SAND2014-18269D

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# Many-to-One Sweeper Redesign

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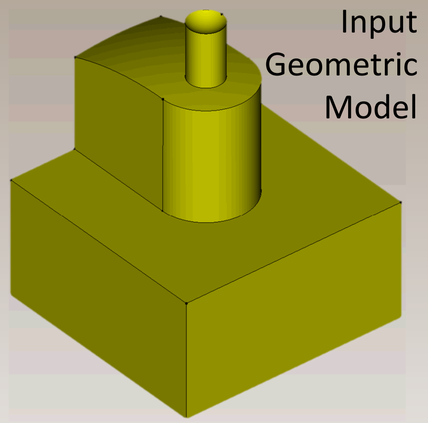
**Problem Statement**

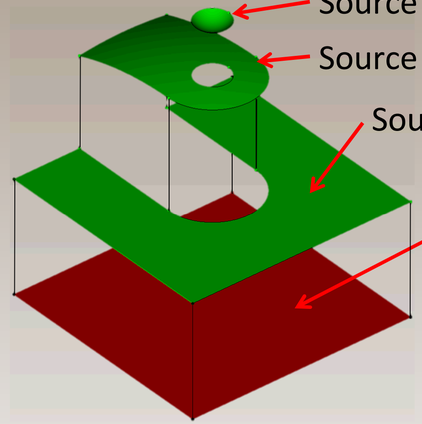
The many-to-one hex sweeper was rewritten for Cubit 15.0 to improve performance and element quality.

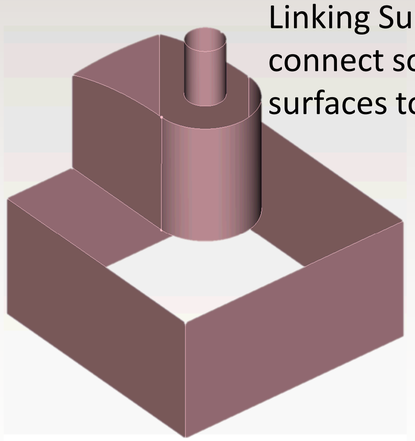
**Sweeper Input**

1. Any number of pre-meshed source surfaces
2. Linking surfaces pre-mesh with mapped or sub-mapped meshes
3. An unmeshed target surface

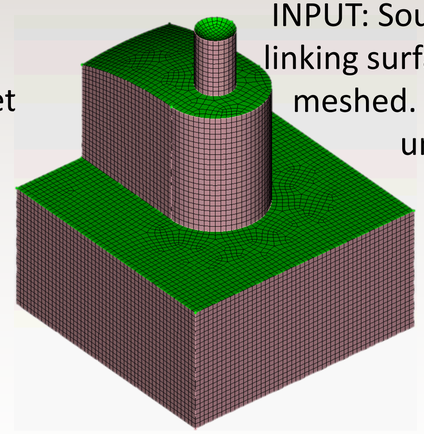


Input Geometric Model



Linking Surfaces connect source surfaces to target

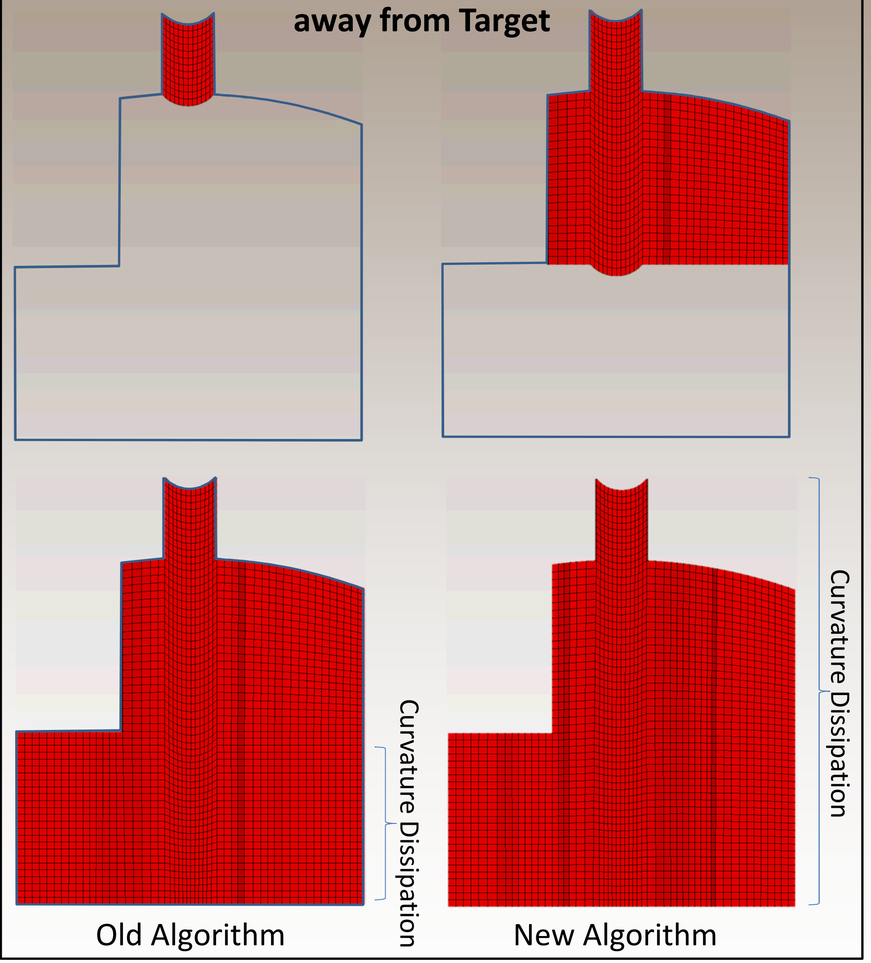


INPUT: Sources and linking surfaces pre-meshed. Target is unmeshed

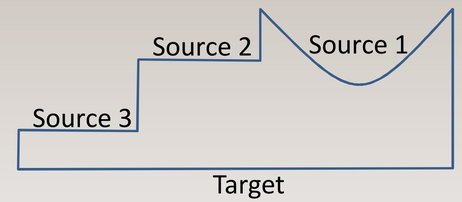
**Motivation:**

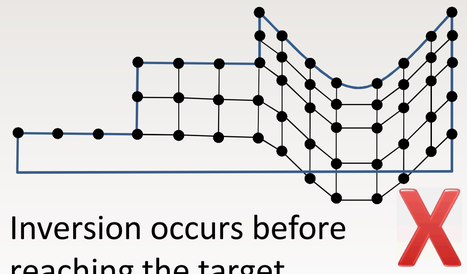
The old sweeper often resulted in poor quality on models with non-planar sources & targets, and was too slow. The old sweeper starts from Source 1 and sweeps to Source 2, and so forth progressing towards the target. However, there is no connection to the target surface yet, so source/target curvature cannot be dissipated. Source/target curvature is only averaged between last source and target, requiring post-processing to redundantly reposition all the nodes in the sweep. Interpolation of layers was also based on layer index, rather than length along the sweep. Target surface smoothing was also enhanced.

**Old Algorithm Sweep from source furthest to closest away from Target**




**Curvature Dissipation becomes a problem with thin models.**



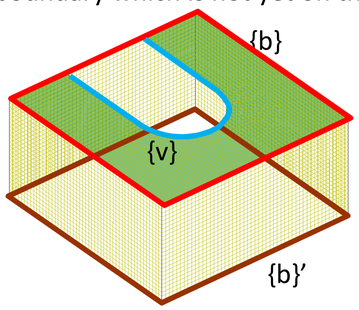



Inversion occurs before reaching the target.

**New Algorithm:**

The new sweeper goes backwards, starting with the source that is *closest* to the target.

***Step 1:*** Choose Source surface CLOSEST to target. Project any of its boundary which is not yet on the target



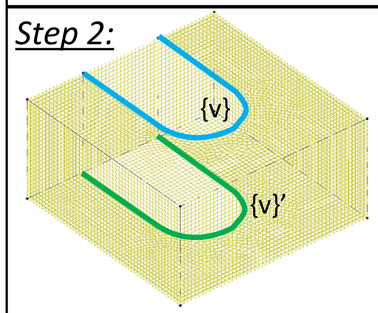

= {b} Part of Source boundary that IS present on Target - KNOWN

= {b}' Part of Target that corresponds to {b} - KNOWN

= {v} Part of Source boundary that IS NOT present on Target - KNOWN

Compute transformation matrix ***M*** between {b} and {b}'. {b} * ***M*** = {b}'

***Step 2:***

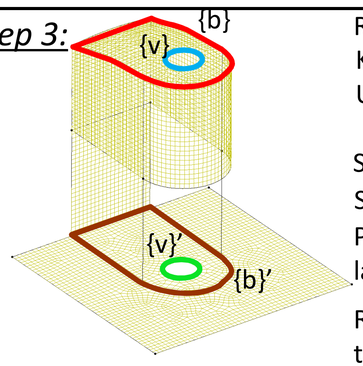



Transform {v} using ***M*** to get {v}'.

{v} * ***M*** = {v}'

Project source mesh onto target. Target is now partially meshed.

***Step 3:***

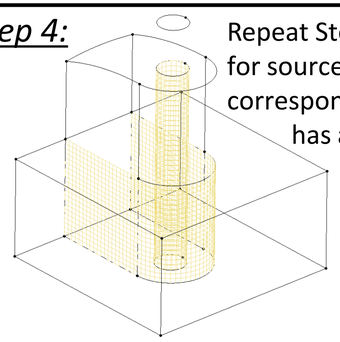



Repeat for source *next* closest to target.
Known: {b}, {b}', {v}
Unknown: {v}'

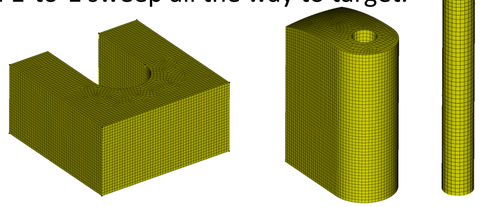
Solve for ***M***: {b} * ***M*** = {b}'
Solve for {v}': {v} * ***M*** = {v}'
Project interior nodes & quads on this layer to target.

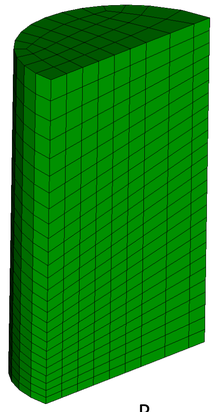
Repeat until all sources projected to target. Smooth target mesh if desired.

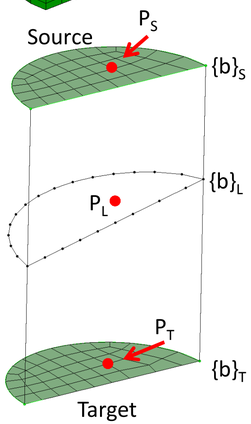
***Step 4:***



Repeat Steps 1-3 but project to intermediate layers for source boundaries. Every source node has a corresponding target node. Every source now has a 1-to-1 sweep all the way to target.








## Improved Interpolation

Known: $P_S$, $P_T$, $\{b\}_S$, $\{b\}_T$, $\{b\}_L$
Unknown: $P_L$

Solve for $\boldsymbol{M_S}$: $\{b\}_S * \boldsymbol{M_S} = \{b\}_L$
Solve for $\boldsymbol{M_T}$: $\{b\}_T * \boldsymbol{M_T} = \{b\}_L$

Solve for $SP_L$: $P_S * \boldsymbol{M_S} = SP_L$
Solve for $TP_L$: $P_T * \boldsymbol{M_T} = TP_L$

$P_L = w_S * SP_L + w_T * TP_L$

How to find $w_S$ and $w_T$?

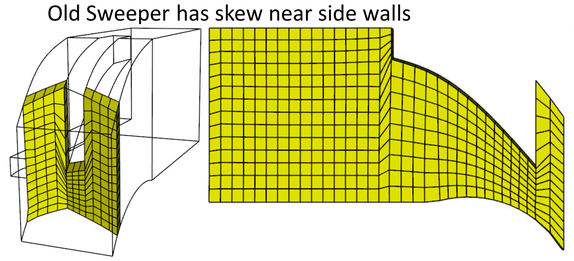
We parameterize each 'rib' along sweep path, each node on a rib gets a t value, which is ratio along sweep path. We then do inverse distance squared weighted interpolation of t values to compute $w_S$ and $w_T$.

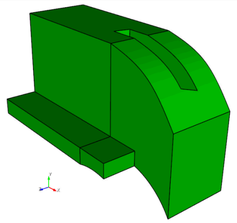
## New Target Smoothing Options

***Option 1***: Smooth all Nodes on target surface
***Option 2***: Fix nodes that are "imprints" from nodes on source curves
***Option 3***: Only smooth nodes which are within *N* elements of a target surface quad that has a scaled Jacobian less than user controlled tolerance.

## Example #1

Old Sweeper has skew near side walls



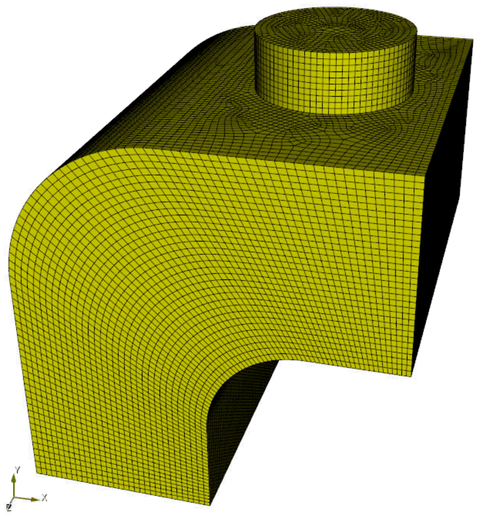


Current Sweeper
TIME: 0.16 sec
Max Scaled J: 1.000
Ave Scaled J: 0.8982
Min Scaled J: 0.1135

New Sweeper gradually tapers to side walls

New Sweeper
TIME: 0.08 sec
Max Scaled J: 1.000
Ave Scaled J: 0.9033
Min Scaled J: 0.2349

## Example #2

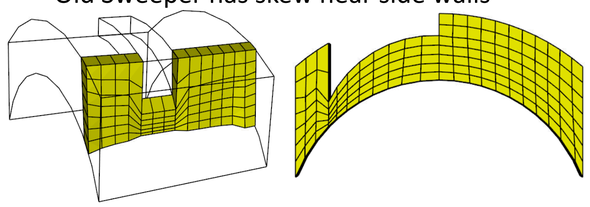


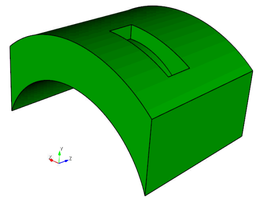
Current Sweeper
TIME: 26.74 sec
Max Scaled J: 1.0
Ave Scaled J: 0.9361
Min Scaled J: 0.4279

New Sweeper
TIME: 1.92 sec
Max Scaled J: 1.0
Ave Scaled J: 0.9380
Min Scaled J: 0.4228

## Example #3

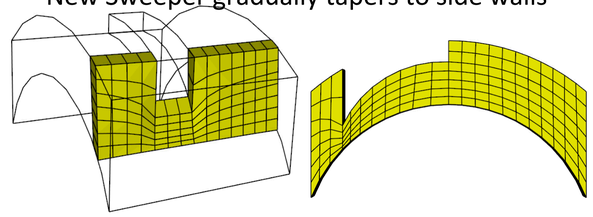
Old Sweeper has skew near side walls





Current Sweeper
TIME: 0.08 sec
Max Scaled J: 0.9990
Ave Scaled J: 0.8061
Min Scaled J: 0.2758

New Sweeper gradually tapers to side walls



New Sweeper
TIME: 0.11 sec
Max Scaled J: 0.9993
Ave Scaled J: 0.7901
Min Scaled J: 0.2563

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SAND No. 2011-XXXXP