Efficient Drag Optimization by FMM Accelerated Gridless Vorticity Discretization and Functional Far-Field Contributors

Tang, Kwuang

Aerodynamic drag is often the largest factor of wasted energy for vehicles traveling at moderate to high velocities. Thus, drag reduction to improve energy efficiency can lead to significant fuel savings. Currently engineers test each slightly modified design individually with wind tunnels or supercomputers. This project developed a versatile computer software that was able to quickly optimize any object in any specified environment, with capability for mass-object testing. This computational efficiency was achieved by introducing a more efficient drag-calculation algorithm based upon gridless vortex methods with the Fast Multipole Method rather than using traditional wind tunnels or Navier-Stokes partial-differentials. Published wind-tunnel data as well as CFD trials verify the algorithm's accuracy in 3D compressible flow. The software evolves a given vehicle or object to minimize its drag while preserving functionality, and was tested with a space shuttle, golf driver club, and wind turbine blade, among other objects and vehicles. The new optimized versions were shown have statistically significant drag reductions when compared with their corresponding original shapes, allowing better fuel efficiency and energy conservation.