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Identifying optimal meshes for high-order implicit large-eddy simulation of turbulent boundary layers using Kriging surrogate models

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This study aims to construct a framework to identify, a priori, grid properties that achieve accurate prediction of turbulent boundary layers when performing implicit large-eddy simulations (ILES) with high-order Flux Reconstruction (FR) schemes [1, 2]. Wall-normal cell distribution is defined by two parameters, α and β, where α determines the minimum wall-normal cell size adjacent to the wall, and β determines the expansion ratio of cell sizes in the wall-normal direction. An extensive parametric study is carried out in $\alpha\beta$-space on a turbulent plane Couette flow ($Re_\tau = 171$) for various polynomial orders (p) and total degrees of freedom (DoF). Three cost functions are defined (J_1: log-layer mismatch; J_2: error in Re_τ; and J_3: allowable time-step size). A Kriging surrogate model of each cost function is then constructed in $\alpha\beta$-space, which provides a continuous map of computational accuracy and cost, with respect to wall-normal cell distributions for high-order FR schemes (Fig. 1). Finally, insights from the surrogate model are used to identify optimal meshing strategies for ILES of turbulent boundary layers with high-order FR schemes.

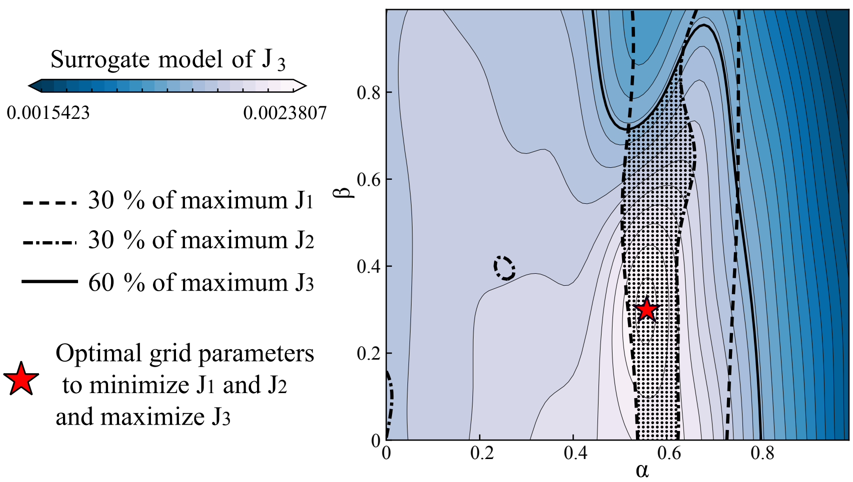

Fig. 1 Visualization of the optimal grid parameters that are identified from the overlap region (black dotted region) of $\alpha\beta$-combinations, where J_1 and J_2 are smaller than 30% of their maximum values and J_3 is larger than 60% of its maximum value. Blue to white contours show the allowable time-step size. The red star indicates the optimal grid parameters for maximizing the allowable time-step size in the overlap region.

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