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A graph approach for the construction of high order divergence-free Raviart-Thomas finite elements

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Resumen

We propose and analyze an efficient algorithm for the computation of a basis of the space of divergence-free Raviart-Thomas finite elements. The algorithm is based on graph techniques. The key point is to realize that, with very natural degrees of freedom for fields in the space of Raviart-Thomas finite elements of degree $r+1$ and for elements of the space of discontinuous piecewise polynomial functions of degree $r \geq 0$, the matrix associated with the divergence operator is the incidence matrix of a particular graph. By choosing a spanning tree of this graph, it is possible to identify an invertible square submatrix of the divergence matrix and to compute easily the moments of a field in the space of Raviart-Thomas finite elements with assigned divergence. This approach extends to finite elements of high degree the method introduced by Alotto and Perugia for finite elements of degree one. The analyzed approach is used to construct a basis of the space of divergence-free Raviart-Thomas finite elements. The numerical tests show that the performance of the algorithm depends neither on the topology of the domain nor or the polynomial degree r.