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Title: the introduction to Lattice Boltzmann Method for high fidelity fluid dynamics simulations

Abstract:
The necessity for high accuracy in predicting aerodynamic loads on objects and turbulence in general have pushed fluid mechanics users to investigate since the mid 1970s the usage of so called high fidelity methods. The most known development in that direction has been the ongoing development of the scale resolving methods based on the conventional Navier-Stokes approach to fluid mechanics such as LES (large Eddy Simulation) or more recently hybrid DES (detached Eddy Simulation). The development of such methods although mathematically very sound have been met with large challenges in the cost of simulation both in time scales as well as hardware requirements. Therefore, the usage and deployment of such methods for industrial purposes have been slow and alternative methods based on statistical mechanics have been increasingly studied and deployed in various fields. The most advanced approach in that direction is the Lattice Boltzmann Method which relies on a mesoscopic modelling of fluid particles instead of continuum mechanics assumptions and provides in hybrid versions an important reduction of costs in comparison to classical approaches. The subject of the presentation will a brief introduction on the mathematical basis for such an approach and further the industrial applications which are tackled today in the field of aerospace and building aerodynamics using the commercial code PowerFLOW from Exa Corp.

Seen in the following image is a vorticity result of a high-resolution LBM simulation of a nose landing gear of a Boeing 777 performed by NASA and Exa Corp as part of the US based ERA research project and a velocity plot of a simulation of a launchpad simulated with fluctuating atmospheric boundary layer conditions for launch conditions to highlight the scope of turbulent scales the method can address.