From Squares and Cubes to Quads and Hexes: Recent Advances in Conforming Finite Elements

Abstract:

The theory supporting conforming finite elements on meshes of squares and cubes requires some care when extended to more general meshes of quadrilaterals and hexahedra in order to preserve desired rates of convergence. In this talk, I’ll present two areas of research related to these issues. First, I’ll describe a new family of methods called “trimmed serendipity elements” that fit within the same framework described by the Periodic Table of the Finite Elements (see https://femtable.org). The computational effort required to employ a trimmed serendipity element method is significantly less that what is required for comparable alternatives from the table, thereby presenting a host of potential benefits to the speed and accuracy of square/cube finite element methods in practice. Second, I’ll present the loss of convergence issues that arise when square/cube elements are mapped non-affinely as well as some recent techniques that restore convergence order. In addition, I’ll show why general quad/hex meshes are of increasing interest in application contexts, including an cardiac electrophysiology example carried out in collaboration with Andrew McCulloch’s research group and NBCR.