Computational fluid dynamics of wind power using the Lattice-Bolzmann method on GPUs

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Background

When planning a new wind farm, it is of utmost importance to know the wind conditions at the site. The first step is to set up a met mast during 1-2 years which measures the velocity up to hub height of the planned wind turbines. Then, using the met mast data, the wind conditions at each planned windturbine are estimated using a simple prediction method (e.g. WaSP or RANS). These simulations are carried out without taking into account the effect of the wakes behind the wind turbines; this effect is estimated using simple wake models. The problem is that WaSP and RANS are not sufficiently accurate.

Large Eddy Simulation is an accurate method. An LES over a windfarm of a size $10 \times 10 km^2$ in the horizontal plane and $1 km$ in the vertical direction requires $4 - 5$ days on 400 cores. This method is too expensive to be used as an industrial tool. A new, promising method is the Lattice-Bolzmann method. It was recently used for windpower problem (see PhD thesis).

In the proposed MSc project, the open-source code LUMA will be used. The LUMA code is an open-source code based based on the Lattice-Boltzmann Method. It was developed at the University of Manchester. The object was to build a collaborative research environment in which researchers of all abilities can study fluid–structure interaction (FSI) problems in engineering applications from aerodynamics to medicine. It is built on the principles of accessibility, simplicity and flexibility. The LUMA software is a capable FSI solver with turbulence modelling and many-core scalability as well as a wealth of input/output and pre- and post-processing facilities. The software has been validated and several major releases benchmarked on supercomputing facilities internationally.

LUMA is written in C/C++ and designed for an x64 machine running Linux, MacOS or Windows. The software may be compiled to run in serial or parallel depending on requirements and target platform capabilities. A fork of the LUMA code has been developed and optimised for use on many-core Graphics Processing Units (GPU) hardware, which enables significantly accelerated calculations. In this content the capability for interactive post processing is implemented as a means of fast exploration of the parameter space.

The MSc project

The LUMA code will be used for computing an atmospheric boundary layer. The code will be run on a regular PC. The GPU on the graphic card will be used. We will compare the results and the required CPU-time with LES (we will use existing LES results for comparison).

The project will be carried out at the Division of fluid dynamics and it should start in Autumn 2020 or early Spring 2021. The windpower company OX2 will act as an industrial partner.

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