DNS simulation of a planar jet using a hybrid MPI-CUDA strategy

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ABSTRACT

The study of Turbulence is permanently in the edge of computational need. The recent availability of the CUDA programming environment, coupled with the ever increasing capabilities of GPUs, may contribute to increase the resolution of DNS and LES simulations.

The objective of this work is to increase the performance of a pseudo-spectral DNS plane jet simulation code (fig 1). This objective is two fold: decrease the simulation time and create a series of kernels that could be used for accelerating post-processing of the resulting data.

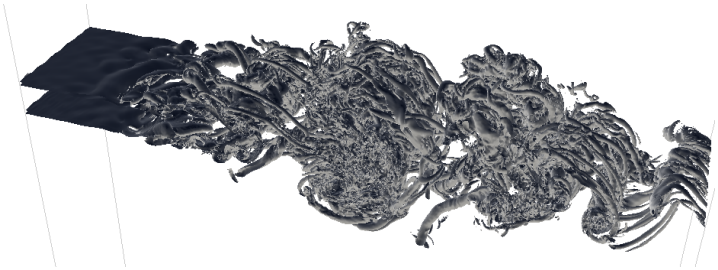

Figure 1: Plane jet, vorticity isosurfaces

The base DNS code is already parallel (using MPI) but still computationally very demanding. It has two spectral directions, Y and Z, with the derivatives in the streamwise direction, X, solved using a 6th order compact scheme, imposing a functional partition on the code, with several all to all communications steps occurring during each iteration. Due to the cost of carrying multiplications in the Fourrier space, these are carried in the physical space, translating into a heavy use of back and forth FFT transforms.

Using the interprocessor communication architecture already in place, the calculations routines were ported to the GGPU. This allowed seamless port to multiboard systems. The code is written in Fortran 95/2003 with calls to CUDA functions using Fortran 2003 mechanisms. Tests were done using a single quadcore host with three NVIDIA TESLA C1060 boards and also in a PC cluster with four nodes, connected by Gb ethernet and with a GeForce 9600 GT board each.

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