Application statement for HPC Autumn Academy 2011

Dear HPC Academy committee,

My PhD research currently centres in the modelling of interfacial phenomena of multi-phase flow using Smoothed Particle Hydrodynamics (SPH). The applications of this research will serve to improve existing state-of-art aero-engine designs. In order to fully encapsulate the complex physical interactions which take place in aero-engines, we have adapted the use of SPH to solve the partial differential equations describing underlying fluid dynamics. This research offers an innovative approach to investigate the high speed jet fragmentation impact and interfacial tension driven phenomena, and to numerically examine these physical phenomena in detail, extracting generic engineering correlations which are otherwise difficult to capture and characterise experimentally.

The essence of SPH is to replace fluid continuum by a collection of particles. The particle system is first built by searching the entire domain for neighbourhood particles, and thereafter the computation of interaction forces between neighbouring particle pairs. Finally, the kinematic behaviour of fluid particles is approximated by a numerical integration with respect to time. From a scientific computing perspective, SPH faces great challenges as both accuracy and numerical resolution depend on the number of particles in consideration. Furthermore, having to deal with the complex geometries involved in coupled particle interactions, the SPH approach often prove to be computationally expensive. In many cases, a serial SPH code is incapable of providing satisfactory resolution to real-world engineering-related problems.

In order to overcome the problem of numerical resolution, it is essential to exploit the parallel architecture in HPC to develop a data-parallel code for our SPH method. Our idea is to construct a domain decomposition on the fluid domain, and each sub-partitioned domain is then distributed across the HPC to limit communication between computation nodes. In each computation nodes, inter-particle forces can be effectively computed with the use of multi-threading techniques.

Having participated in interdisciplinary High Performance Computing (iHPC) conference at the University of Nottingham and as a current member of Computational Physics Group in Institute of Physics, I would like to add that I am highly ebullient to partake in the Autumn Annual HPC school 2011. As a first year PhD iHPC student, I strongly believe that the opportunity to gain a solid foundation in the understanding of HPC technologies would prove invaluable in my use of HPC in any research work I will undertake in the future.

Best Regards,

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