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High-fidelity Isosurface Extraction of Topology Optimized Shapes for Additive Manufacturing

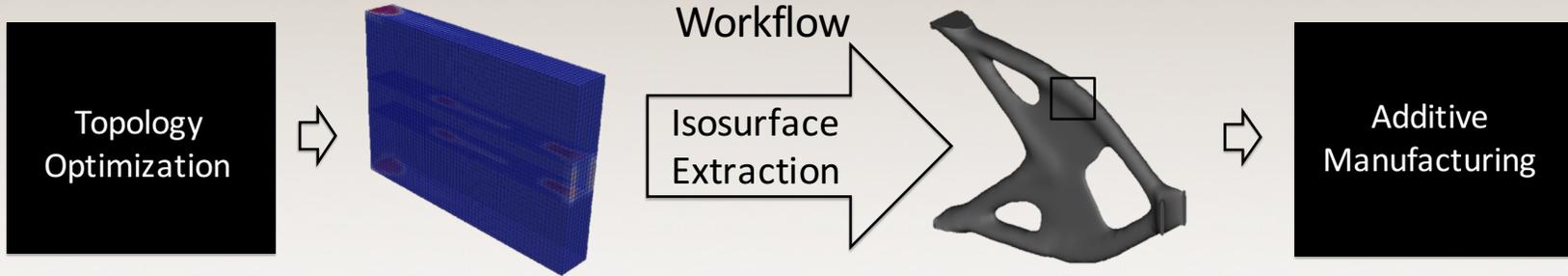
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Goal

Extract high-fidelity smooth isosurfaces from implicit data of topology optimized shapes for additive manufacturing



1. Extract Coarse Isosurface

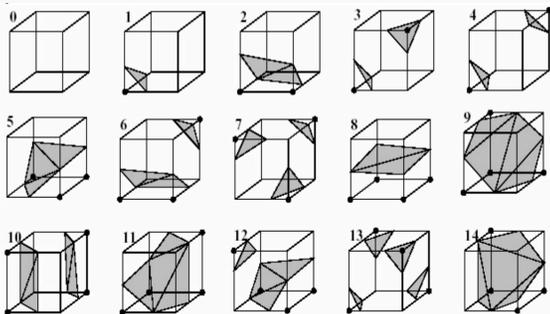


Fig 1: Marching Cubes generates triangles at each cube/hex using the scalar field at nodes. Fifteen unique cases convert a hex mesh into a coarse triangulation that may contain high- and low-frequency noise.

2. Refinement

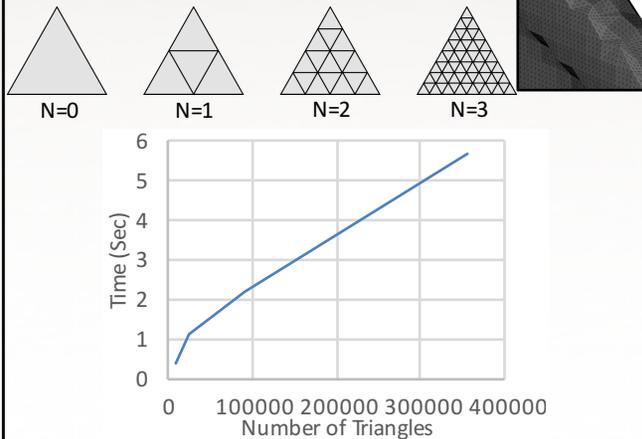


Fig 2: N-level refinement gives desired level of high-fidelity with 4^N triangles. $O(4^N n)$ for $N=2$, $O(16n)$

3. Stitching

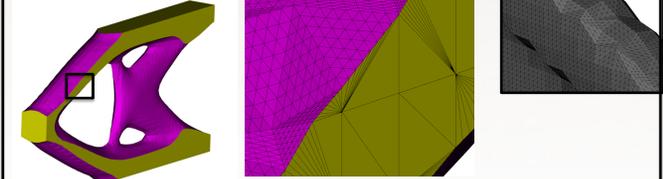


Fig 3: Stitch optimized (pink) and fixed (yellow) blocks

4. Projection

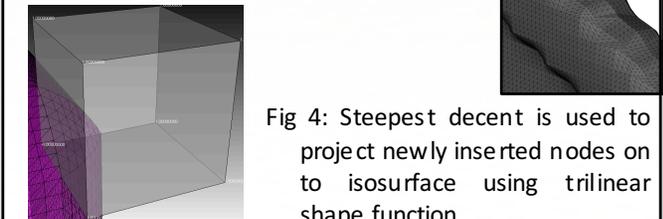


Fig 4: Steepest decent is used to project newly inserted nodes on to isosurface using trilinear shape function

5. Smoothing

$M(V, E, T)$: Surface mesh

$f: V \rightarrow \mathbb{R}^3$

$\nabla^2 f = 0$

$\Delta f(V_i) = -f(V_i) + |V_i^*|^{-1} \sum_{j \in i^*} f(V_j)$

$f(V_i)^{n+1} = f(V_i)^n + \lambda \Delta f(V_i)^n$

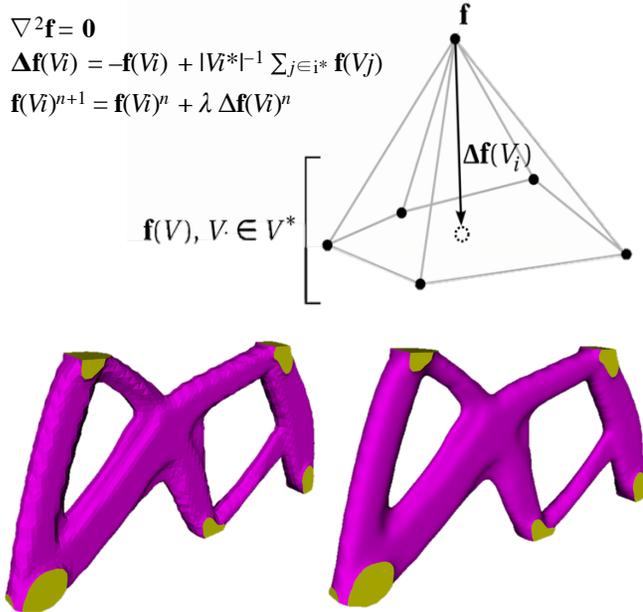


Fig 5: Smoothing removes high-frequency noise

Implicit Data:
(hex mesh with density field)

1. Extract Coarse Isosurface

2. Refinement Operation

3. Stitching Operation

4. Projection Operation

5. Smoothing Operation

6. Visualize Isosurface

Explicit Data: STL file

6. Visualization

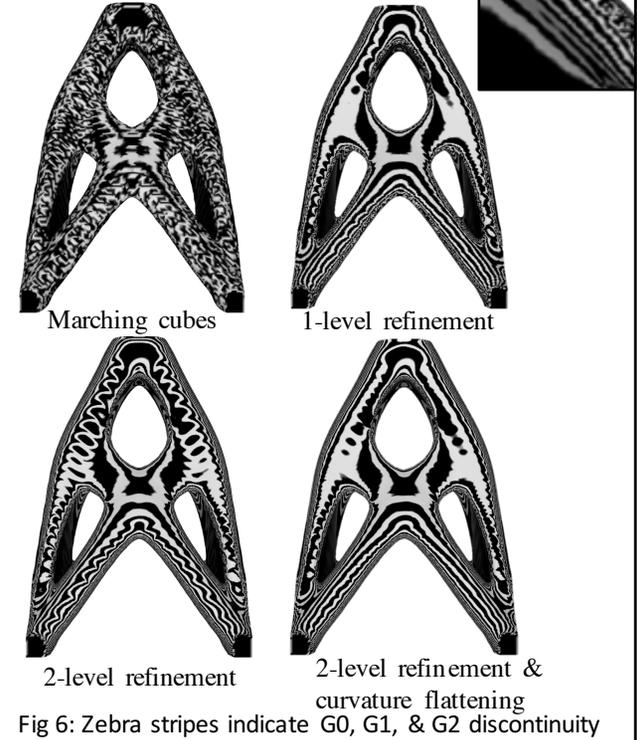


Fig 6: Zebra stripes indicate G0, G1, & G2 discontinuity

Results

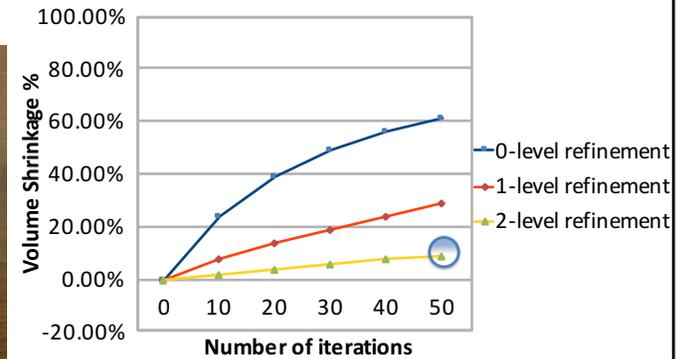
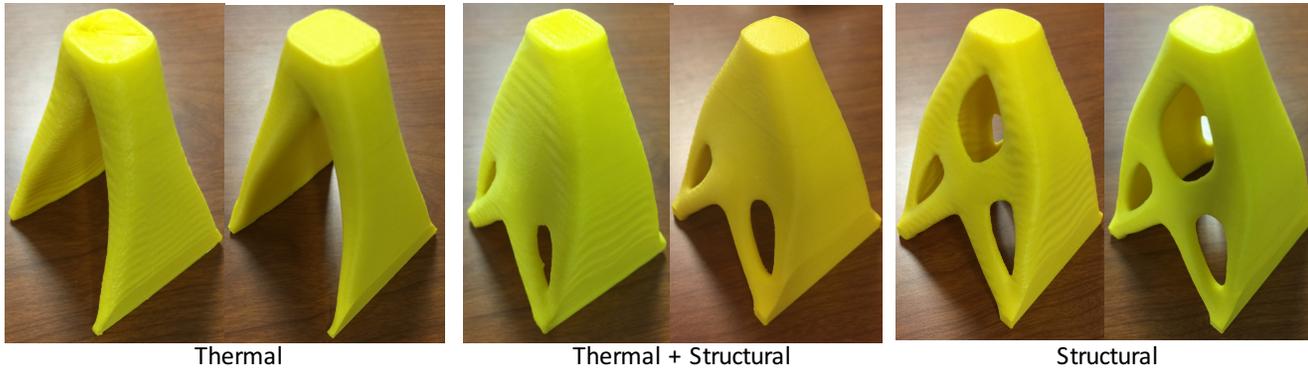


Fig 7: Lower shrinkage with 2-level refinement & 50 iterations