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ABSTRACT:

The Dual Mesh Control Domain Method: A Marriage of the Finite Element and Finite Volume Methods

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Currently, the finite element method (FEM) and finite volume method (FVM) are the most commonly used numerical methods for the solution of differential equations, with FEM dominating solid and structural mechanics and FVM witnessing popularity in heat transfer and fluid mechanics. Both methods suffer from certain drawbacks. The major disadvantage of the FEM is that it introduces discontinuity in the dual variables at the element interfaces in the post-computation unless the approximations are C1-continuous. On the other hand, the FVM borrows ad-hoc approaches like upwinding and artificial viscosity from the finite difference method to make the numerical scheme perform satisfactorily. In addition, there are no explicit and unique forms of approximations used and no concept of duality exploited in the FVM. In 2019, Reddy [1] introduced a numerical approach termed the dual mesh control domain method (DMCDM), which utilizes the desirable features of the FEM and FVM. In the DMCDM, the domain is represented with a primal mesh of finite elements (defining the approximations used for the dependent variables), and a dual mesh is

superimposed on the primal mesh such that the nodes of the primal mesh are at the center of the dual mesh of the control domains. In addition, the governing equation is satisfied in an integral sense (not a weighted-integral sense) over the control domain, as in the FVM. Thus, in the DMCDM the dependent variables are approximated using finite element interpolation functions (as in the FEM), and the governing equation is satisfied in an integral sense over a typical control domain of the dual mesh (as in the FVM). In this lecture, the DMCDM is explained and its application to a variety of linear and nonlinear problems is presented to illustrate the workings of the DMCDM [2-5].

References

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