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Conservative and consistent data reconstruction for multi-physics applications

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ABSTRACT

The presentation focuses on a particular aspect of data mapping for multi-physics applications called “reconstruction”. Consider a multi-physics simulation environment where multiple physics solvers interact through data exchange over an interface. A typical example would be fluid-structure interaction, where the fluid and structure are in separate volumetric spatial domains and interact with each other through exchange of forces and displacements over a common surface interface separating the domains. Interfaces can also be volumetric, as is the case for coupling an electro-magnetic solver with a fluid solver on a common spatial domain.

Though the solvers share a common geometric interface, the meshes on those interfaces is expected to be different. There is therefore a need to map the data between the two interface meshes. For intensive data, such as displacements, this can be done using interpolation. For extensive variables, such as forces, an algorithm which conserves the total quantity can be used. This can be done by separating on the source side and accumulating on the target side based on the intersecting mesh element areas of the source and target meshes.

Data can be provided or consumed by physics solvers on either mesh element vertices or element centroids, depending on what is convenient for the individual solvers. The algorithm to map data can vary depending on where the data is provided or consumed. If an algorithm is not implemented for a particular data location, a reconstruction algorithm can be leveraged. For example, the conservative mapping algorithm is natural for centroid-based data, but not for nodal data. If an extensive quantity is consumed by a solver on vertices, the centroid-based mapping algorithm can be used to transfer data from source to target centroid, then the data can be reconstructed onto the nodes.

The presentation focuses on some details of data reconstruction, especially for extensive data. We show how to ensure that the algorithm is conservative on curved interfaces as well as different consistency conditions which can be enforced for generic unstructured meshes of any order or element types.