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A Parallel Computation Based on GPU Programming for a 3D Compressible Fluid Flow Simulation

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Abstract : A computation of a 3D compressible fluid flow for virtual environment with haptic interaction can be a non-trivial issue. This is especially how to reach good performances and balancing between visualization, tactile feedback interaction, and computations. In this paper, we describe our approach of computation methods based on parallel programming on a GPU. The 3D fluid flow solvers have been developed for smoke dispersion simulation by using combinations of the cubic interpolated propagation (CIP) based fluid flow solvers and the advantages of the parallelism and programmability of the GPU. The fluid flow solver is generated in the GPU-CPU message passing scheme to get rapid development of haptic feedback modes for fluid dynamic data. A rapid solution in fluid flow solvers is developed by applying cubic interpolated propagation (CIP) fluid flow solvers. From this scheme, multiphase fluid flow equations can be solved simultaneously. To get more acceleration in the computation, the Navier-Stoke Equations (NSEs) is packed into channels of texel, where computation models are performed on pixels that can be considered to be a grid of cells. Therefore, despite of the complexity of the obstacle geometry, processing on multiple vertices and pixels can be done simultaneously in parallel. The data are also shared in global memory for CPU to control the haptic in providing kinaesthetic interaction and felling. The results show that GPU based parallel computation approaches provide effective simulation of compressible fluid flow model for real-time interaction in 3D computer graphic for PC platform. This report has shown the feasibility of a new approach of solving the compressible fluid flow equations on the GPU. The experimental tests proved that the compressible fluid flowing on various obstacles with haptic interactions on the few model obstacles can be effectively and efficiently simulated on the reasonable frame rate with a realistic visualization. These results confirm that good performances and balancing between visualization, tactile feedback interaction, and computations can be applied successfully.

Keywords : CIP, compressible fluid, GPU programming, parallel computation, real-time visualisation
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