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An Intergrid Boundary Reconnection Technique for Conservative Unstructured Overset Mesh Scheme

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In practical applied aerodynamic problems, simulations of time-accurate unsteady flows involving multiple bodies in relative motion are frequently required. Among several moving-grid CFD techniques to attack this complicated unsteady flow problems, overset mesh technique has been regarded as the most prominent approach. In spite of the successful applications of the overset mesh techniques to realistic flow problems, several practical problems still exist for overset mesh methods. For conventional overset mesh techniques, transfer of flow variables between mesh blocks is achieved through interpolation, and therefore conservation of fluxes is usually not guaranteed across the overset mesh block boundary. Because of this problem, numerical difficulties arise when severe flow gradients such as shock wave or massively separated flow exist. These numerical errors are further magnified as the characteristic cell sizes between overlapping mesh blocks are significantly different from each other.

In the present study, a conservative overset mesh scheme is proposed for the efficient and accurate numerical simulation of unsteady time-accurate flows around multiple bodies in relative motion on unstructured meshes. In this new approach, the boundaries between mesh blocks after hole cutting are separated by a blank region with a gap size of local cells. This region is refilled with new triangular elements generated by re-connecting the boundary nodes between mesh blocks. By executing this procedure, all overset mesh blocks are connected instantaneously at each time step and can be treated as a single block. Thus the conservation property of flow over the global computational domain is automatically satisfied, even when the objects are in an arbitrary relative motion, without any spurious mass, momentum and energy production from inside of the flow domain. For this purpose, an intergrid boundary reconnection technique is developed to enhance the efficiency and the robustness of generating new elements inside the blank region. In the case of the flow problems without mesh movement, the overset mesh blocks reduces to a single block unstructured mesh.

Application of the present intergrid boundary reconnection technique was made to a 2-D store separation problem, and the results are presented in Fig. 1. Initially, overlapped mesh blocks are generated for the main wing and the store independently as shown in Fig. 1(a). After hole cutting, a non-overlapping blank region is

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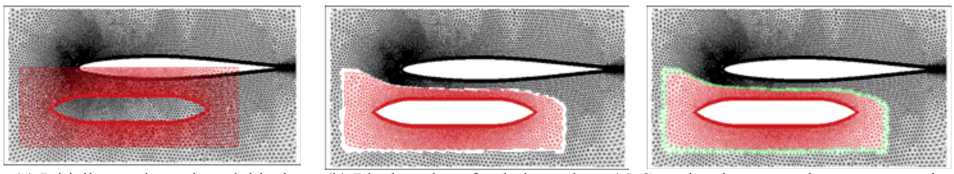
obtained as shown in Fig. 1(b). Then new triangular elements are generated and fill the blank region by reconnecting the vertices between the intergrid boundaries. As a result, the two mesh blocks are connected, generating a mesh similar to a single block topology for the complete computational domain as shown in Fig. 1(c). Then the flux can be evaluated in a conservative manner, without any additional numerical treatment, similar to the method applied to a single block mesh, even across the mesh block boundaries.



(a) Initially overlapped mesh blocks (b) Blank region after hole cutting (c) Completed conservative overset mesh

Figure 1: Process of constructing a conservative overset mesh around a 2-D wing and an external store.