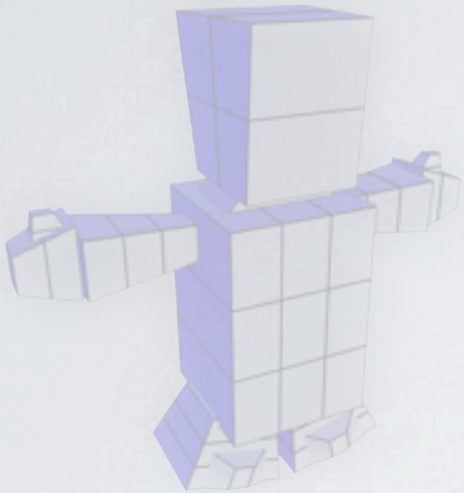

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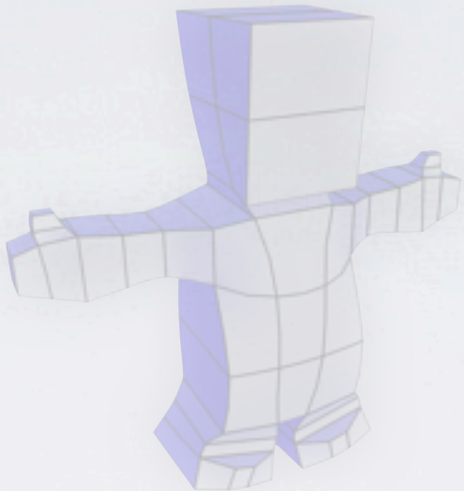

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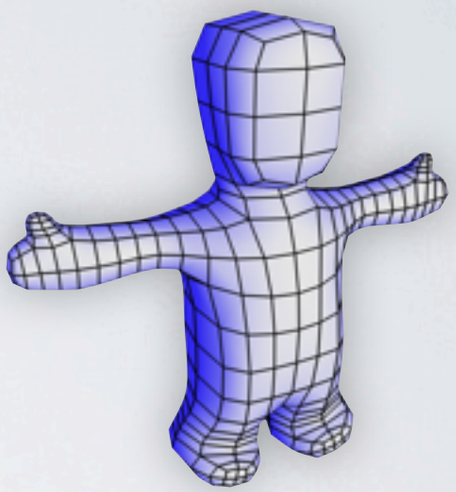

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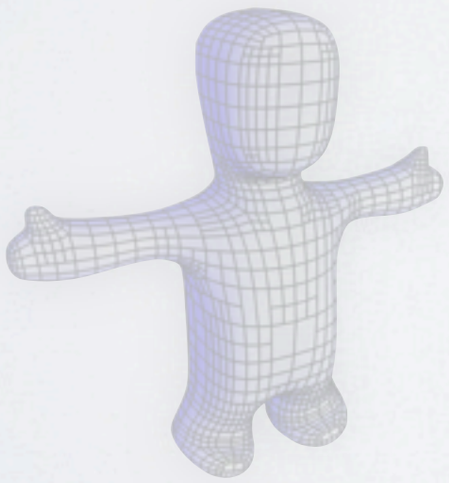

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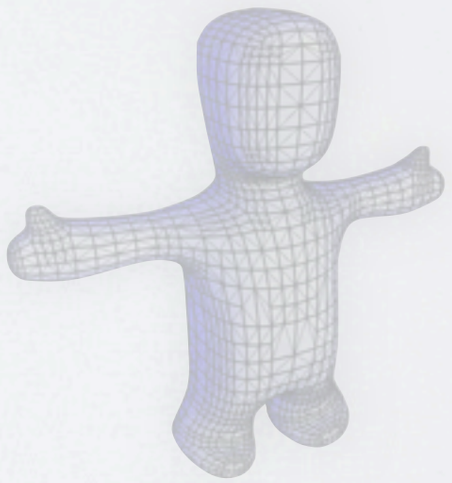
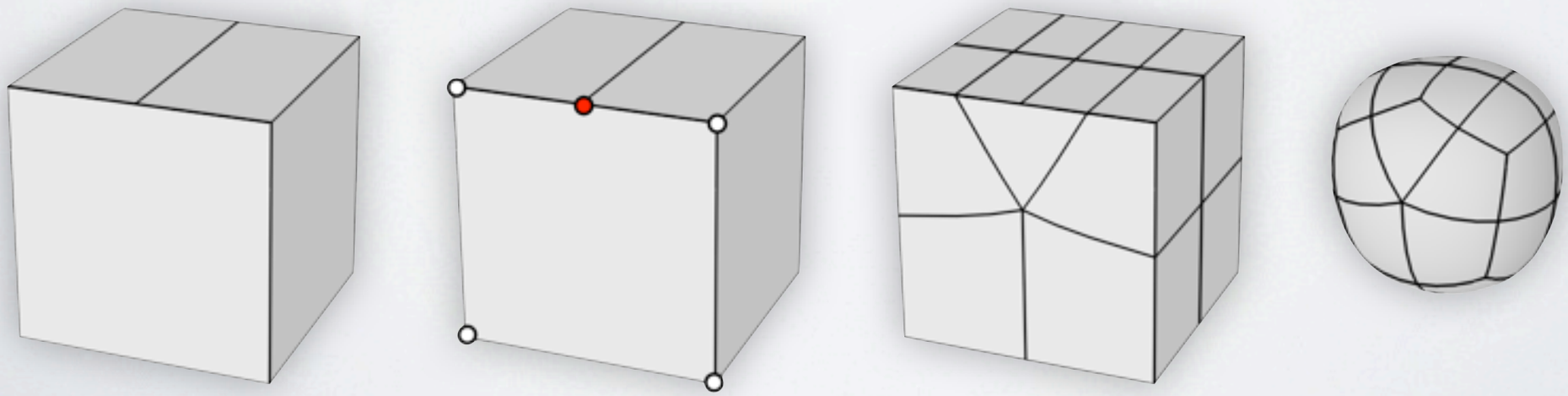


Final triangle mesh

CONTROL MESH

- Assemble all exterior (not connected) sub-faces in a watertight mesh
- If one connected edge is sharp → all sharp
- Add vertices to eliminate T-vertices
- Catmull-Clark to obtain quads



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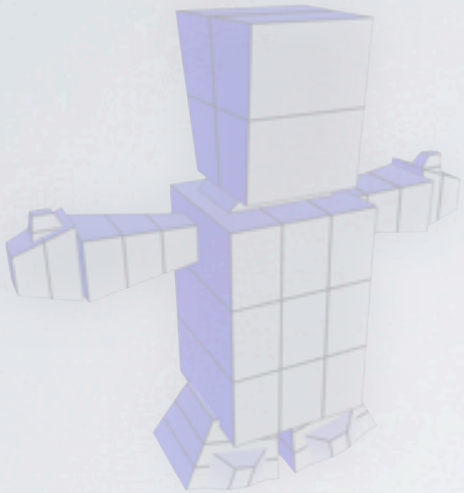

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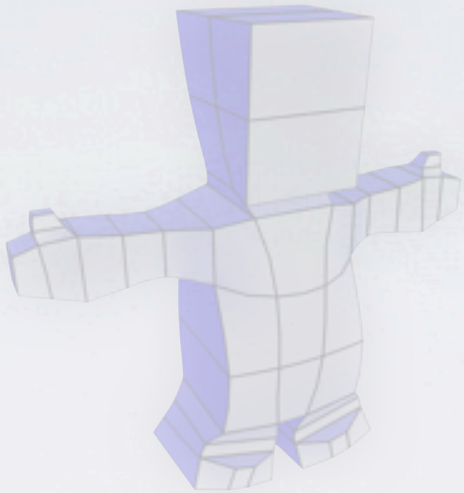

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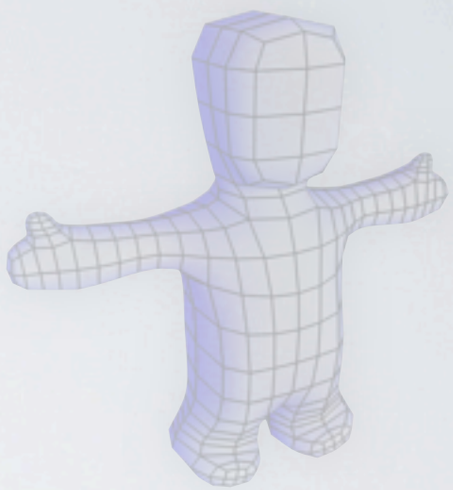

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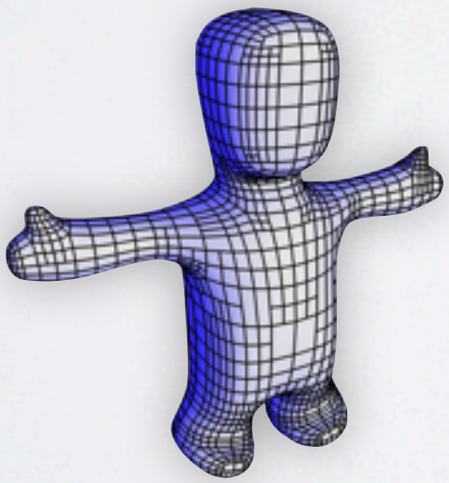

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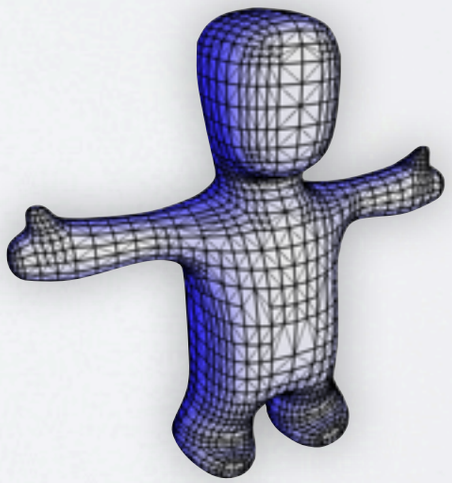
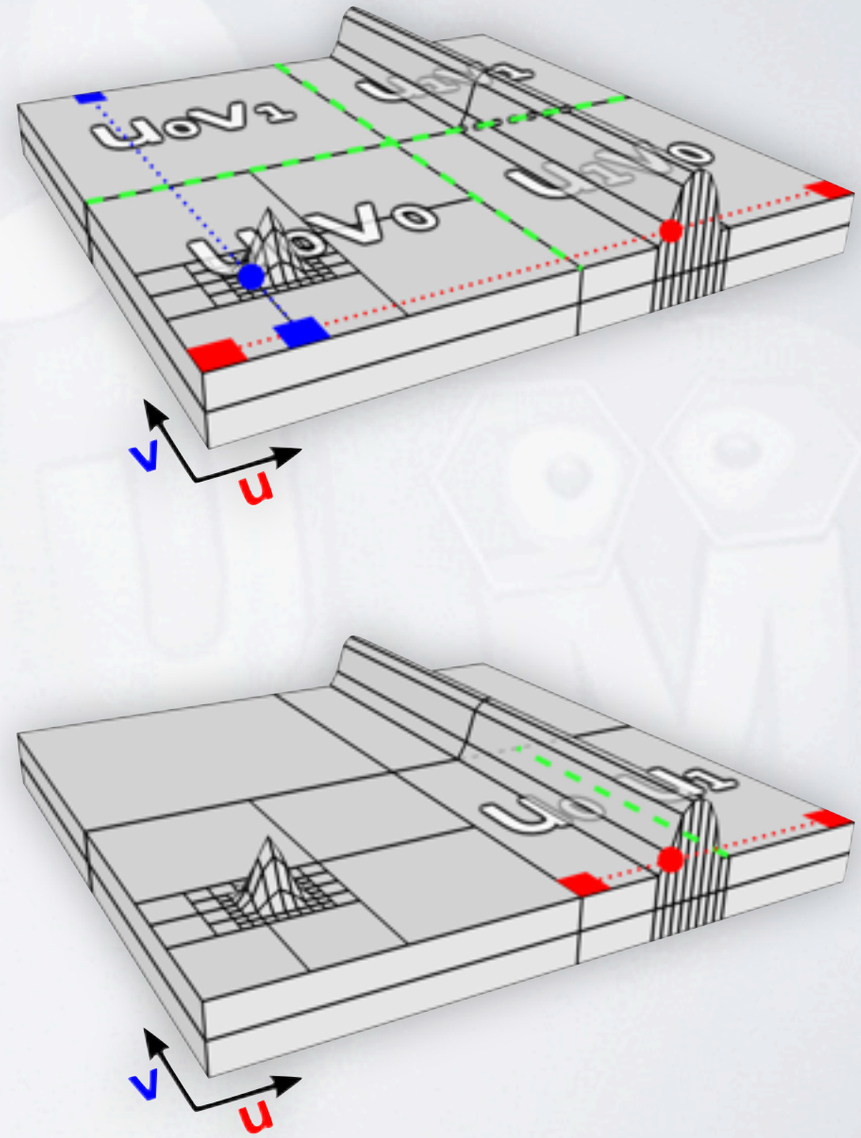


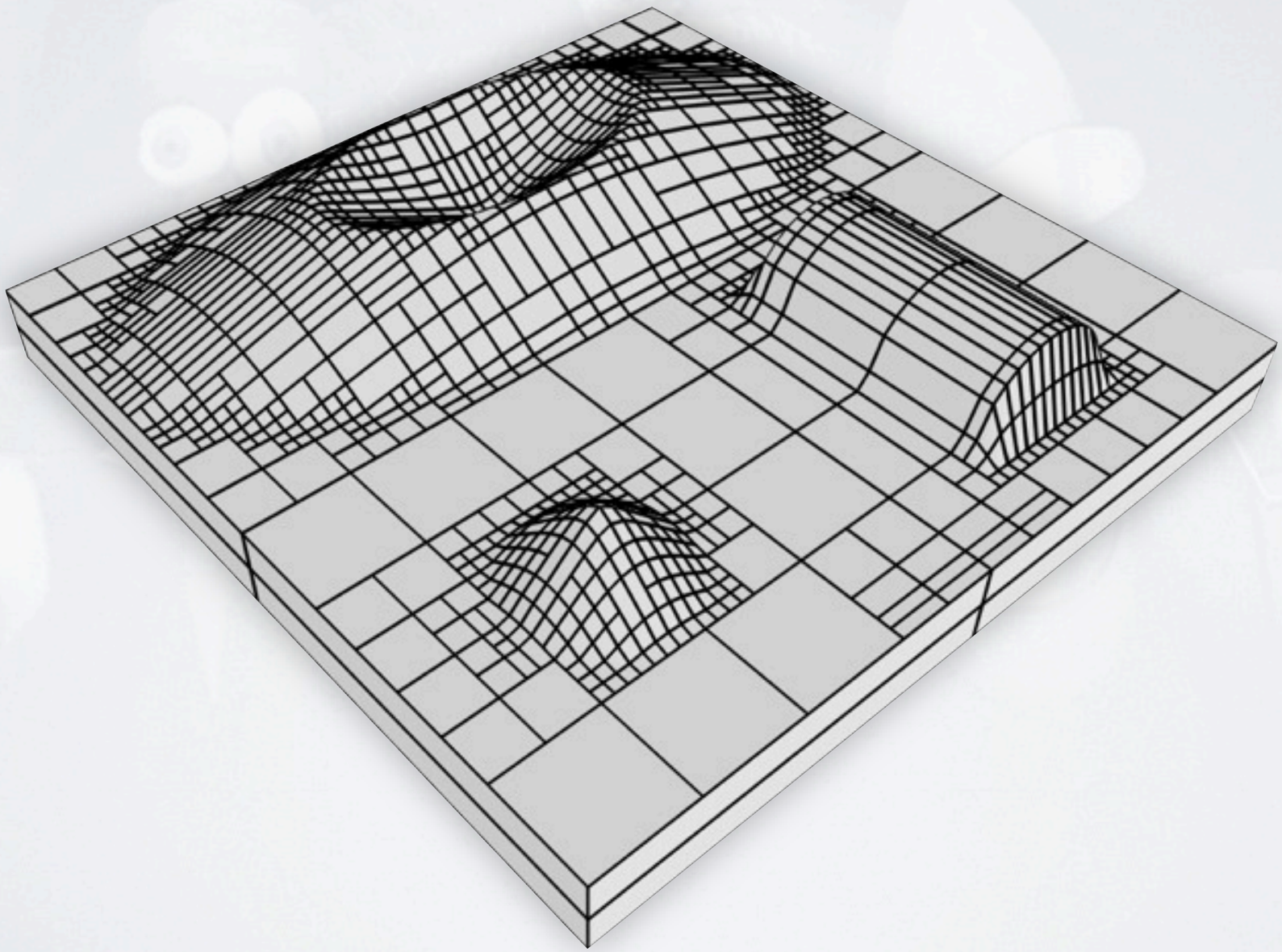
Final triangle mesh

ADAPTIVE SUBDIVISION

- Recursive subdivision of sub-patches
- Patch evaluation + displacement
- Two pass evaluation (U,V)
  - no subdivision
  - subdivide in U
  - subdivide in V
  - subdivide in UV



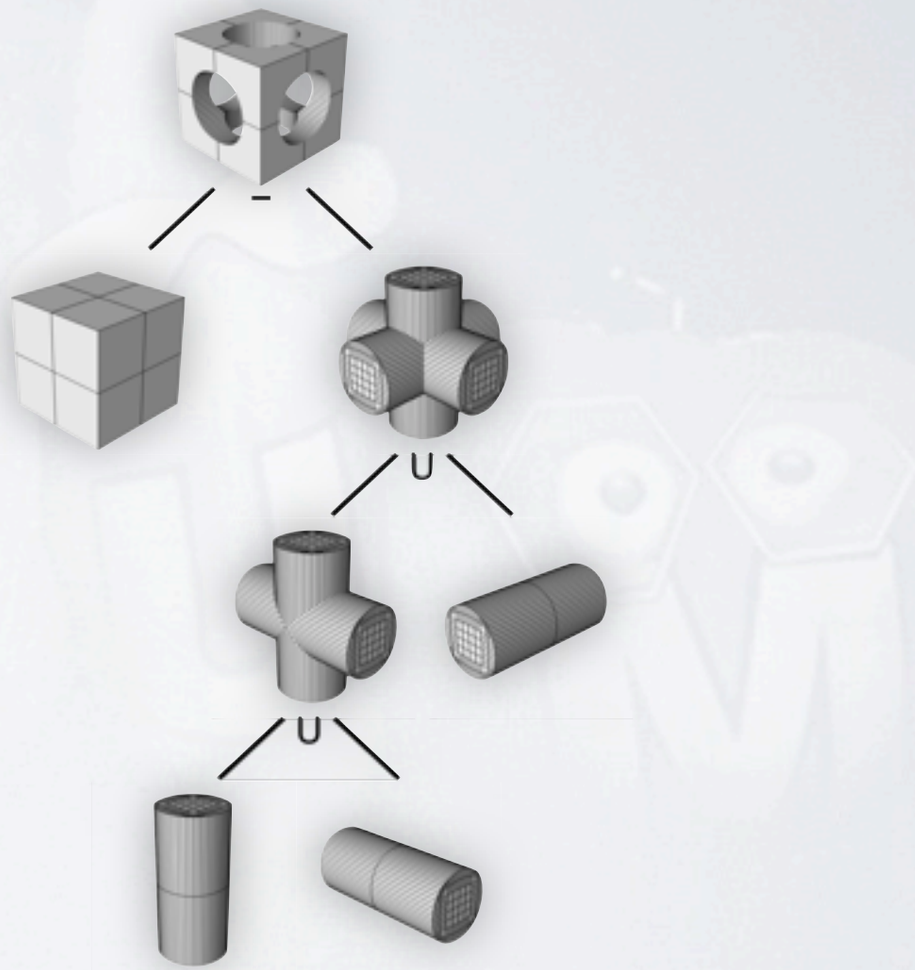
ANISOTROPIC SUBDIVISION



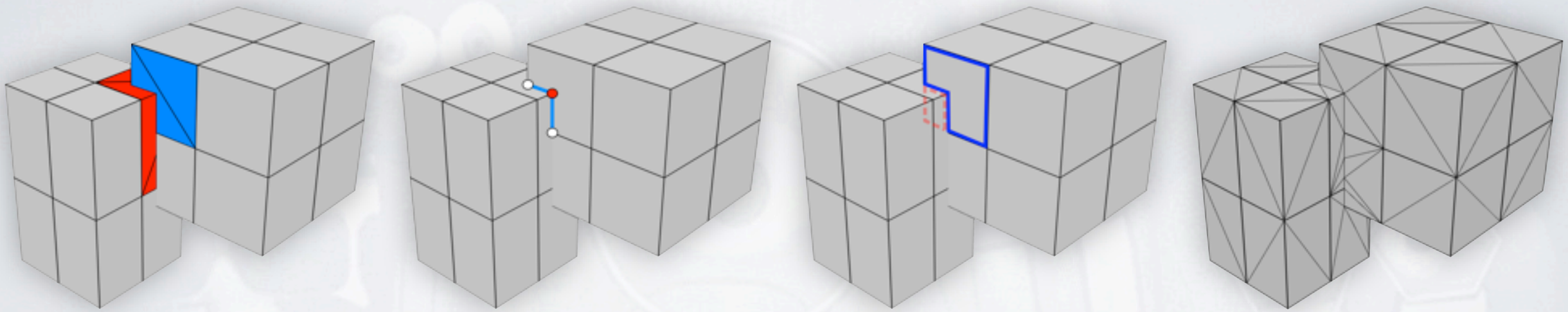
LEVELS OF DETAIL

CSG OPERATIONS

- Compute by intersecting sub-patches
- Insert vertices and segments



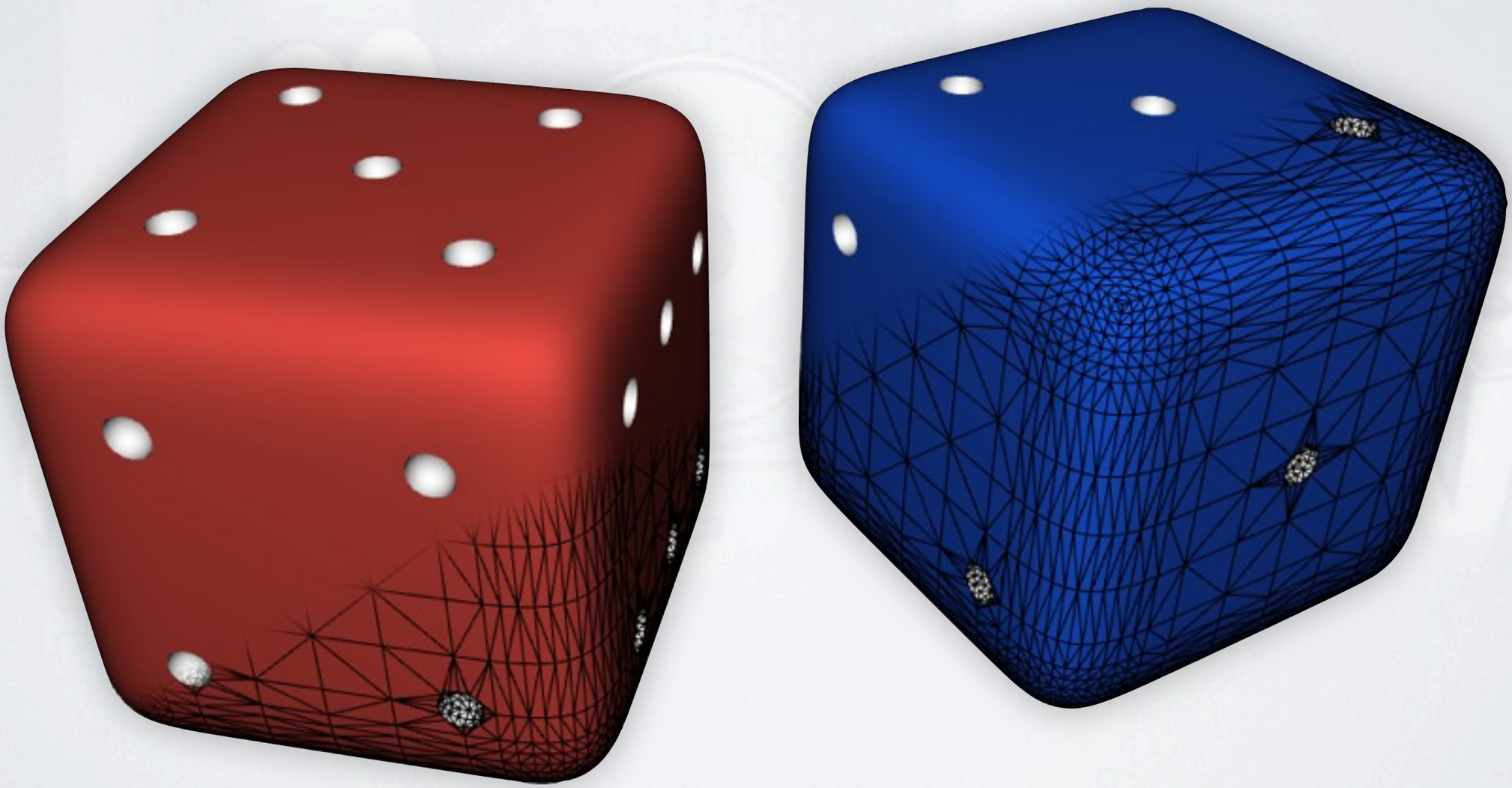
CSG



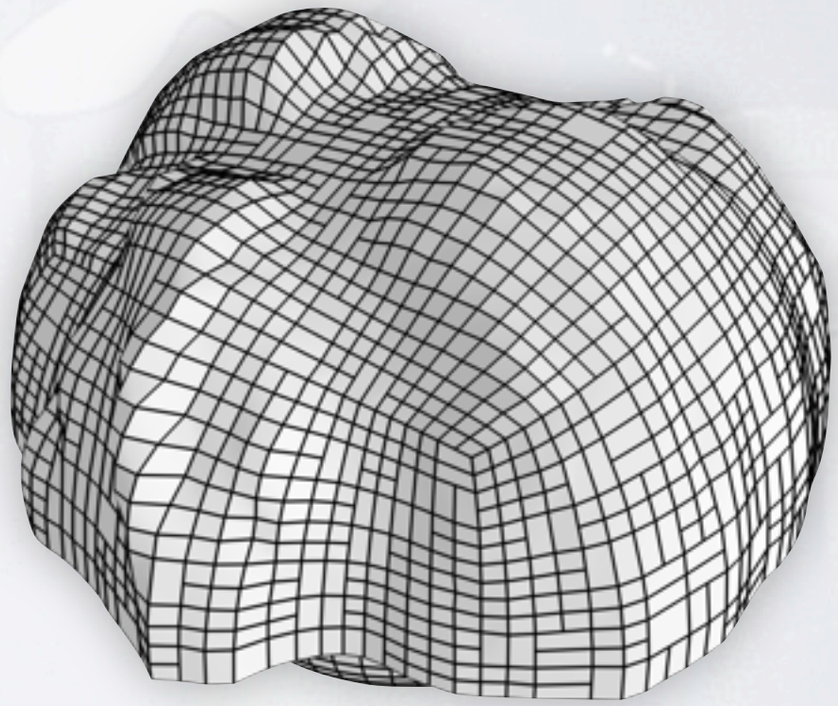
TESSELLATION

- Simple triangulation for convex sub-patches
- ear-clipping algorithms (concave, CSG)

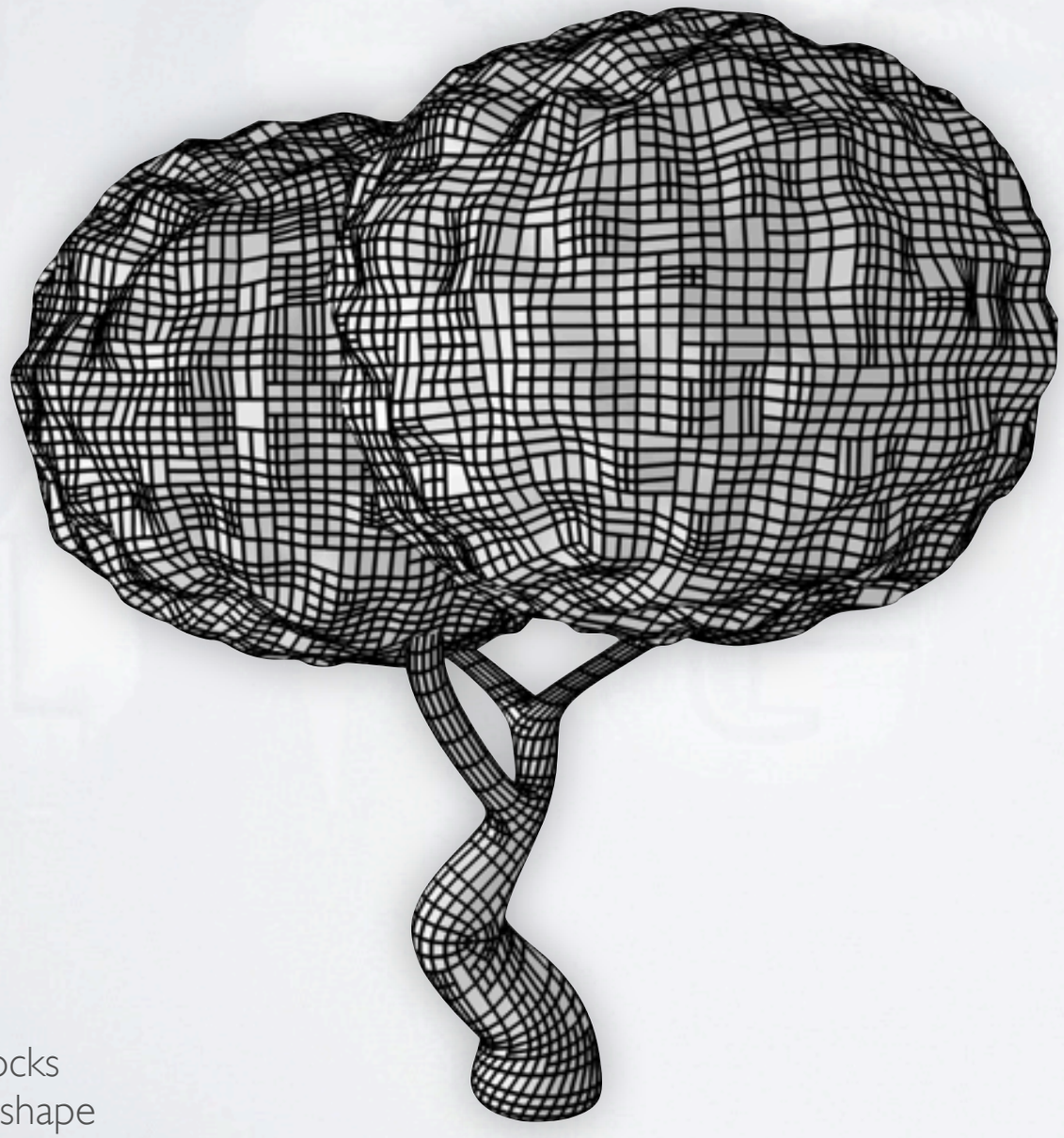
DICE



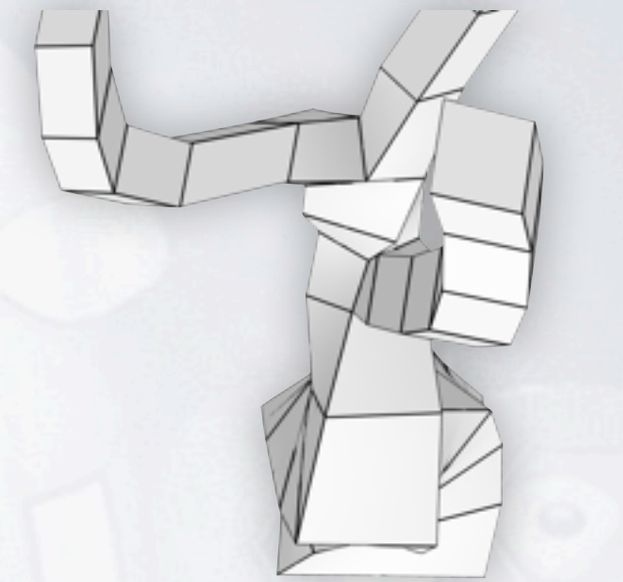
TERRAIN ON FLAT OR CURVED BLOCK

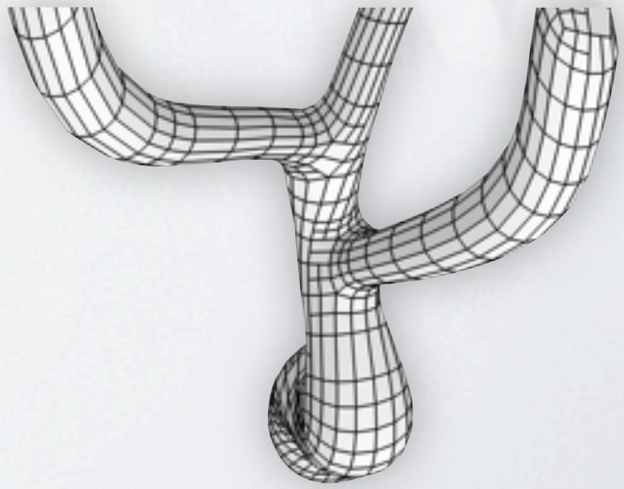


TREES

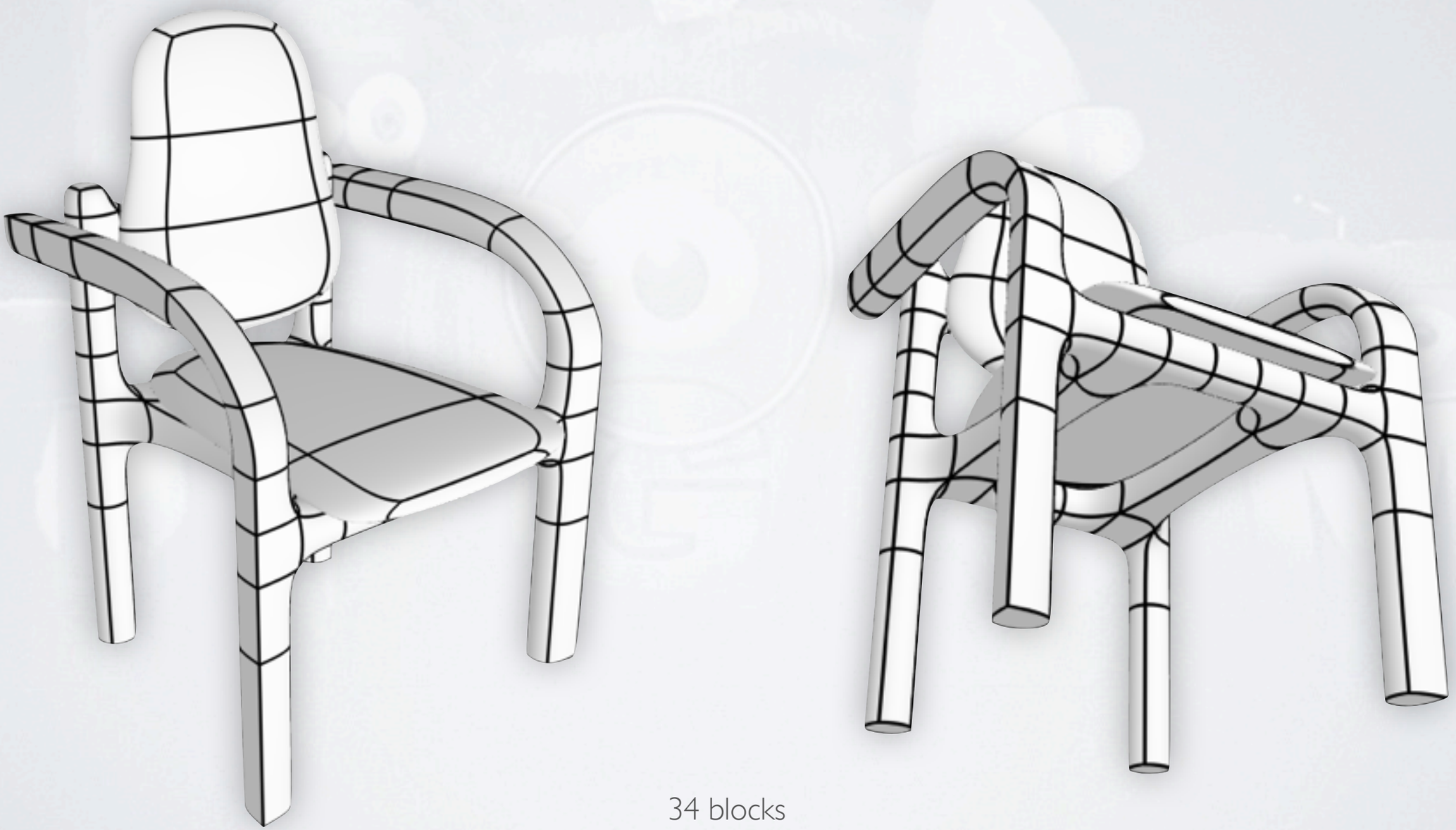


30 blocks
organic shape



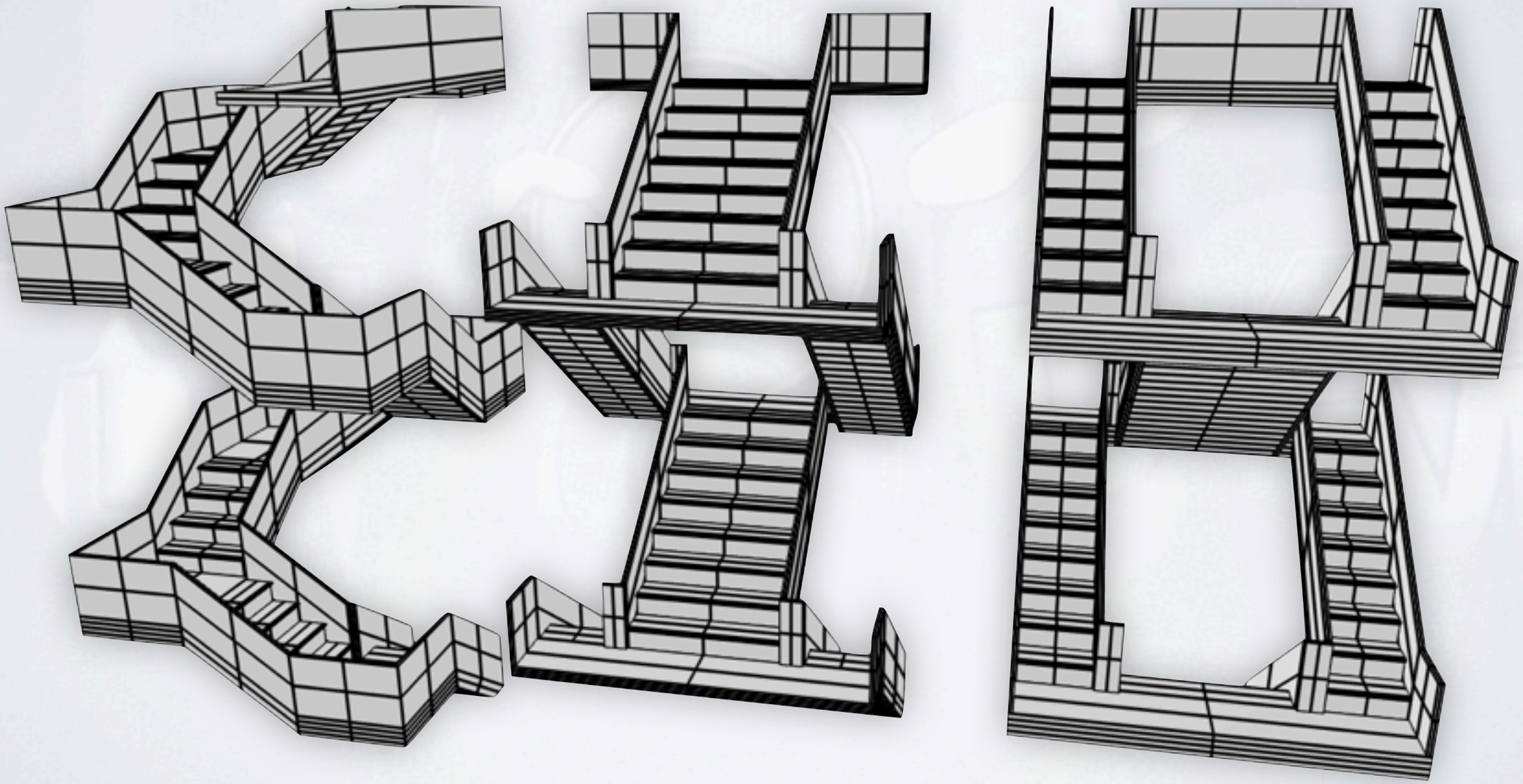


CHAIR



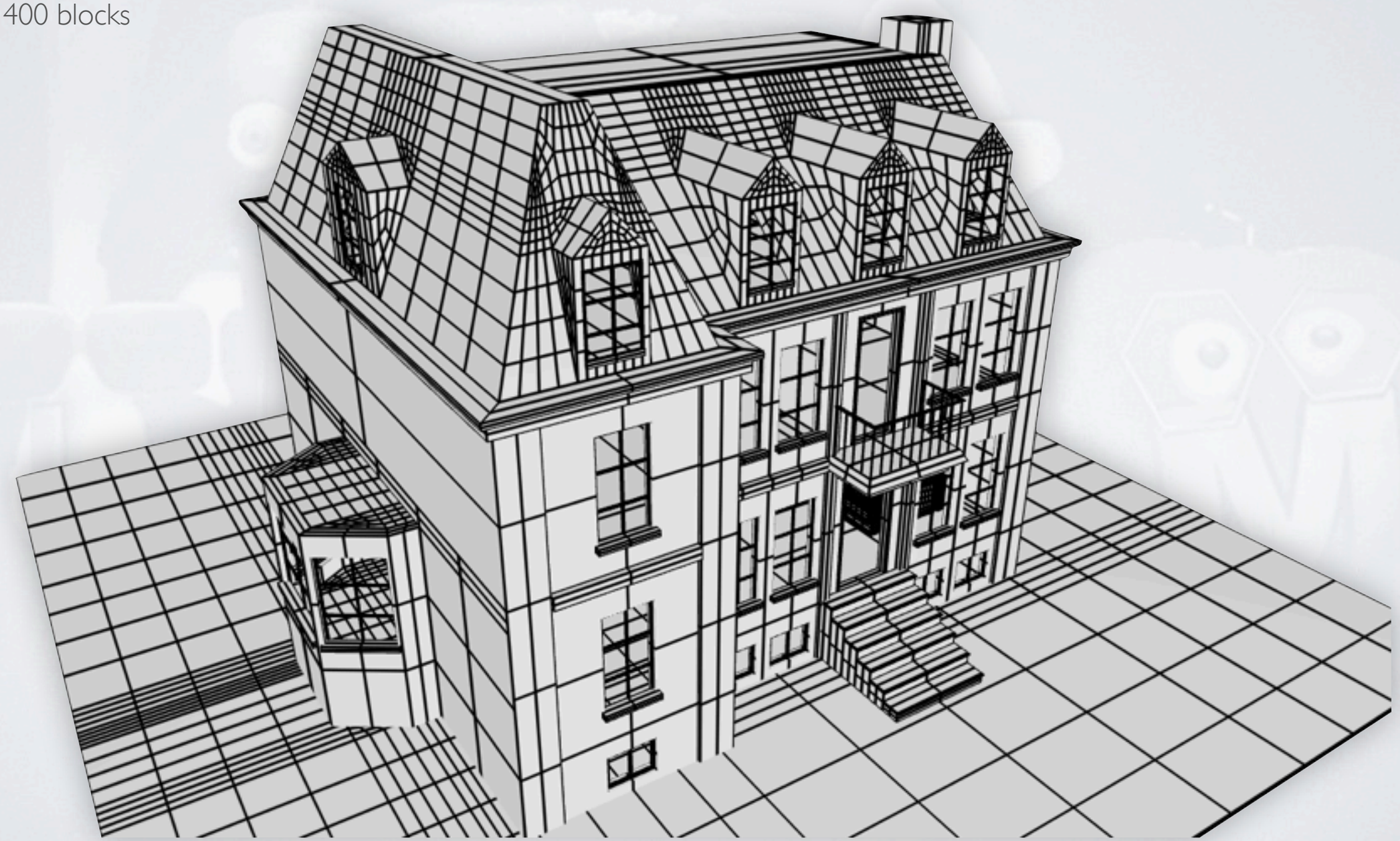
34 blocks
CAD shape

STAIRCASES



HOUSE

1400 blocks



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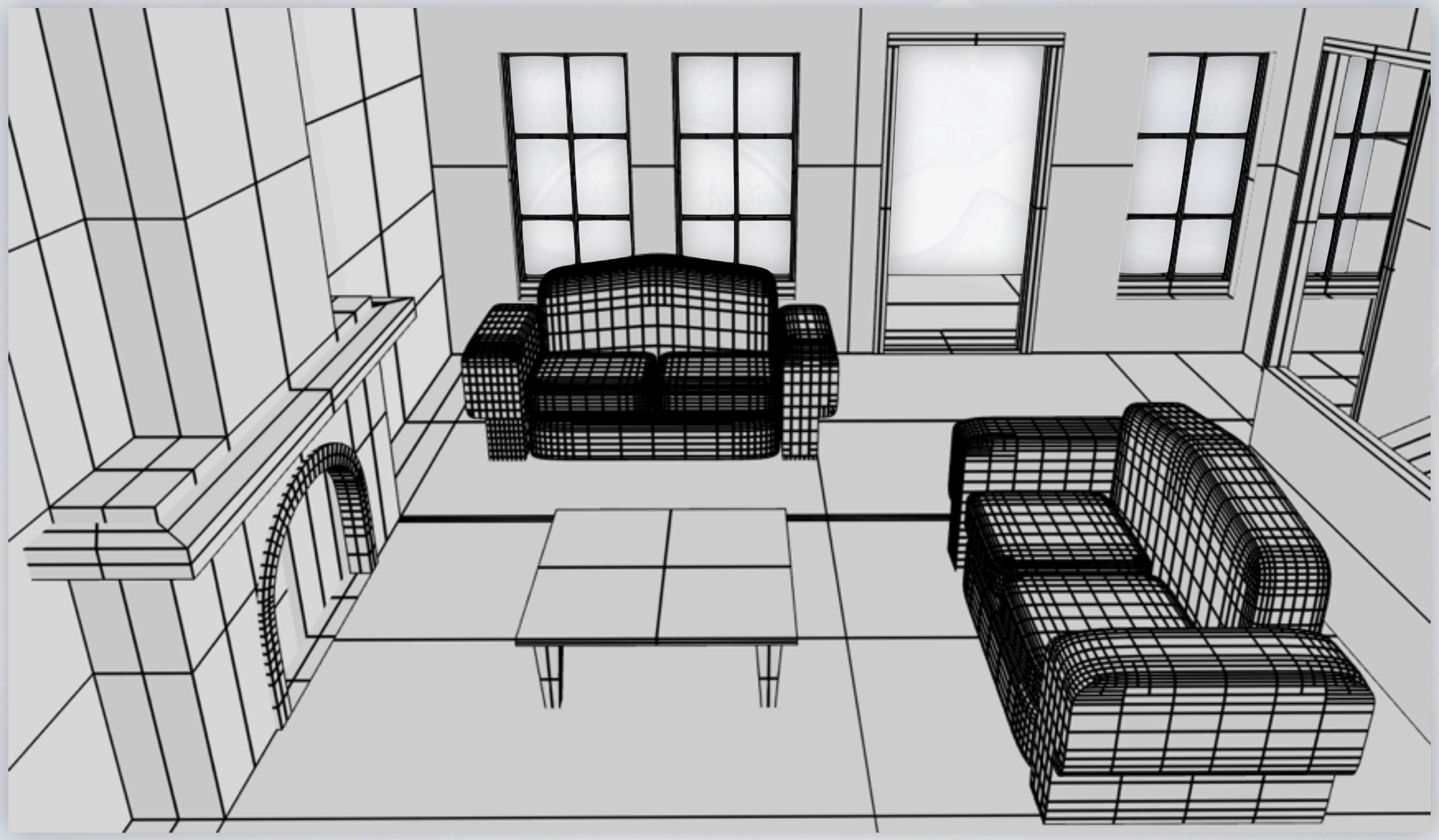


CONCLUSION

- Flexible
  - Organic objects
  - Mechanical/architectural objects
- Simple to use
  - Topology specification
- Volumetric
  - Boolean operations
- Surface control
  - Vertex positioning
  - Displacement mapping

FUTURE WORK

- Room for improvements
  - Some limitations on connections
  - Some distortion on the parameterization
- Incorporate within an interactive modeler

PROCEDURAL AND INTERACTIVE ICICLE MODELING

J. GAGNON AND E. PAQUETTE

TUESDAY, 15:30 PM - 17:30 PM (SITE B)

QUESTIONS

leblanc@iro.umontreal.ca

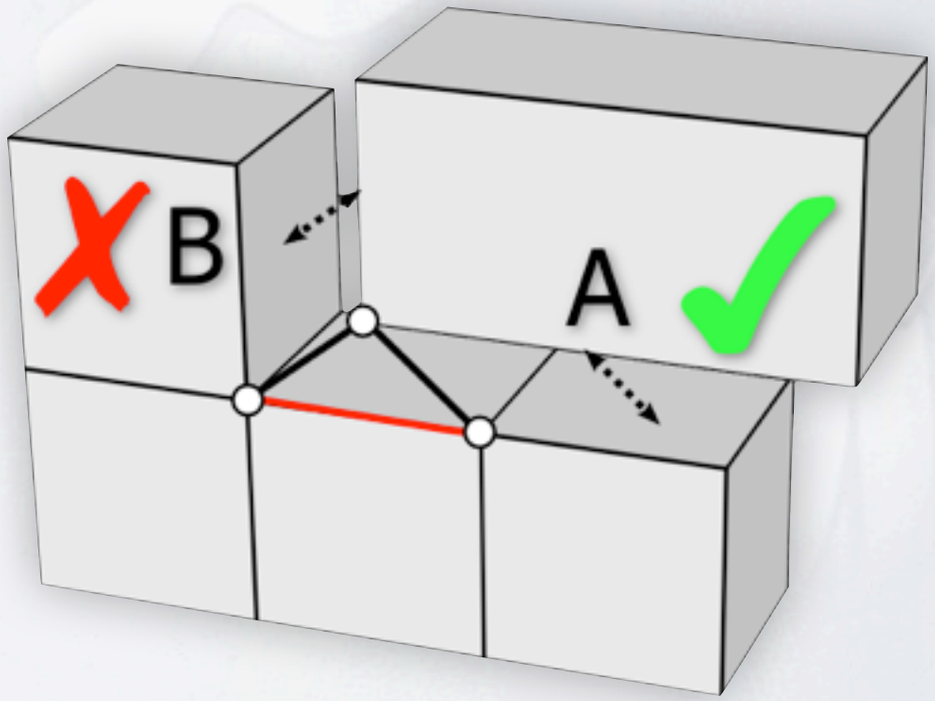
PUBLICATIONS

- Component-Based Modeling of Complete Buildings
  Graphics Interface 2011
  Luc Leblanc, Jocelyn Houle, Pierre Poulin

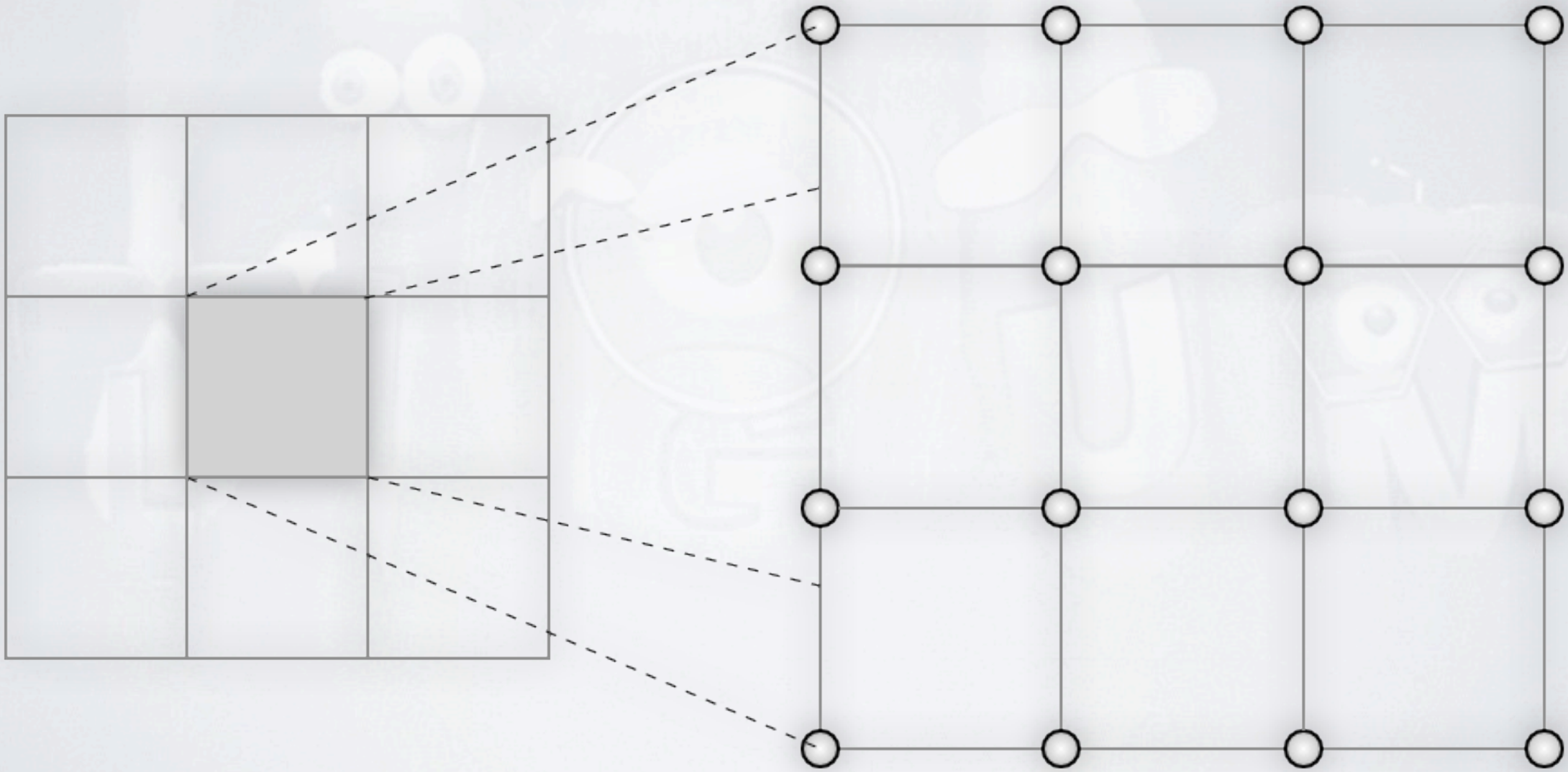
EXTRA

CONNECTING SUB-FACES

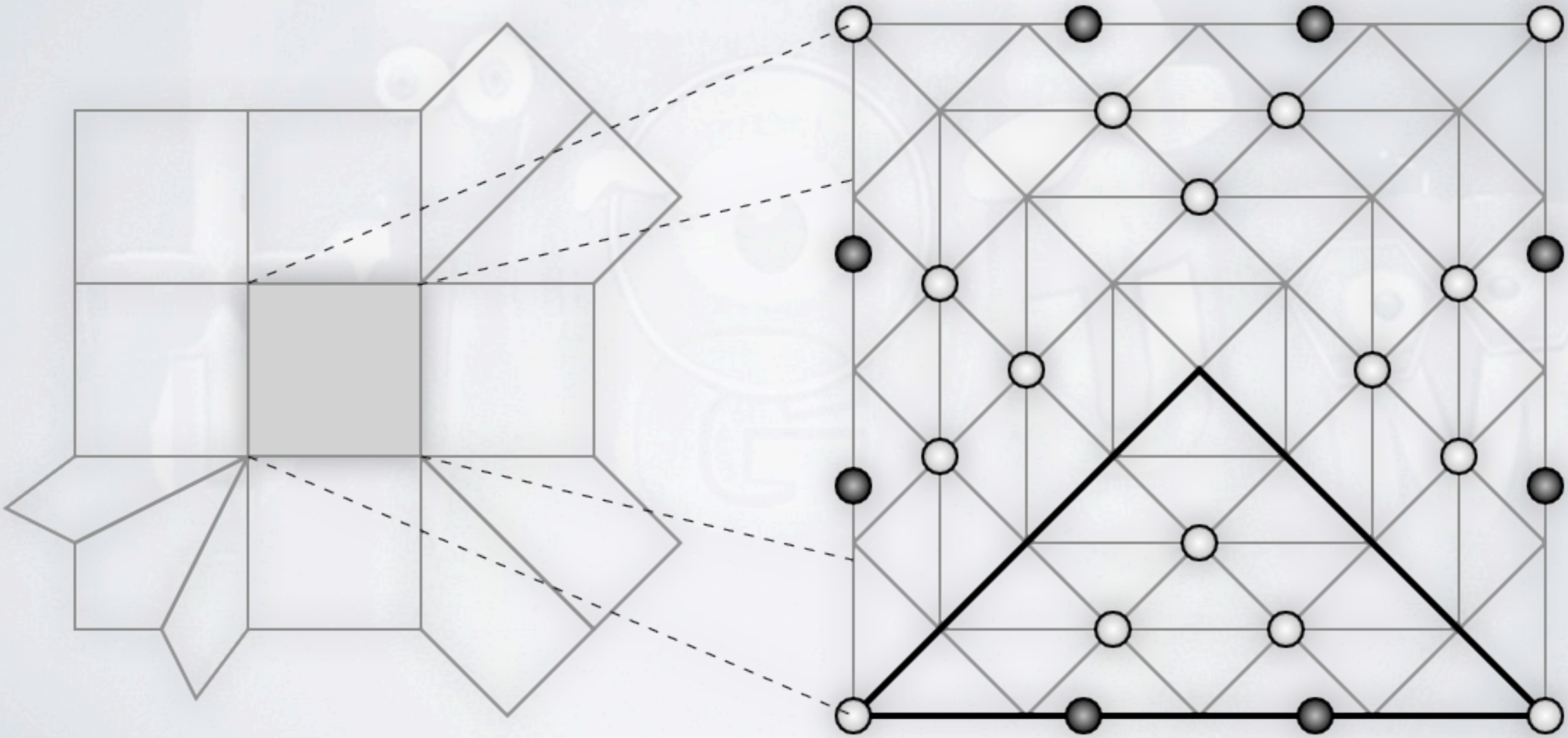
- Invalid connection
  - Degenerate edges



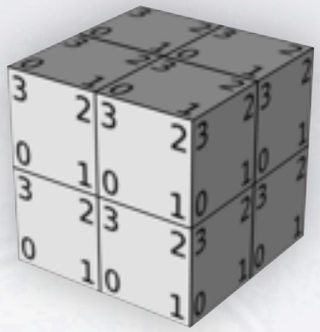
REGULAR PATCH

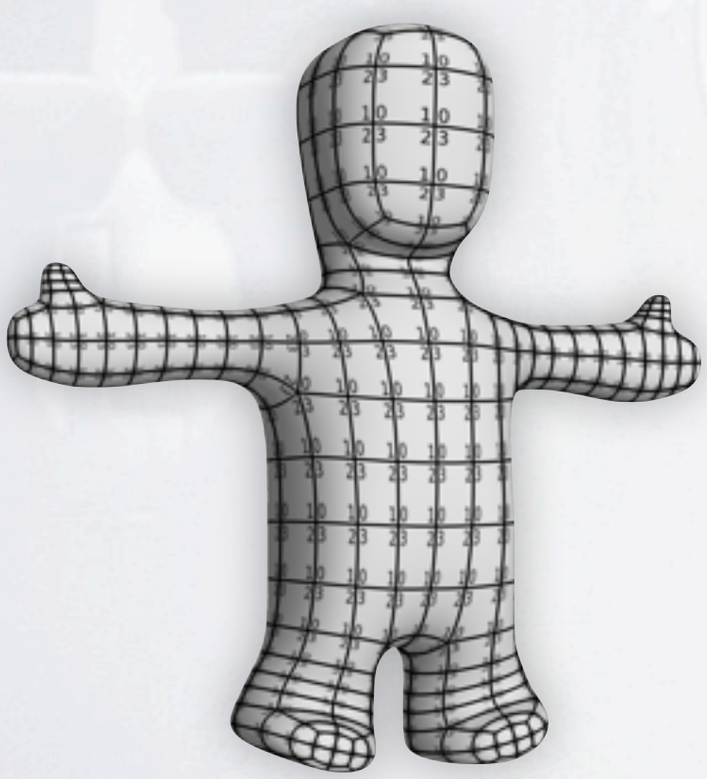


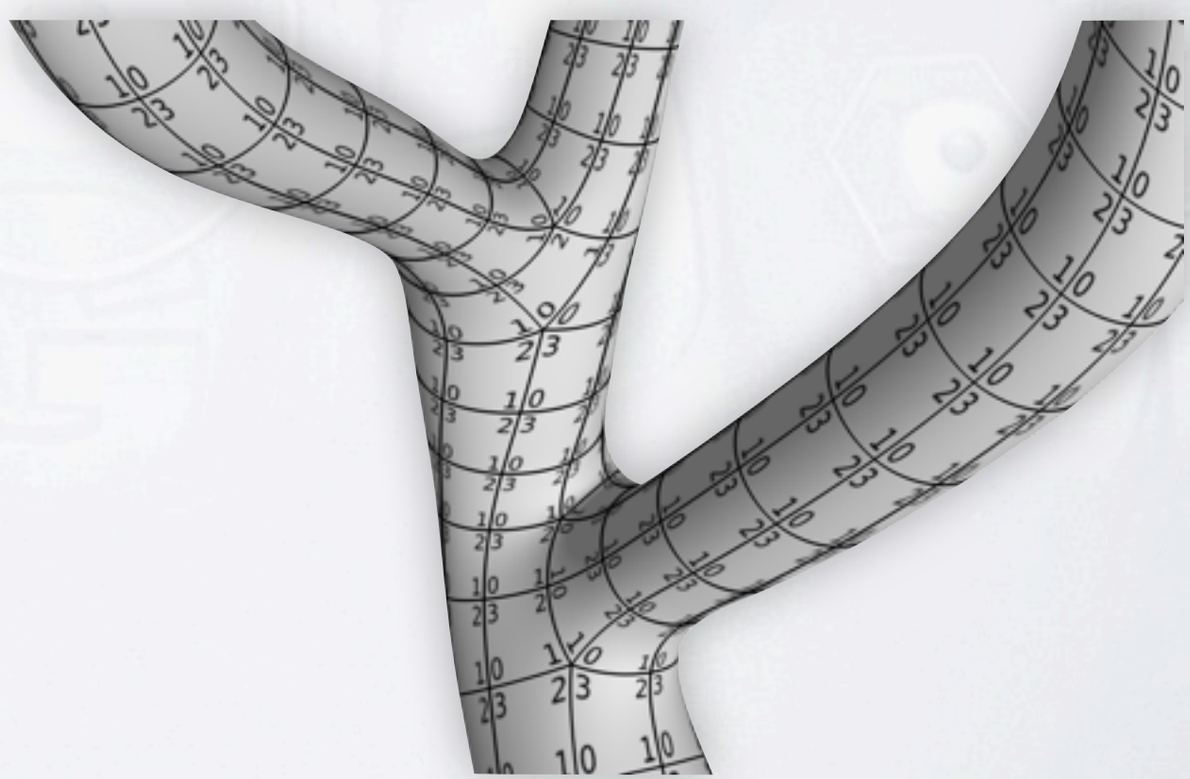
IRREGULAR PATCH



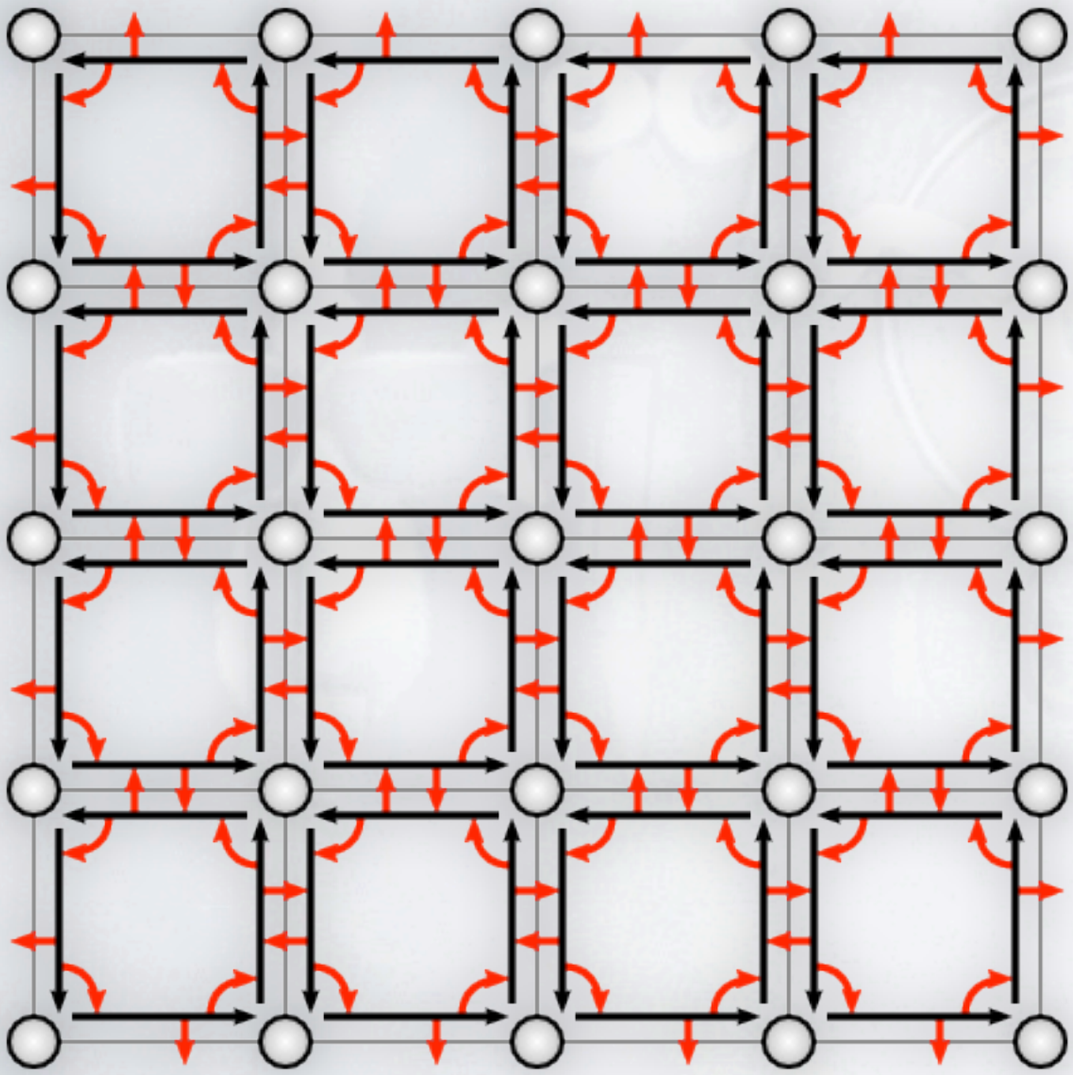
PARAMETERIZATION

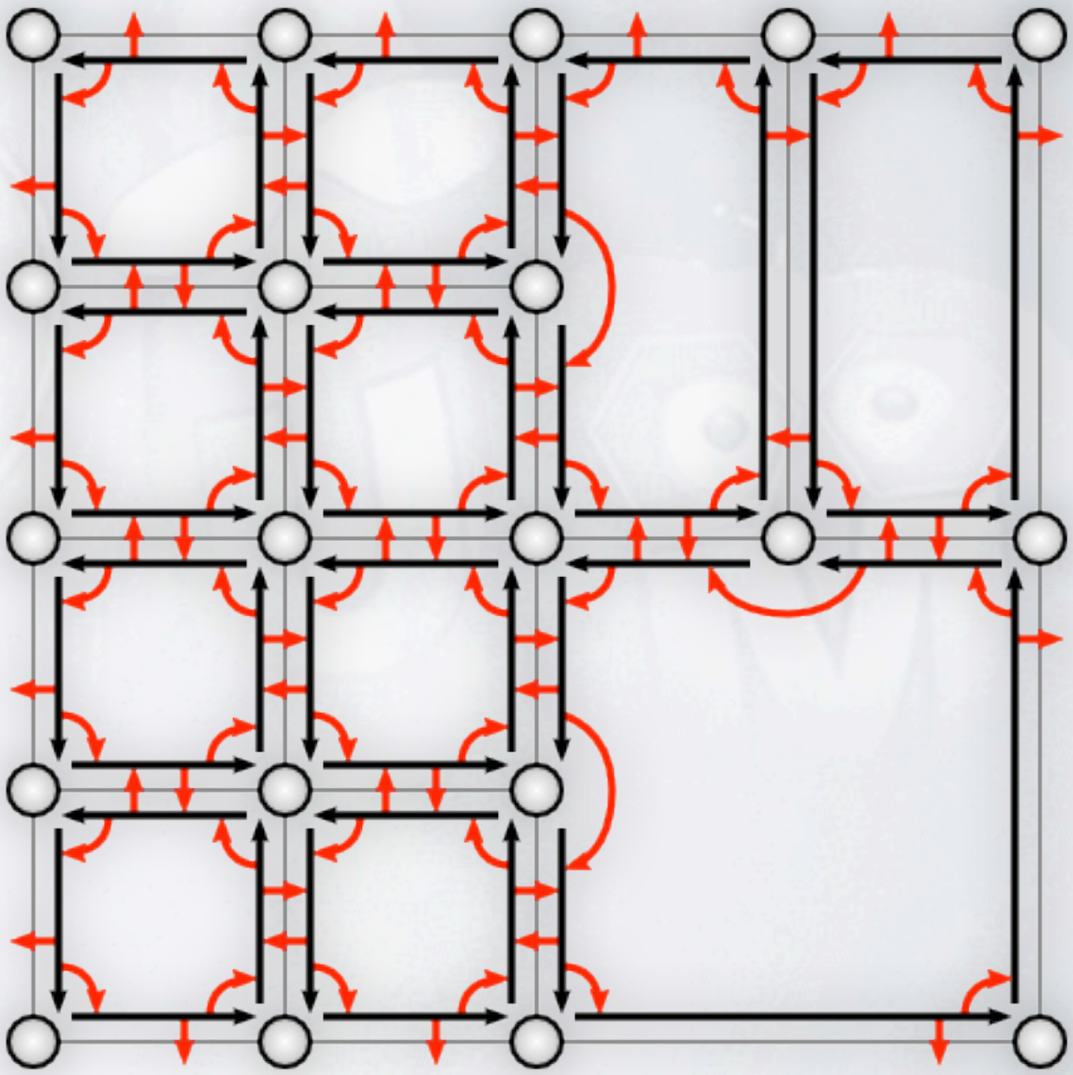




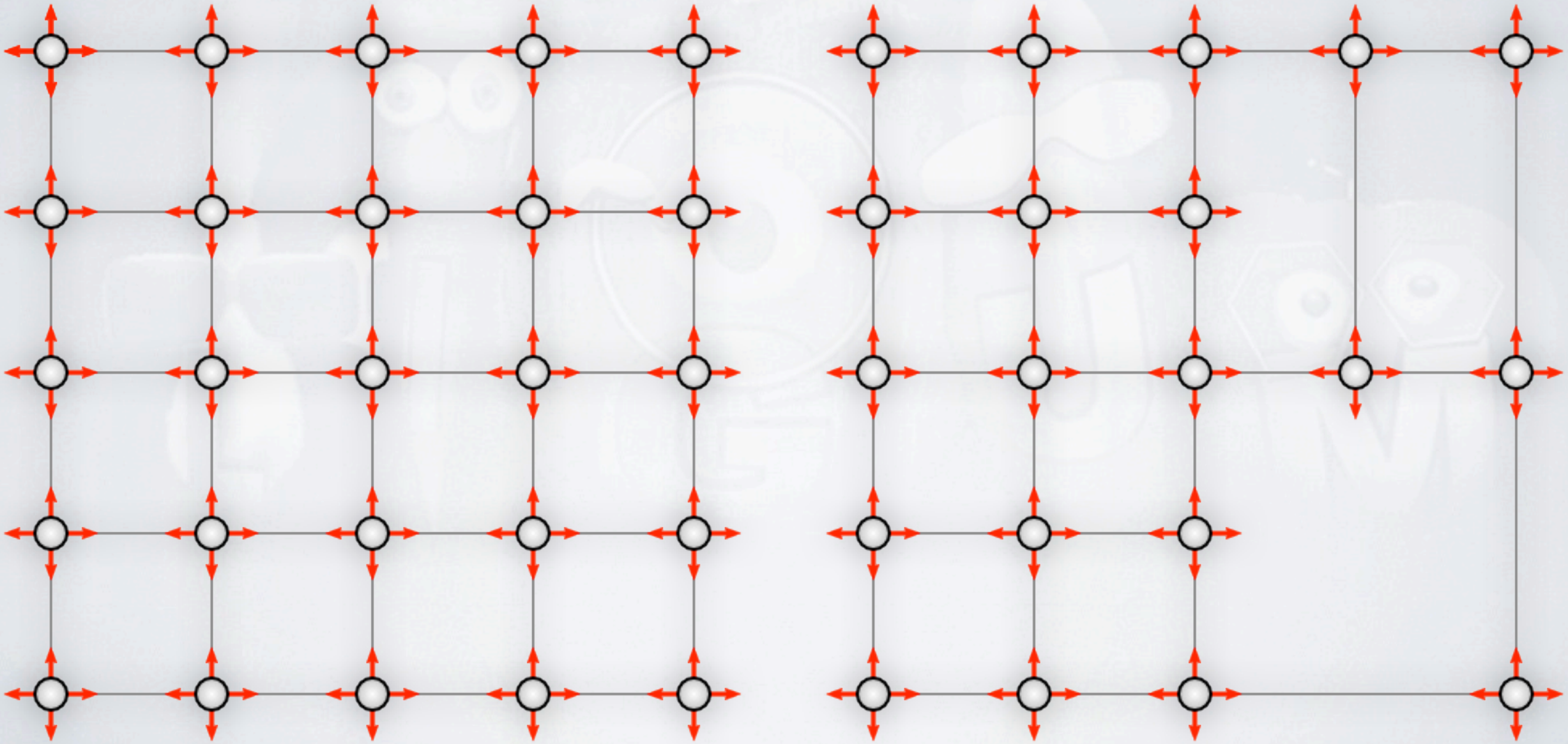


MESH STRUCTURE

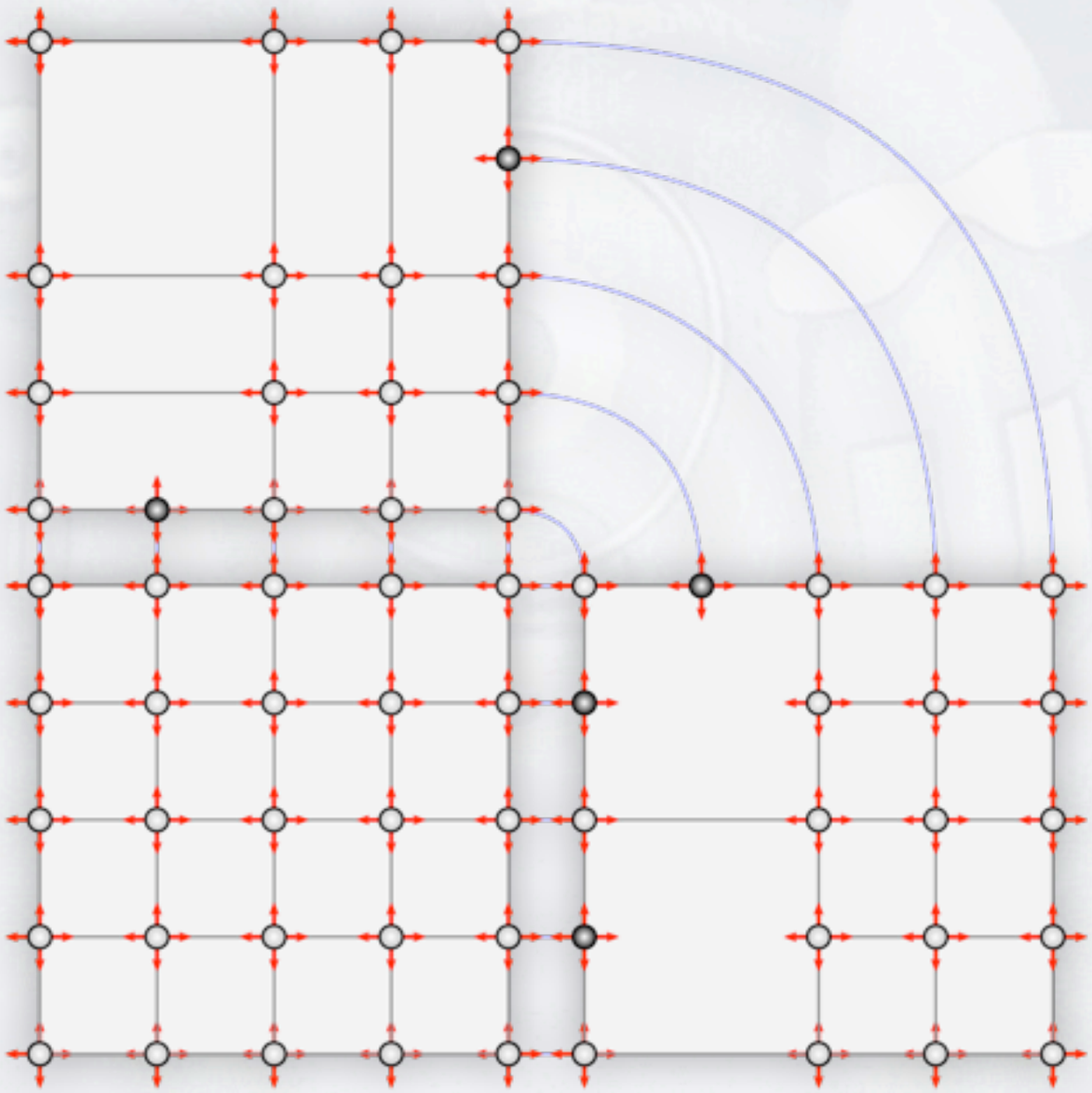




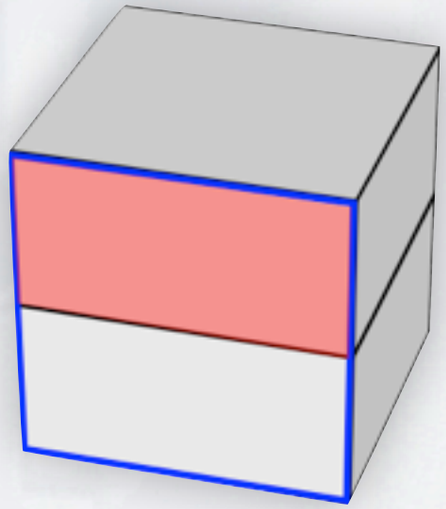
NEW MESH STRUCTURE



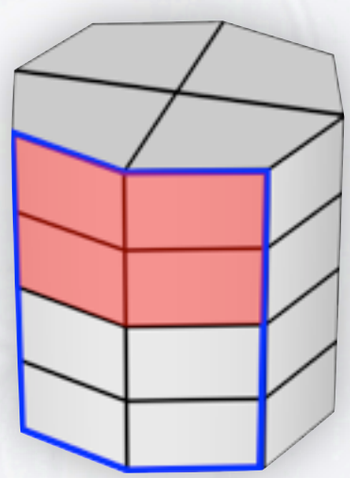
NEW MESH STRUCTURE



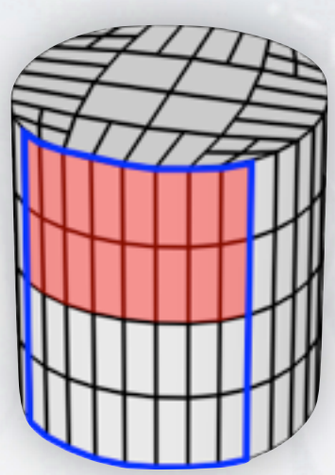
NOTATION



Sub-faces



Patches

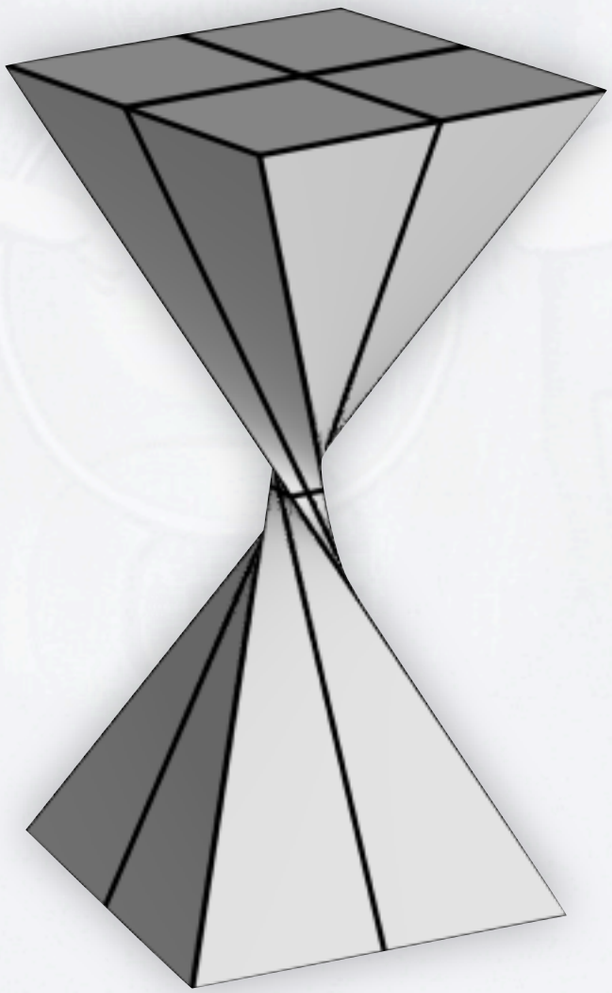


Sub-patches

MODELING PIPELINE

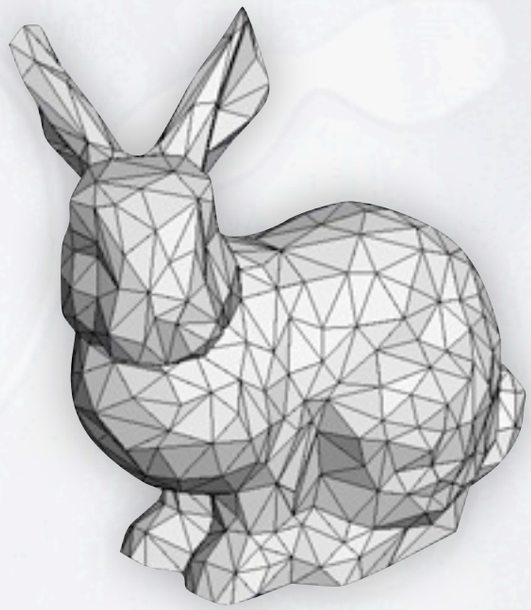
- Place blocks to approximate the shape of the object
- Topology results by connecting neighboring sub-faces of blocks
- Refine the surface to provide details

INVALID BLOCK



OBJECT REPRESENTATION

- Polygonal meshes
- Polynomial patches
- Subdivision surfaces
- Point sets
- etc.



OBJECT REPRESENTATION

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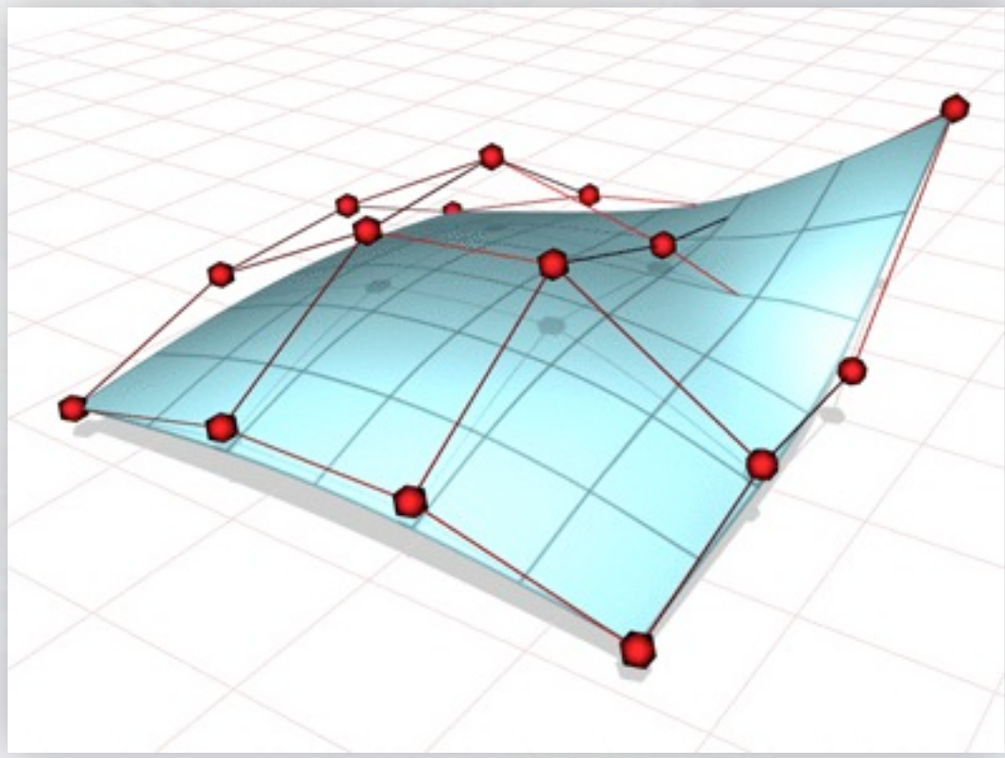

from Autodesk

OBJECT REPRESENTATION

- Polygonal meshes
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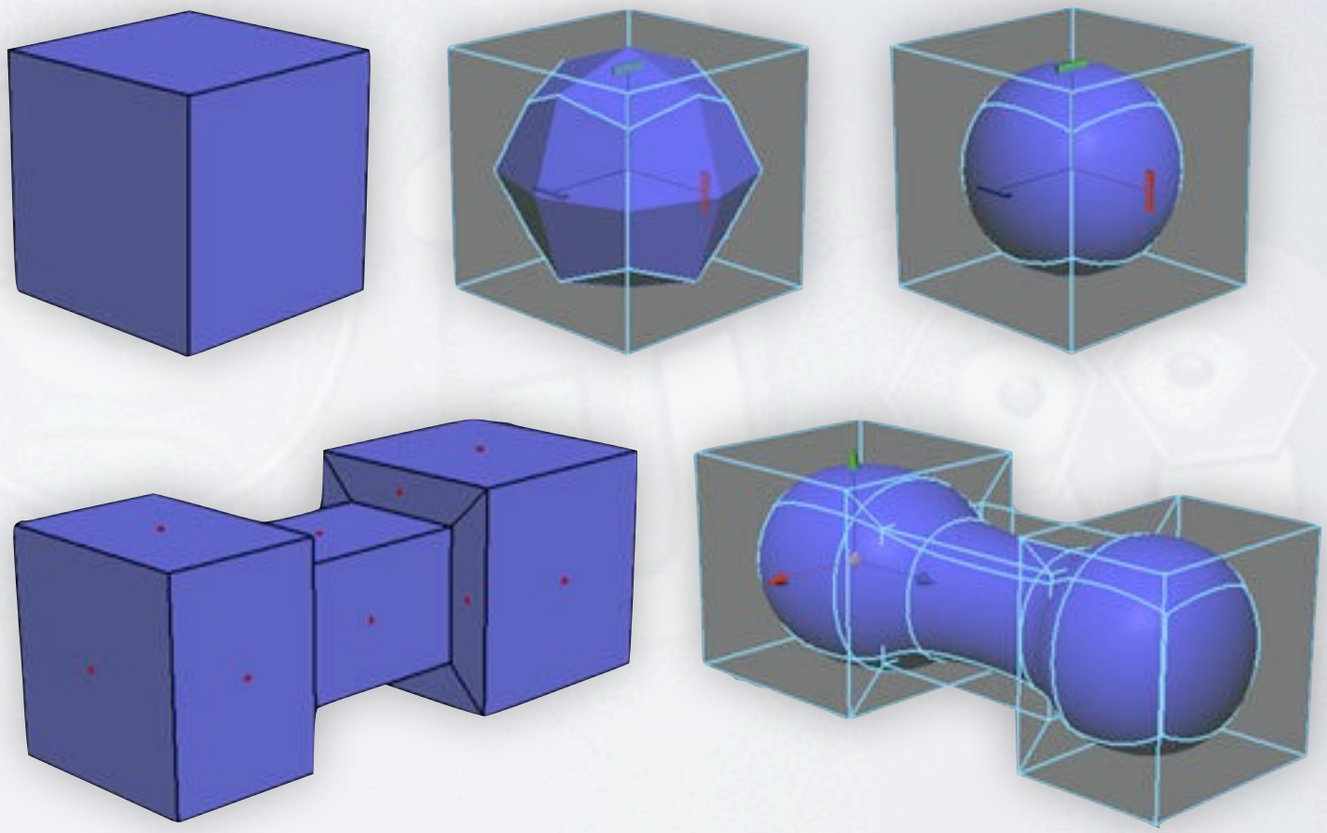
- etc.



from subdivisionmodeling.org

OBJECT REPRESENTATION

- Polygonal meshes
- Polynomial patches
- Subdivision surfaces
- Point sets
- etc.