OOF Project Update

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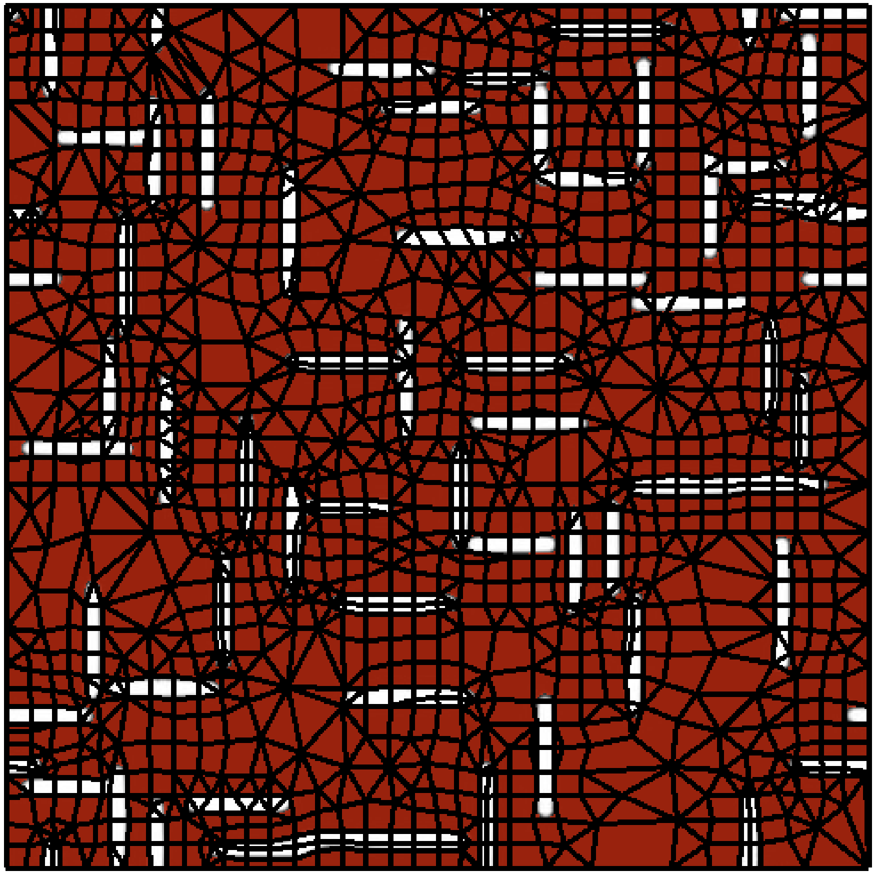
Outline

I. Automatic Skeleton construction
II. One-dimensional interfaces
III. 3D Viewer mock-up
IV. Plasticity overview

I. Automatic Skeleton

(Stephen Langer)

- Encapsulates an effective strategy for combining and tuning skeleton modification methods to yield a good mesh.
- Accessible as a single button in oof2’s Skeleton page.

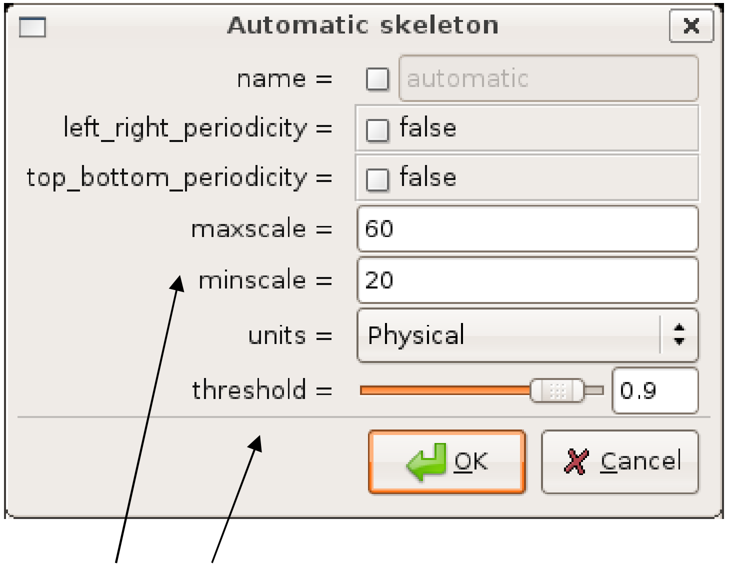


Auto-Skeleton Components

Recipe:

1. Initial skeleton with resolution at *maxscale*
2. Refine elements to resolution *minscale*
3. SnapRefine (1x)
4. Rationalize (2x) – to fix badly-shaped elements.
5. Smooth (1x)

Supply a few parameters:



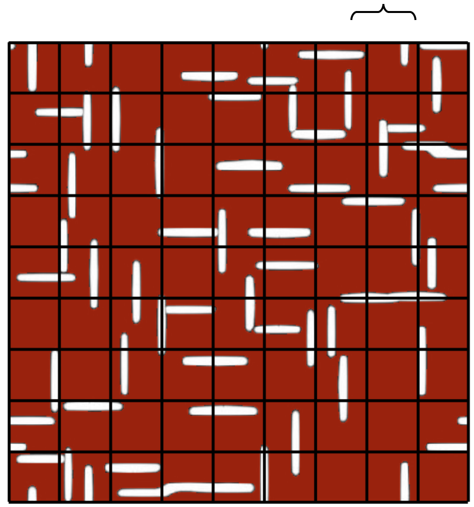
Important: *maxscale, minscale, threshold*

Auto-skeleton example

Start: 1. Microstructure/image

2. Initial skeleton

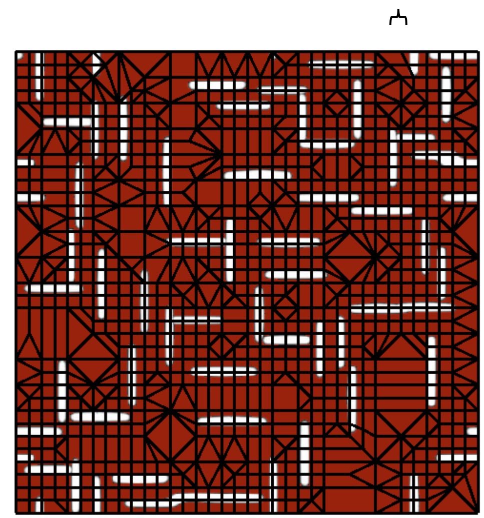
maxscale



Homogeneity index = 0.846
81 elements

3. Refine skeleton

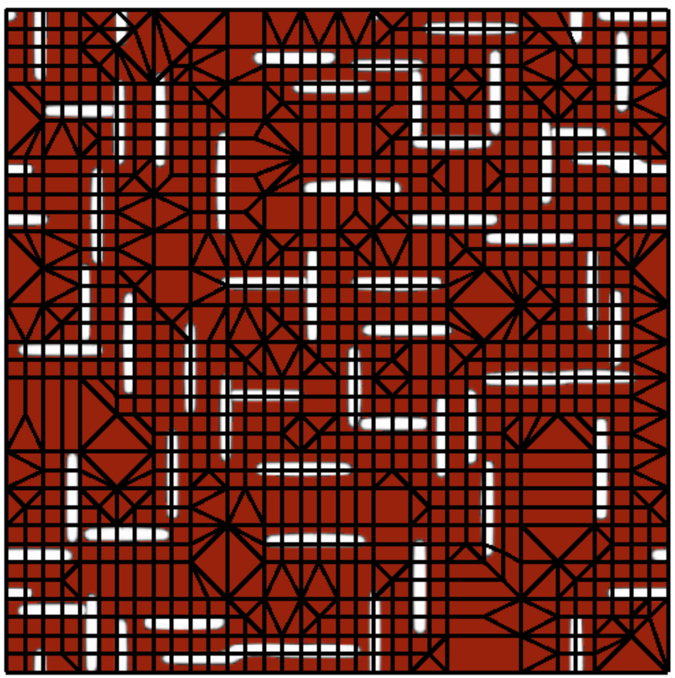
minscale



Homogeneity index = 0.890

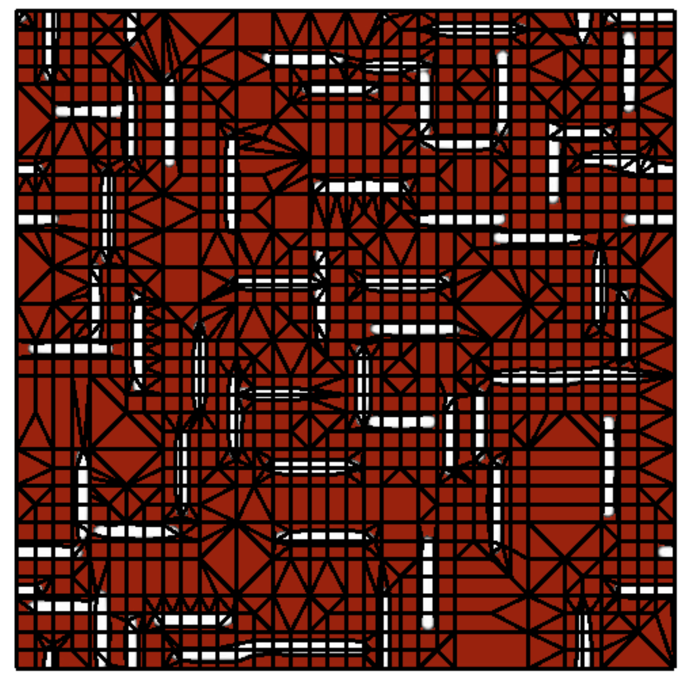
...example continued

3.



Homogeneity index = 0.890

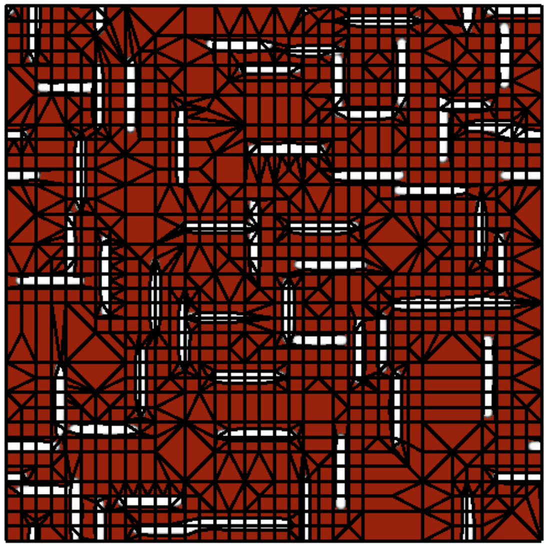
4. SnapRefine skeleton
(place new edges and nodes
at material boundaries)



Homogeneity index = 0.981

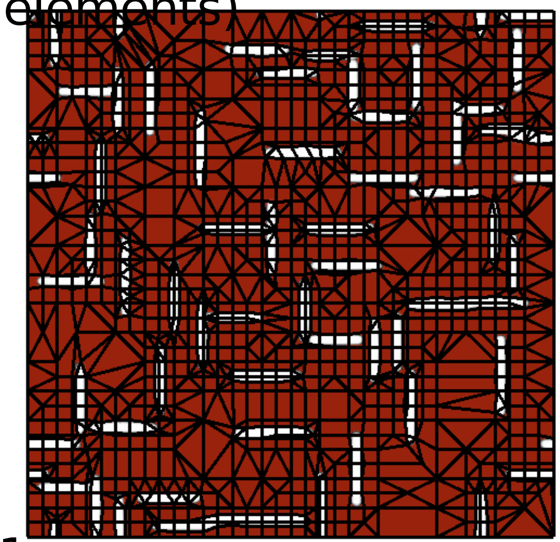
...example continued

4.



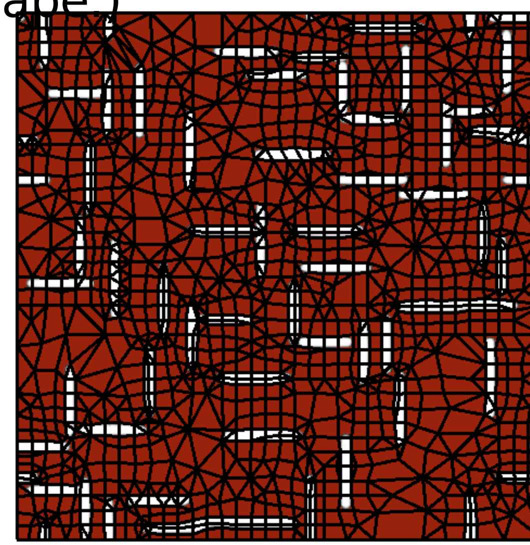
Homogeneity index = 0.981

5. Rationalize skeleton (fix badly-shaped elements)



Homogeneity index = 0.981

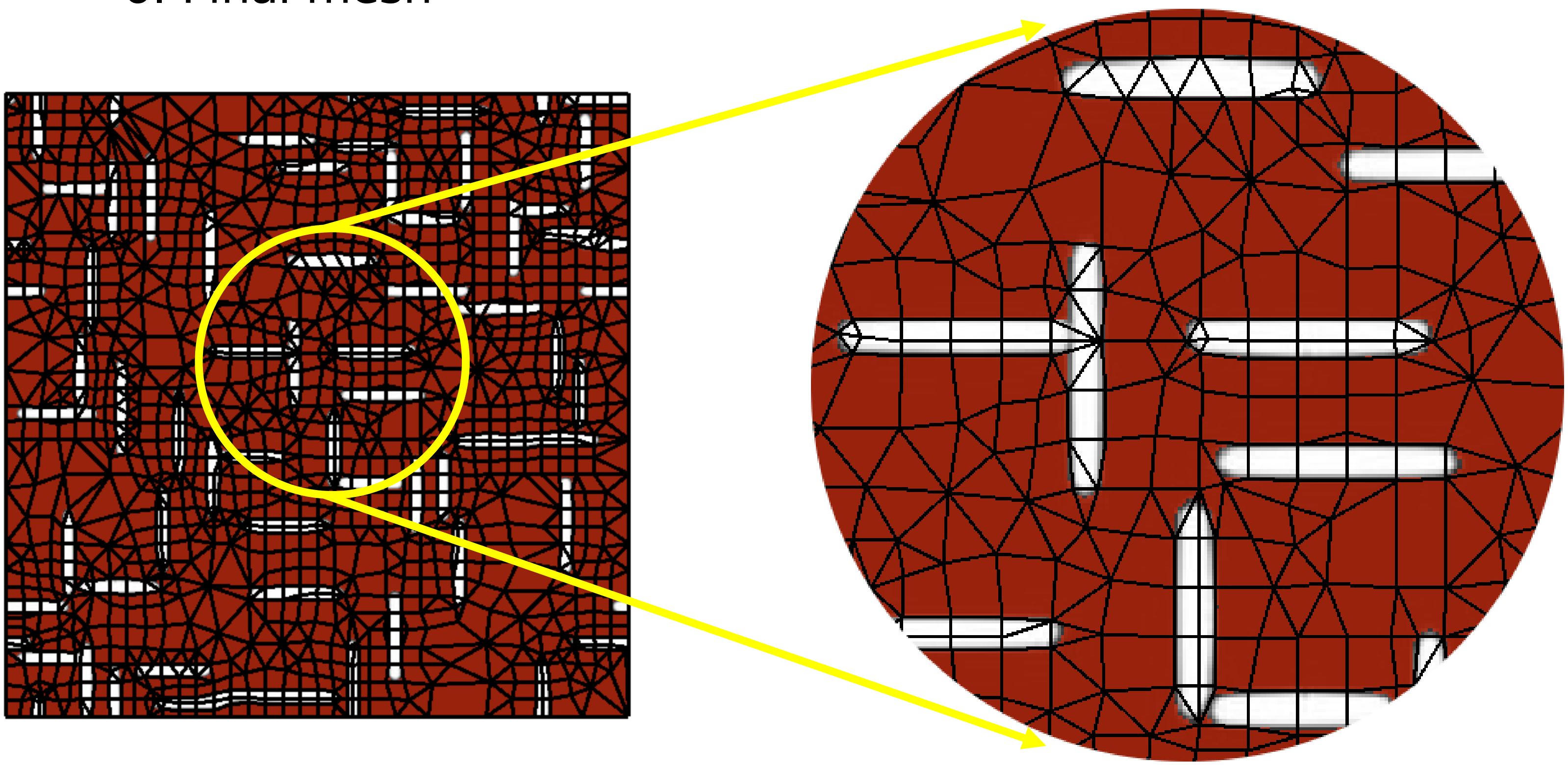
Finish: 6. Smooth skeleton (move a node to the average position of its neighbors. Improves element quality and/or shape.)



Homogeneity index = 0.982

...example continued

6. Final mesh



Homogeneity index = 0.982
1842 elements

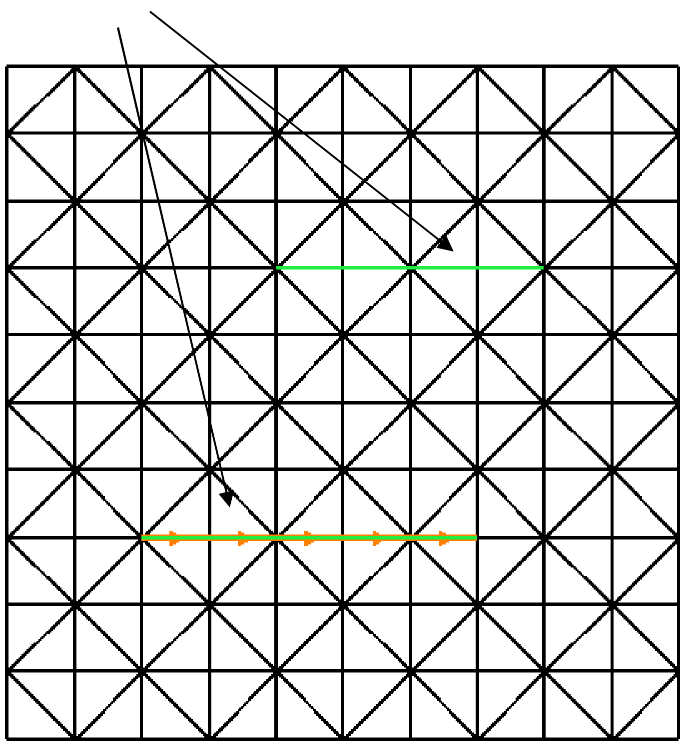
II. One-dimensional Interfaces: goals

- Define one dimensional interfaces and create associated 1-D elements within 2-D mesh.
- Incorporate physics of surface (line) tension, heat source/line charge. Define cracks (insulation) and jumps or discontinuities in field values across an interface.
- Attach materials and properties to 1-D elements. Specify constitutive rules.

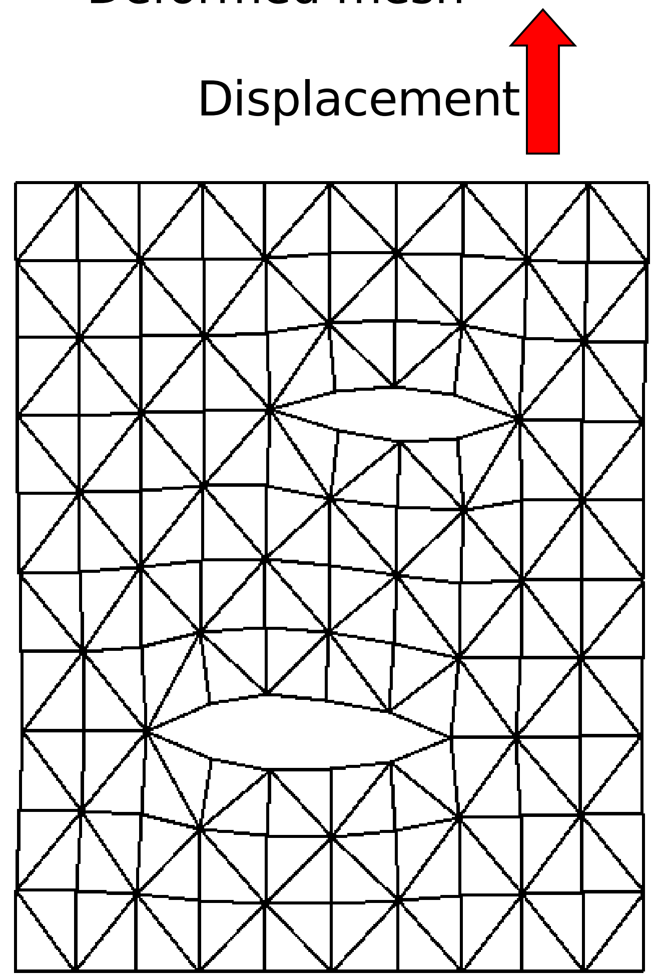
“Cracks”

Initial skeleton

User-defined interfaces
(skeleton boundaries)

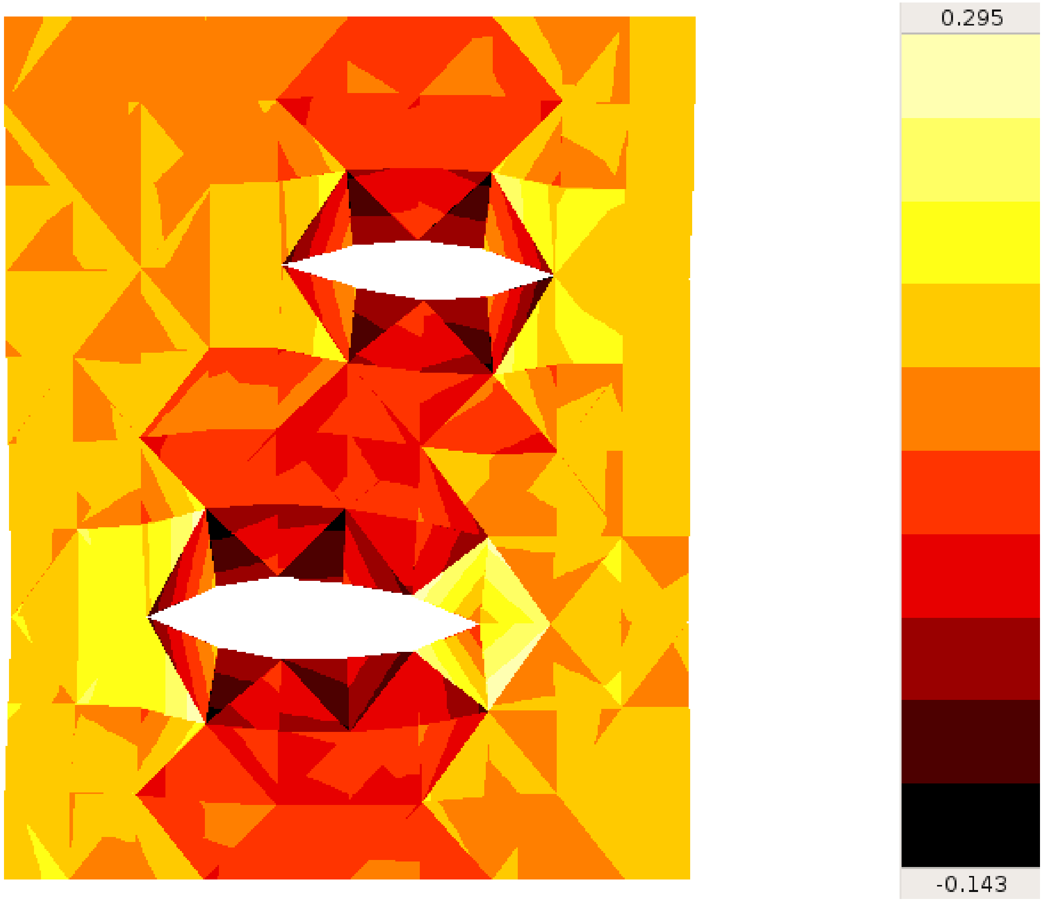


Deformed mesh



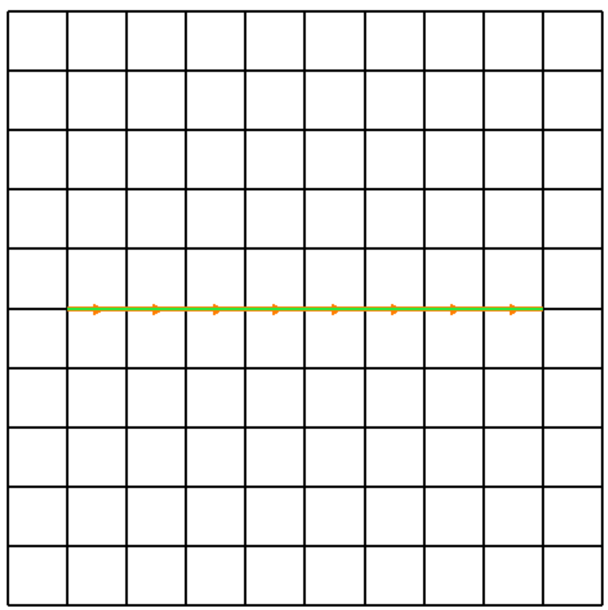
...continued

Stress (trace) field

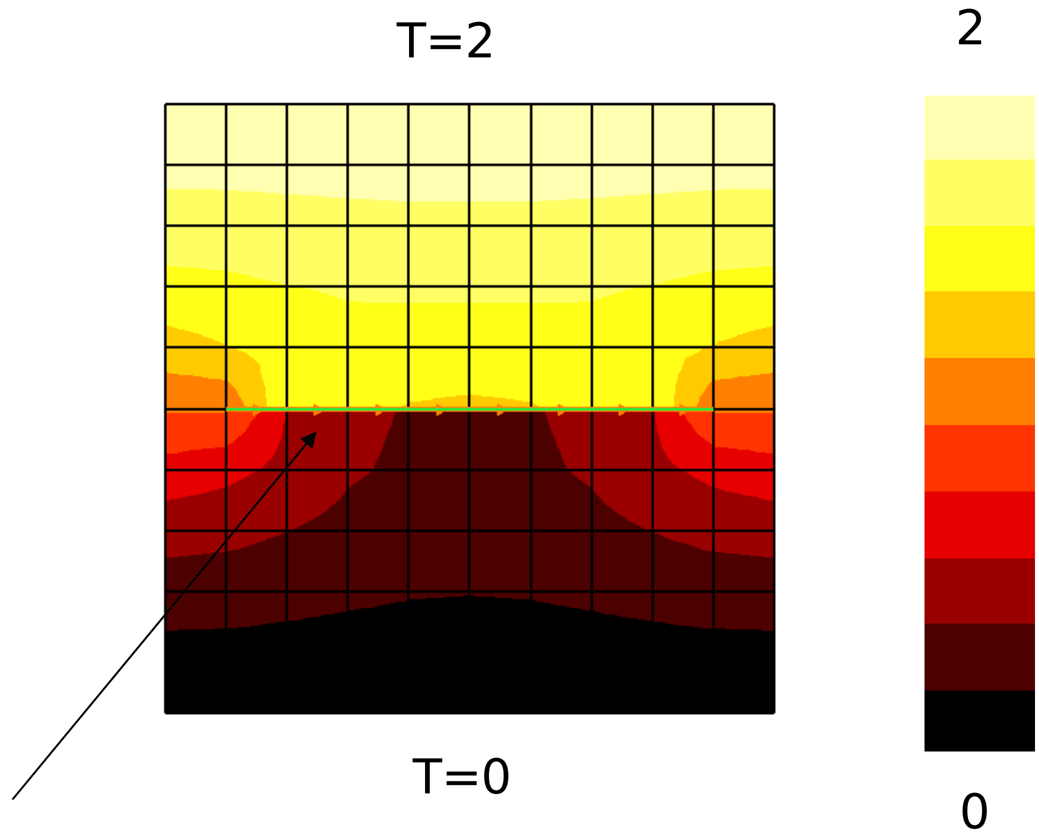


Field Jump/Discontinuity

Skeleton with interface

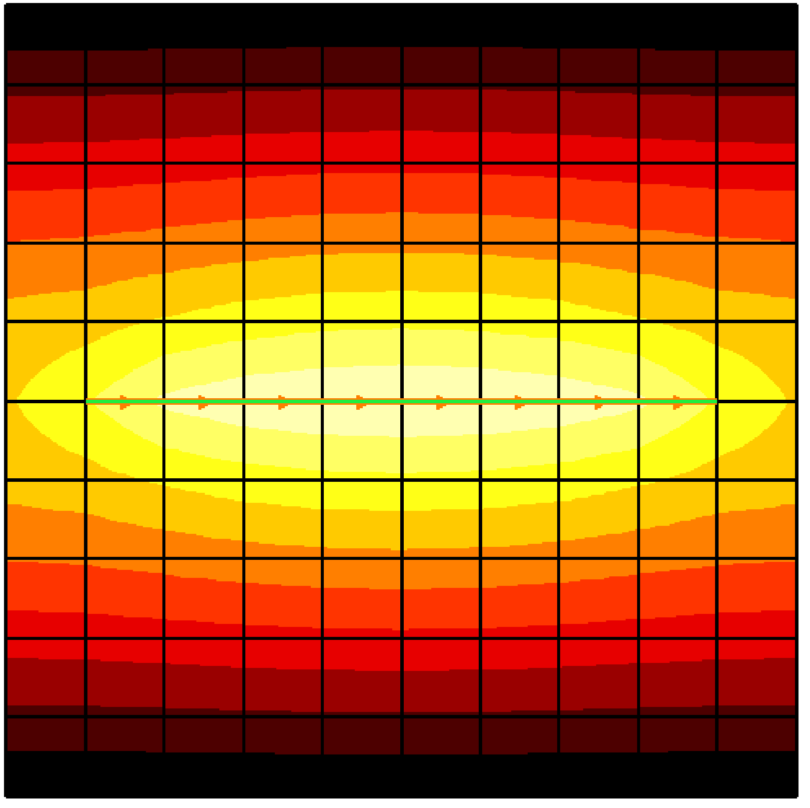


Solved mesh (thermal)



T(upper)-T(lower) = 1

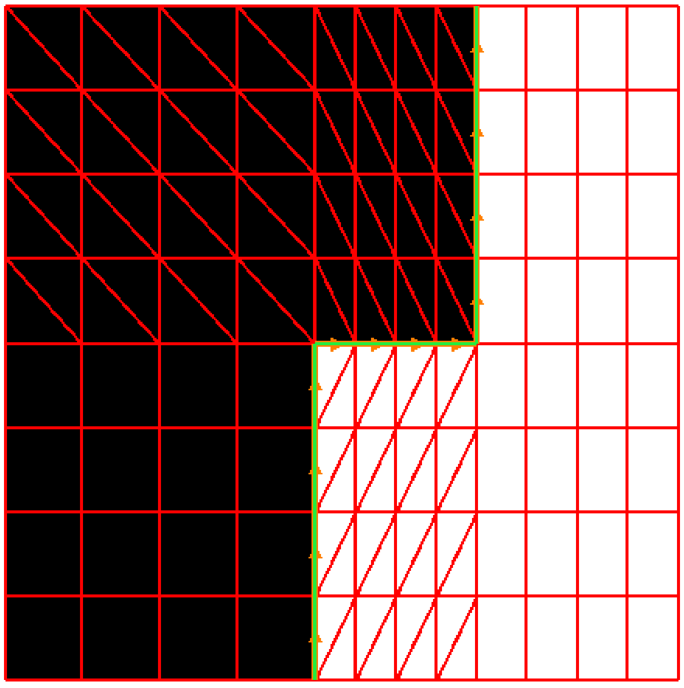
Heat Source/Line Charge



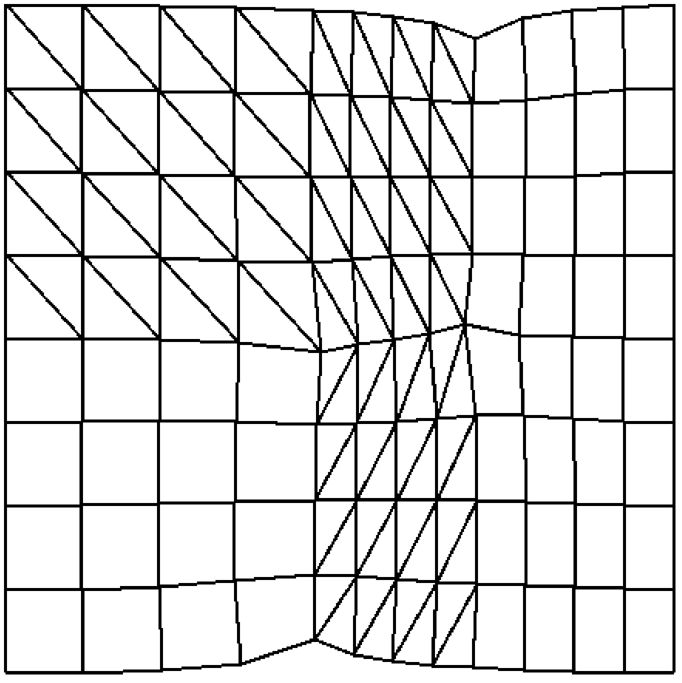
(Demo implemented using neumann boundary condition mechanism in oof2.)

Line Tension

Skeleton with zig-zag interface



Deformed mesh



(Demo implemented using force boundary conditions on the nodes.)

III. OOF 3D Viewer

- Rely on the Visualization ToolKit (VTK) from KitWare Inc. for the visualization and graphics pipelines.

(Actual VTK app embedded in this document, based on ActiViz example. Demo works if you have MS Powerpoint with Visual Basic macros enabled and ActiViz installed.)

Create

Reset Camera

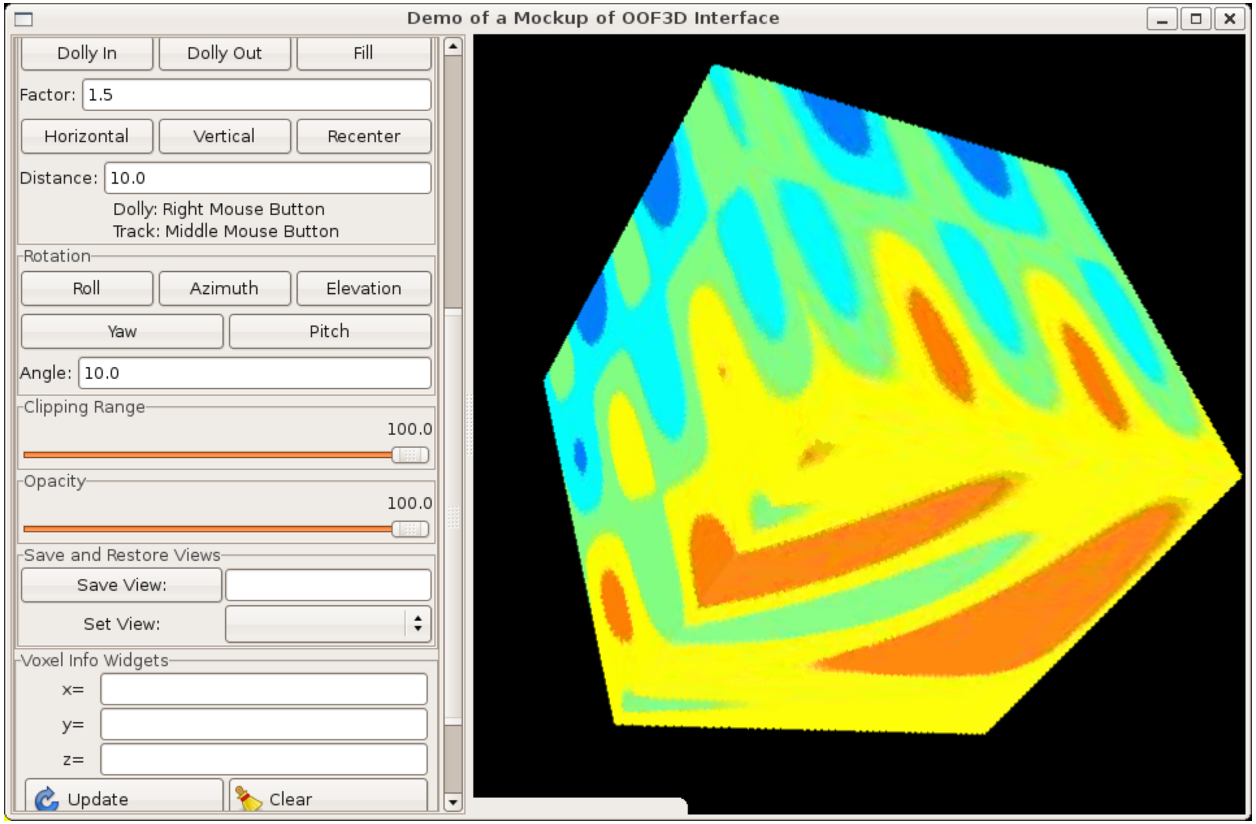
Spin Camera

Inactive VTK control

vtkRenderWindow control

Mock-up
(Valerie Coffman)

Written in Python, VTK, PyGTK and PyGTKGLExt.
GTK provides GUI controls. PyGTKGLExt provides drawing area.



3D microstructure constructed from 2D image slices.

Has (some) capabilities in common with MayaVi, ParaView, and VolView, which are also based on VTK.

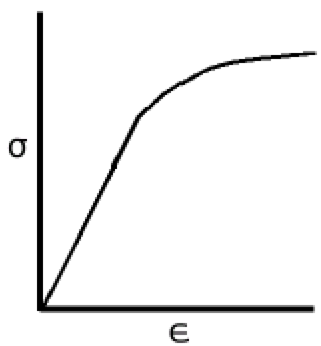
Features of the Viewer

- View object from different perspectives (tumble, pan, zoom, etc.)
- View sections of the object (clipping, cross sections on arbitrary planes, etc.)
- Vary transparency or opacity (depth-dependent, etc.)
- Pick or select voxels.

IV. (Contributed by Andrew Reid)

Plasticity in OOF: Progress and Plans

Isotropic classical plasticity



Sub-features:

- Plasticity (rate-independent)
  - Well-defined yield surface
  - Isotropic and kinematic hardening
- Viscoplasticity (rate-dependent)
  - Time-constant for relaxation back to yield surface
  - Conceptually includes creep phenomena
- Viscoelasticity
  - Response to time-varying strains
  - Back-stress and dissipation

Viscoelasticity is not a plastic phenomenon, but it fits in to first-order time-dependent solid mechanics at this level of sophistication.

Plasticity in OOF: Progress and Plans

Status

Prototype code exists, ready for OOF implementation

Awaiting clean-up of OOF time evolution code

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Plasticity in OOF: Progress and Plans

Anisotropic (“crystal”) plasticity

- Plastic strains develop along specified crystal planes
  - Yield depends on directional shear stress
  - Variety of hardening rules possible
  - May also be rate-dependent

Because of the directional character of anisotropic plasticity, and consequent sensitivity to rotations of the material, this feature is dependent on large-strain elasticity.
This will be a longer-term addition to OOF.

The end. Thank you.