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Shape functions for velocity interpolation in general hexahedral cells. (English)

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Summary: Numerical methods for grids with irregular cells require discrete shape functions to approximate the distribution of quantities across cells. For control-volume mixed finite-element (CVMFE) methods, vector shape functions approximate velocities and vector test functions enforce a discrete form of Darcy's law. In this paper, a new vector shape function is developed for use with irregular, hexahedral cells (trilinear images of cubes). It interpolates velocities and fluxes quadratically, because as shown here, the usual Piola-transformed shape functions, which interpolate linearly, cannot match uniform flow on general hexahedral cells. Truncation-error estimates for the shape function are demonstrated. CVMFE simulations of uniform and non-uniform flow with irregular meshes show first- and second-order convergence of fluxes in the L^2 norm in the presence and absence of singularities, respectively.

MSC:

76M10 Finite element methods applied to problems in fluid mechanics
76S05 Flows in porous media; filtration; seepage

Keywords:

control-volume method; CVMFE method; distorted grid; hexahedral grid; local Darcy law; local mass conservation; mixed method; Piola transformation; vector shape function; 3-D

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