A Framework for Implementing Virtual Element Spaces

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Abstract :

The Virtual Element Method (VEM) is a recent approach to define a wide range of finite element type spaces on general element shapes. We will discuss an construction of these methods to extend existing finite element software packages with these spaces without requiring a major overhaul of the existing code base. We provide a description which can be viewed as an extension of the well known FEM constructing based on finite element triples (K, B, L). Here K is a grid element, B is the basis of a finite dimensional space, and L is a set of functionals with |L| = |B|.
To achieve some desirable properties for the discrete space (approximation order and conformity for example) the choice for L is often known but defining a suitable B can be challenging. We introduce the concept of a VEM tuple using a fixed B depending on the approximation order but not on L thus avoiding the problem described above. The similarity with the FEM construction simplifies the implementation of VEM schemes within existing FEM codes. We will discuss a number of examples includes a range of spaces suitable for forth order problems and some unusual vector valued spaces, e.g., curl-free spaces and divergence conforming spaces. The latter is especially of interest for simulating fluid flow since it provides a stable, higher order approximations with a low number of degrees of freedom.