SPECTRAL-LIKE ELEMENT METHODS ON HYBRID MESHES FOR THE WAVE EQUATIONS

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Spectral finite element methods using hexahedral meshes have been developed by Cohen and others but currently, the only way to automatically generate unstructured hexahedral meshes for a complex geometry is to generate a tetrahedral mesh and split each tetrahedron into four hexahedra, which introduce needlessly substantial increase in the cost. However, some mesh generators are able to produce hexahedral-dominant meshes that include a minor number of tetrahedra, wedges and pyramids. The purpose of our study is to construct high-order finite element methods on hybrid meshes in order to preserve the efficiency of the method developed for hexahedra.

Finite elements for tetrahedra, hexahedra and wedges are detailed in Hesthaven [2], Cohen [1] and Solin [3]. In this work, the main effort is devoted to the construction of pyramidal finite elements, preserving conformity with the other types of elements. Only few papers are dealing with pyramidal elements (Bedrosian [4], Graglia [5], Chatzi [6], Nigam and Phillips [7]) since obtaining a proper base for these elements is a tricky point.

Our work leads to an arbitrarily high-order finite element space for pyramidal elements coupled in a continuous way with other types of elements, such that these elements can be used in hybrid meshes which include a high percentage of hexahedra, and some tetrahedra, wedges and pyramids. Numerical results are given to demonstrate the efficiency of these new elements.

References

[1] G.C. Cohen, *Higher-Order Numerical Methods for Transient Wave Equations*, Springer Verlag, 2000.
[2] J.S. Hesthaven and C.H. Teng, *Stable Spectral Methods on Tetrahedral Elements*, SIAM J. Numer. Anal., 21-6 (2000), pp 235-2380.
[3] P. Solin, K. Segeth and I. Dolezel, *Higher-Order Finite Elements Methods*, Studies in Advanced Mathematics, Chapman and Hall, 2003.
[4] G. Bedrosian, *Shape Functions and Integration Formulas for Three-Dimensional Finite Element Analysis*, Int. J. Numer. Meth. Eng., 35 (1992), pp 95-108.
[5] R. D. Graglia, D. R. Wilton, A. F. Peterson and I. L. Gheorma, *Higher Order Interpolatory Vector Bases on Pyramidal Elements*, IEEE Trans. Ant. and Prop., 47-5 (1999), pp 775-782.
[6] V. Chatzi and F.P. Preparata, *Using Pyramids in Mixed Meshes - Point Placement and Basis Functions*, Brown University, 2000.
[7] N. Nigam and J. Phillips, *Higher-Order Finite Elements on Pyramids*, to appear.