Automatic Mesh Generation and Interface Definition with OOF2

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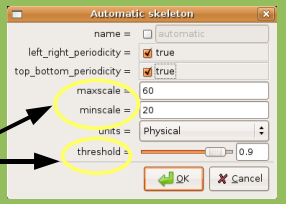
Automatic Skeleton feature

- Encapsulates an effective strategy for combining and tuning skeleton modification methods to yield a good mesh that "fits" a microstructure.
- Little user intervention (i.e. thinking) required.
- Suitable to be implemented as part of an automated task such as that required by the MATCASE project.
- Accessible as a single button in oof2's Skeleton task page.

Auto-skeleton main sequence

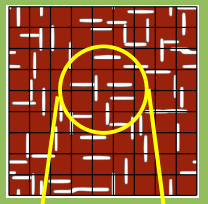
Image (484x484) → Initial skeleton → Refine heterogeneous elements → Snap-Refine elements → Rationalize skeleton → Smooth skeleton

Example microstructure

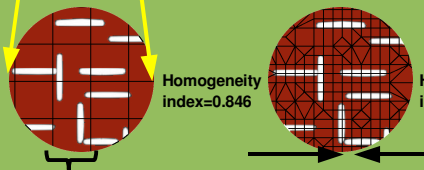


Important!

Inputs



maxscale

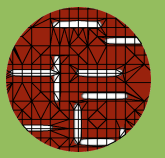


Homogeneity index=0.846

Homogeneity index=0.890

minscale

Refine elements with homogeneity<threshold, until elements reach a resolution *minscale*

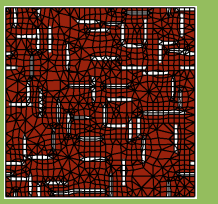


Homogeneity index=0.980

Place ("snap on") new edges and nodes at material or pixel boundaries. Up to two (2) transition points are found for a given edge of a target element.

Homogeneity index=0.981

Fix badly-shaped elements (e.g. long or flat triangles and wide quads)



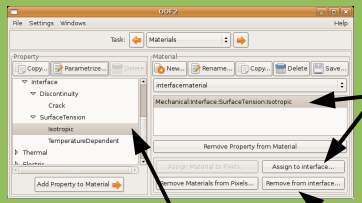
Final: 1851 elements

Move a node to the average position of its neighbors, while nodes at internal boundaries are pinned. Improves element quality.

Implementing physics of interfaces into OOF2 (experimental)

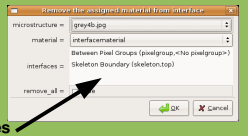
I. Defining interfaces

Interfaces are defined along element edges. Relies on edges being reasonably placed at material boundaries. Interfaces are specified implicitly by a pair of element properties (e.g. pixel group or bulk material), or explicitly by assigning interface materials to skeleton boundaries.



Assign properties to an interface material.

Assign interface material to an interface, e.g. to a pair of pixel groups or bulk materials.



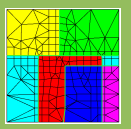
List of defined interfaces

II. Surface tension (small deformations)

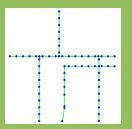
One-dimensional interfacial elements ("edgements") contribute to the stiffness matrix. Forces are applied at the interface nodes.

Skeleton material display

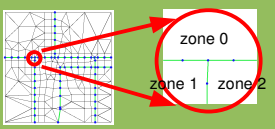
Deformed mesh material display



An interface graph is constructed when the mesh is created. Ex.



To split the mesh along the interface, "zones" are defined around interface nodes. Ex.



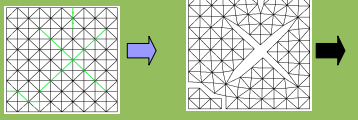
III. Dividing the mesh along "crack"-like interfaces

Initial skeleton and interfaces defined along a set of skeleton boundaries

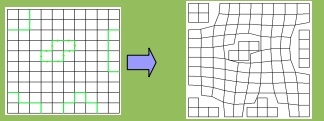
Deformed mesh

Displacement

Ex. 1

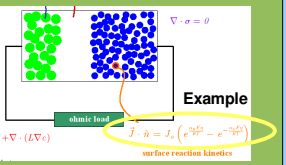


Ex. 2



IV. Future developments

- Discontinuity in fluxes (currents) and fields across an interface
- Anisotropic surface tension
- Non-linear solvers for non-linear properties
- Time-dependence



R. Edwin Garcia

General OOF Papers in the works:

- *Modeling Microstructures with OOF2*, Andrew C.E. Reid, Rhonald C. Lua, R. Edwin Garcia, Valerie R. Coffman, Stephen A. Langer. Submitted to the International Journal of Materials and Product Technology.
- *OOF: A Generalized Image-Based Finite Element Analysis of Material Microstructures*, R. Edwin Garcia and the OOF Team.
- *Image-Based Adaptive Meshing*, the OOF Team.
- *Systematic Testing of a GTK Graphical User Interface*, Andrew C.E. Reid, Stephen A. Langer, R. Edwin Garcia, Rhonald C. Lua, Valerie R. Coffman.

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http://www.ctcms.nist.gov/oof