LEAST-SQUARES MESH SMOOTHING ALGORITHM TO UPDATE THE ACOUSTIC MESH IN COUPLED ACOUSTIC-STRUCTURAL ANALYSIS

M.F. Snyman[a] and **J.C. Nagtegaal**[b]

ABAQUS, Inc.
1080 Main Street, Pawtucket, RI 02860, USA.
[a]michael.snyman@abaqus.com
[b]joop.nagtegaal@abaqus.com

When a Lagrangian finite element formulation is used in problems where the material becomes severely distorted, the elements become similarly distorted since they deform with the material. In such a case the original mesh may no longer provide a good discretization of the problem and must be replaced by a mesh of better quality before the analysis can continue.

This presentation describes a new mesh smoothing algorithm that can be used to periodically improve the mesh quality during the solution process. The algorithm assumes that the new mesh uses the same topology as the original mesh but nodal locations are adjusted to avoid element distortion. Such algorithms are typically used in combination with Arbitrary Lagrangian Eulerian (ALE) formulations. In this presentation, however, the algorithm is applied to the acoustic domain in coupled structural-acoustic analysis. The acoustic elements in our formulation do not have mechanical behavior and, therefore, cannot model the deformation of a fluid when the structure undergoes large deformation. As long as the boundary between the structure and fluid does not experience large deformation, the structural-acoustic calculations can be performed with reference to the original configuration. However, when the geometry of the acoustic domain changes significantly as a result of structural loading, the original acoustic mesh must be updated along with the structure. An example is the interior cavity of a tire subjected to inflation, rim mounting, and footprint loads.

The mesh smoothing equations are solved explicitly by sweeping iteratively over the adaptive mesh domain. During each mesh sweep, nodes in the domain are relocated based on the positions of neighboring nodes obtained during the previous mesh sweep. The new position, $\mathbf{x}_{i+1}$, of a node is obtained as

$$\mathbf{x}_{i+1} = \mathbf{X}+\mathbf{u}_{i+1} = \mathbf{N}^N\, \mathbf{x}^N_i$$

where $\mathbf{X}$ is the original position of the node, $\mathbf{u}$ is the nodal displacement, $\mathbf{x}^N$ are the neighboring nodal positions obtained during the previous mesh sweep, and $\mathbf{N}^N$ are weight functions obtained from a least-squares minimization procedure that minimizes displacement in the original configuration. In other words, the algorithm assumes that the original mesh is an appropriate discretization of the problem.

The presentation will focus on deriving a suitable set of weight functions and demonstrating the effectiveness of the algorithm through illustrative examples.