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Decomposition management for automatic hexahedral-dominant meshing

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Pre-processing and good-quality simulation model generation can require extensive user efforts and is often the most time consuming step of analysis workflows. As a result, it is difficult to automate these workflows to allow engineers to fully benefit from simulation tools. Another major bottleneck toward automation is the difficulty to generate hexahedral (hex) meshes which are essential for many non-linear time-dependent analysis workflows, such as crash or fan-blade off analysis. In absence of robust automatic hex-meshing tool, the current industry process consists of manually sub-dividing the design geometry into sweep-meshable sub-domains.

Herein, a fully automated approach for hex-dominant mesh generation from the design CAD model is built on top of the automated decompositions described in [1], [2]. These describe a two-step process to identify and isolate thin-sheets (having two prevalent dimensions) and long-slender (having one prevalent dimension) regions, which are both hex sweep-able. This manifold decomposition is enriched by generating an equivalent non-manifold cellular topological representation [3]. This representation uses virtual topology operations to track the subdivision history thus capturing information lost through the manifold decomposition and maintaining links with the design component. In addition, each cell in the non-manifold cellular decomposition is assigned appropriate simulation attributes defined by the geometric reasoning tool used to dictate the decomposition.

Integer programming routines and adjacency information contained in the enriched data structure are used to automatically create a fit-for-analysis hex-dominant mesh. Correct mesh controls are applied, with mesh-mating at the interfaces between the different regions. Thin-sheet and long-slender regions are hex-meshed, and residual regions are meshed using tetrahedral elements, with pyramid elements applied at the hex-tet interface.

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