Wind field simulation over complex terrain with isogeometric analysis

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Abstract

For wind field simulation with isogeometric analysis, firstly it is necessary to generate a spline parameterization of the computational domain, which is an air layer above the terrain surface. This parameterization is created with the meccano method from a digital terrain model. The main steps of the meccano method for tetrahedral mesh generation were introduced in [1]-[2]. Based on the volume parameterization obtained by the method, we can generate a mapping from the parametric T-mesh to the physical space [3]-[4]. Then, this volumetric parameterization is used to generate a cubic spline representation of the physical domain for the application of isogeometric analysis.

We consider a mass-consistent model [5] to compute the wind field simulation in the three-dimensional domain from wind measurements or a wind forecasted by a meteorological model (for example, WRF or HARMONIE). From these data, an interpolated wind field is constructed. The mass-consistent model obtains a new wind field approaching the interpolated one, but verifying the continuity equation (mass conservation) for constant density and the impermeability condition on the terrain. This adjusting problem is solved by introducing a Lagrange multiplier, that is the solution of a Poisson problem. The resulting field is obtained from the interpolated one and the gradient of the Lagrange multiplier. It is well known that if we use classical Lagrange finite elements, the gradient of the numerical solution is discontinuous over the element boundary. The advantage of using isogeometric analysis with cubic polynomial basis functions [6] is that we obtain a C^2 continuity for the Lagrange multiplier in the whole domain. In consequence, the resulting wind field is better approximated. Applications of the proposed technique are presented.

Keywords: Wind Simulation, Isogeometric Analysis, Adaptive T-Mesh, Polinomial Splines.

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