Massively Parallel High-order Spectral Difference Method for Large Eddy Simulation of Vertical Axis Wind Turbine and Oscillating Wing Wind Turbine

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Recently, the high-order methods based on the strong forms of the compressible Navier-Stokes equations, e.g., flux reconstruction method or the spectral difference method, are proven efficient, robust, and accurate for large eddy simulations on unstructured grids using CPU/GPU platforms as pioneered by Stanford HiFiLES code [1] and Imperial College PyFR code [2] for fixed grids.

Recently, the PI pushed the spectral difference (SD) method for large eddy simulations from fixed grids [3,4] to moving, deforming, and sliding meshes [5,6]. The coupled sliding/deforming spectral difference (SD²) method is extremely promising for large eddy simulations of a farm of vertical axis wing turbines (see Figure 1) or the oscillating wing wind turbine (see Figure 2).

Figure 1: Vertical Axis Wind Turbine

Mesh with two circular sliding interfaces (left).  Vorticity contour at Re=1000.

The SD² method is high-order accurate even on the sliding interface [6] and in deforming regions [5]. The sliding interface approach [6] is conservative, simple for implementation, suitable for parallel computing, and also easy for re-meshing. The PI expects that the high-order SD² method to be more efficient and accurate than the finite volume method [7] for large eddy simulation of the oscillating wing power generators.

In summary, the SD² method is designed for handling complex geometries with coupled rotating and deforming domains. It has light requirement of cross-processor communication and is an exciting novel numerical algorithm that is suitable for exascale computing to predict unsteady flow and aeroacoustics associated with wind turbines with high-order accuracy.
Figure 2: Oscillating Wing Wind Turbine

Mesh with one sliding interface.  
Vorticity contour at Re=1000.

References: