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LayTracks3D: Hex Meshing General Solids using Medial Axis Transform

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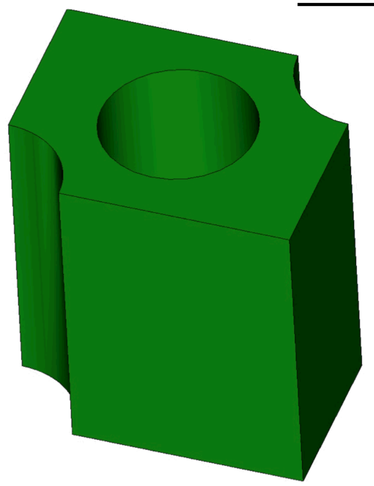
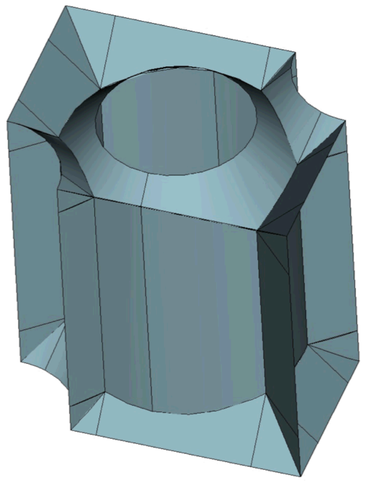
This poster presents an extension of LayTracks[1] to generate hex & hex-dominant meshes of general solids using the Medial Axis Transform (MAT). LayTracks3D generates meshes with desired properties such as near cube shape elements at the boundary, structured mesh along the boundary normal with any irregular nodes restricted to the MA, sharp boundary feature preservation, and conformal mesh at interfaces of an assembly model.

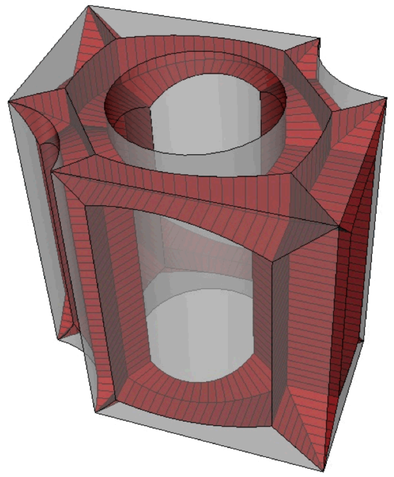
Overview of LayTracks3D



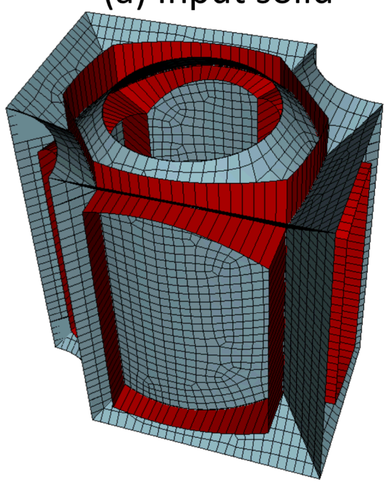
(a) Input solid



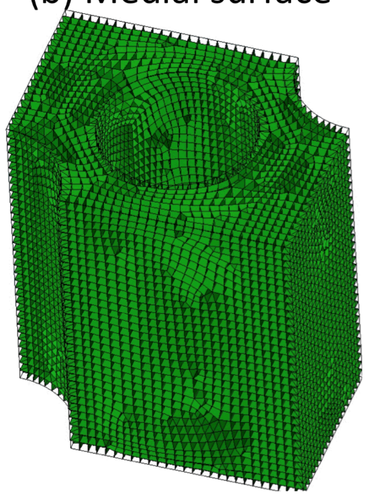
(b) Medial surface



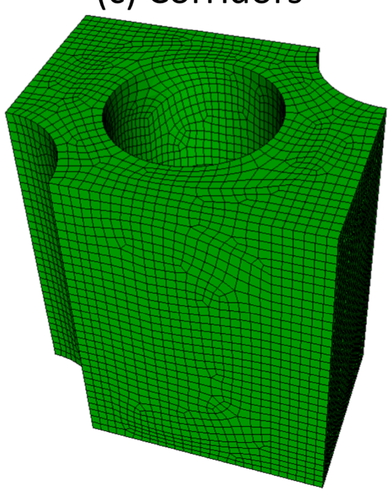
(c) Corridors



(d) Mesh on medial in corridors

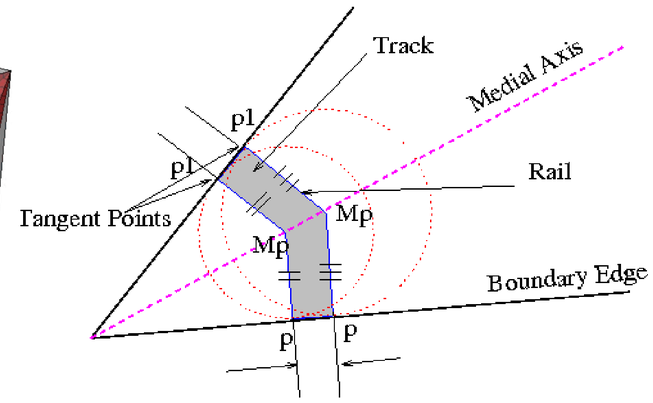


(e) Tracks in 3D



(f) Hex dominant Mesh

Fundamental Operator

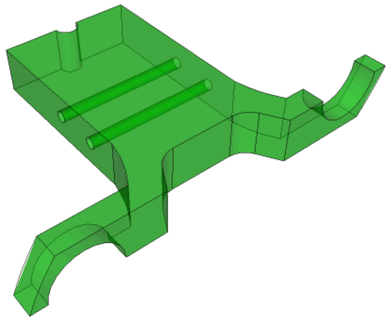


The map $M: p \rightarrow Mp$ connects a point p on the boundary to maximal ball center *Mp* and vice versa . This operator is central in (1) creating corridors from MA branch points, (2) creating tracks inside the corridor by placing rails, (3) resolving imprints from all directions on the MA, and (4) cutting the assembly interface orthogonally respecting all imprints to guarantee conformal mesh.

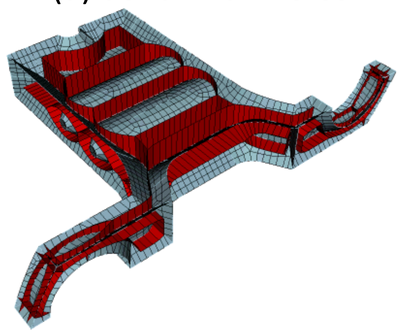
LayTracks3D Characteristics

- Handles general solids & assemblies
- Boundary sensitive: Corridors and Tracks intersect boundary orthogonally
- Orientation insensitive
- Dimension reduction: MA reduces 3D hex meshing to quad meshing on MA
- Preserves imprints and sharp features
- Geometry adaptive: MA radius function can provide sizing and anisotropy control
- Fast remeshing: MA & Corridors remain unchanged during interative remeshing
- Mesh is morphable if MA remains unchanged
- Parallelizable as decomposition based method
- Potential All-Hex: Medial N-to-1 and 1-to-N maps need to be transformed to 1-to-1 map

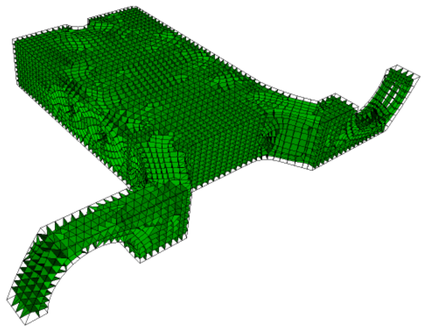
Hex-dominant Meshing



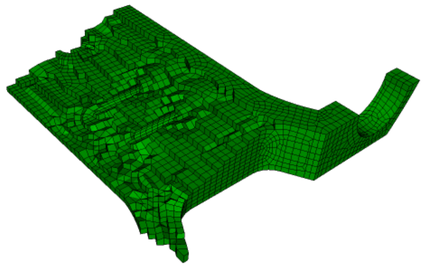
(a) Solid with Holes



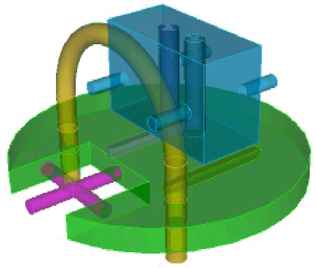
(b) Mesh on MA inside Corridors



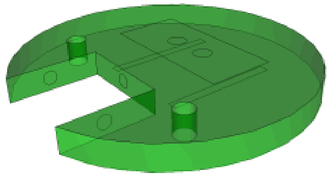
(c) Tracks



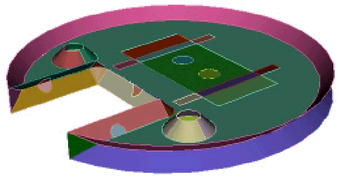
(d) Mesh Cross Section



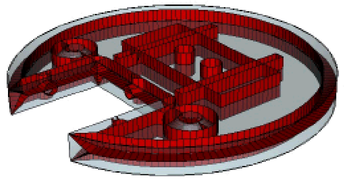
(a) Assembly



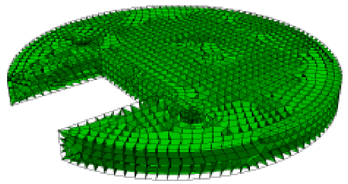
(b) Imprints on Solid



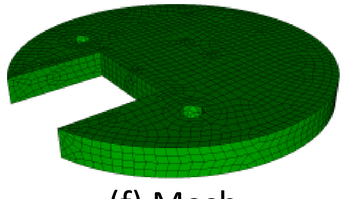
(c) Imprints on MA



(d) Corridors



(e) Tracks



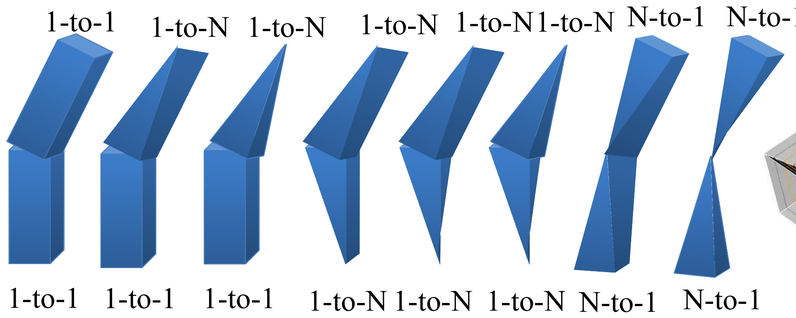
(f) Mesh

Extension to All-Hex Meshing

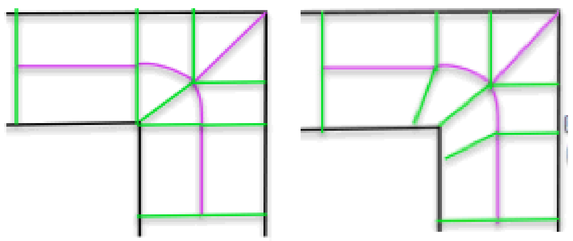
Claim 1: A general solid can be decomposed into a set of connected quad cross-section 3D tracks

Lemma 1.0 Uniqueness and Continuity of Mapping to MAT

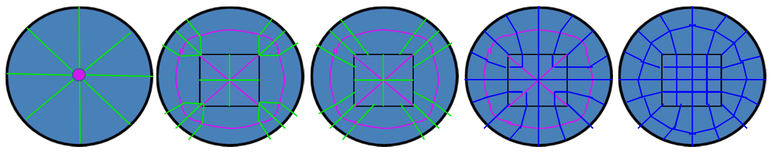
Let A be an n-dimensional compact sub-manifold of R^n and let MA(A) be its medial axis. Let P be an open subset of δA which is G^1 and piecewise C^2 continuous. Then for every point $p \in P$ there is one and only one maximal ball touching p. Furthermore, the function $M: P \rightarrow MA(A)$, which maps each point $p \in P$ to the center of its maximal ball, is continuous.



1-to-1, 1-to-N and N-to-1 tracks in 3D



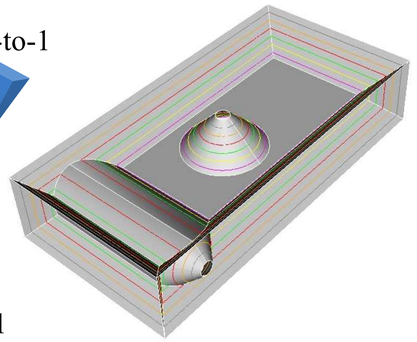
1-to-N tracks transformed to quad cross-section 1-to-1 tracks



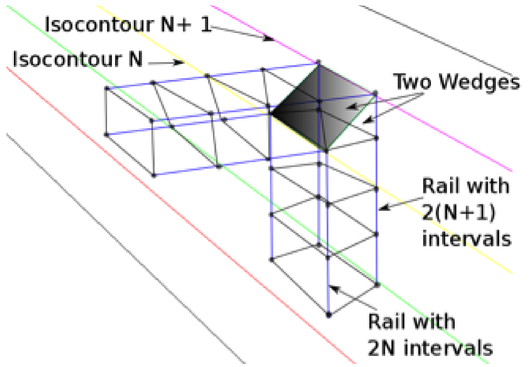
N-to-1 tracks transformed to quad cross-section 1-to-1 tracks

Claim 2: A quad cross-section 3D track can be meshed with all-hex elements

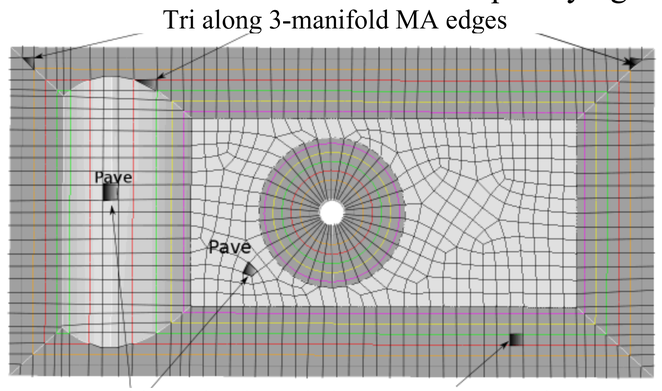
In order to obtain an all-hex mesh inside a quad cross-section track, Case 1: all four rails must have the same intervals or Case 2: two rails must have 2N intervals and the other two rails must have 2(N+1) intervals. With Case 1, equal number of hex elements are generated on both sides of MA and with Case 2, two wedges at the MA are merged to form a hex.



(a) Isocontours on MA



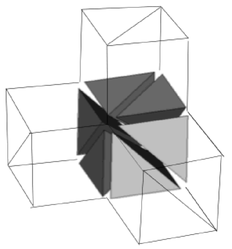
(b) Case 2: two wedges form a hex at a quad lying on N & N+1 isocontours



Case1: quad in region bounded by one isocontour

Case 2: quad incident on N & N+1 isocontours

(c) Meshing MA using isocontours guarantees correct intervals on rails to satisfy Case 1 or Case 2 in each track



(d) Six tets form a hex at 3-manifold MA

All-hex mesh topology visualization on isocontours of MA

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[1] Quadros W. R., et al., "LayTracks: A New Approach to Automated Quadrilateral Mesh Generation using MAT", Proc. 9th International Meshing Roundtable, Oct 2000.

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