THE VIRTUAL ELEMENT DECOMPOSITION: A NEW PARADIGM FOR DEVELOPING NODAL INTEGRATION SCHEMES FOR MESHFREE GALERKIN METHODS

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Abstract. In meshfree Galerkin methods to solve partial differential equations, a cloud of nodes is used to discretize the domain. On using the nodal data, smooth, compactly-supported, non-polynomial basis functions are constructed to form the trial and test functions. Instead of using Gauss cubature points to compute the weak form integrals, use of nodal integration [1] (material state variables are stored at the nodes thereby avoiding the need for remapping) is attractive for meshfree Lagrangian simulations; however, stability of meshfree nodal integration schemes remains an unsolved problem.

This work presents a new paradigm for developing nodal integration schemes for meshfree Galerkin methods via the virtual element decomposition [2, 3] on Voronoi cells that are associated with a node. In doing so, both consistency and stability of the meshfree method are ensured. A few benchmark problems in two-dimensional linear elastostatics and elastodynamics will be presented to demonstrate the accuracy and robustness of the nodal integration method.

Keywords: meshfree Galerkin methods, nodal integration, Voronoi cells, consistency and stability, virtual element decomposition.

References

[1] M. A. Puso, J. S. Chen, E. Zywicz, W. Elmer. Meshfree and finite element nodal integration methods. *International Journal for Numerical Methods in Engineering*. 74(3): 416–446, 2008.

[2] L. Beirão da Veiga, F. Brezzi, A. Cangiani, G. Manzini, L.D. Marini, A. Russo. Basic principles of virtual element methods. *Mathematical Models and Methods in Applied Sciences*, 23(01):199–214, 2013.

[3] A. Ortiz-Bernardin, A. Russo, N. Sukumar. Consistent and stable meshfree Galerkin methods using the virtual element decomposition. *International Journal for Numerical Methods in Engineering*. 112(7): 655–684, 2017.

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