EFFICIENT ACOUSTIC ANALYSIS THROUGH THE GPU-ACCELERATED DISCONTINUOUS GALERKIN METHOD

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ABSTRACT

In most industrial applications involving acoustic simulation, the fidelity of the numerical model is constrained by considerations on the available computational resources and the required solution time. Numerical methods taking benefit of high-performance computing environments therefore allow increasing the modelled acoustic domain size and/or the maximum frequency of analysis. In this context, graphic processing units (GPUs) provide a mean to perform computations in a more efficient way than conventional CPUs, as they feature thousands of cores that can work in parallel by sharing a dedicated memory space. There is now a clear trend to have GPU's accompanying CPUs as co-processors for increasing the computation power of workstations and clusters. However, the powerfulness of GPUs is plainly achieved with highly intense and local arithmetics. Software codes exploiting the high order Discontinuous Galerkin Method (DGM) for acoustic simulations are therefore perfect candidates for GPU acceleration.

This presentation aims at illustrating the performance enhancements obtained in acoustic simulations thanks to a GPU-accelerated DGM solution scheme, allowing the solution of problems previously hardly feasible in an industrial context. Different examples solved by means of the Actran DGM commercial software are presented with different ranges of acoustic domain sizes and analysis frequencies. In all cases, the machine used is equipped with 2 NVidia Tesla K80 cards (each K80 being composed by 2 GPUs).

The first example covers the exterior acoustic analysis of a full truck at 5 kHz (see Figure 1). In this type of analysis, a monopole is used to describe different sources such as the tire noise, the intake or exhaust noise. The obtained results can be exploited for pass-by noise simulations or for computing the acoustic transfer functions towards the

passenger compartments. This problem has been simulated in less than 2 hours 22 min; the analysis involves about 221 Millions of degrees of freedoms.

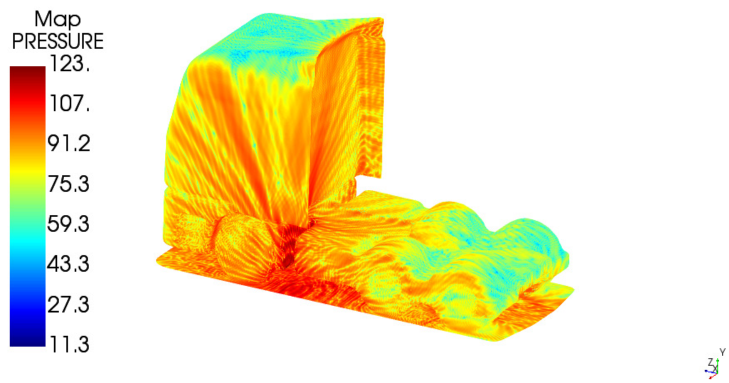

Figure 1. Full truck acoustic radiation, analysis frequency 5 kHz.

The second example analyses the interior acoustics of a car, including dissipation mechanisms, at 15 kHz. In this case a loudspeaker installed in the car door is simulated by exciting a circular surface with a given pattern. Furthermore, trim components effects such as carpets and headliner are accounted for through admittance boundary conditions. The analysis involves about 383 millions of degrees of freedoms and has been carried out in about 4 hours.

Finally, an even more challenging application is considered: ultrasonic proximity sensors. These sensors equip current vehicles for helping drivers in parking manoeuvres or can equip future autonomous vehicles for more complex tasks. In this example, a set of acoustic waves at 50 kHz is radiated from a car back bumper towards a basic obstacle (see Figure 2). From a physical perspective, for example, it is required to discriminate between the waves reflected by the object and the waves reflected by the ground floor which are of less importance. A 3D portion of the back part of the car is considered. This yields to an analysis of almost 1 billion degrees of freedoms and has been carried out in 14 hours and 42 minutes.

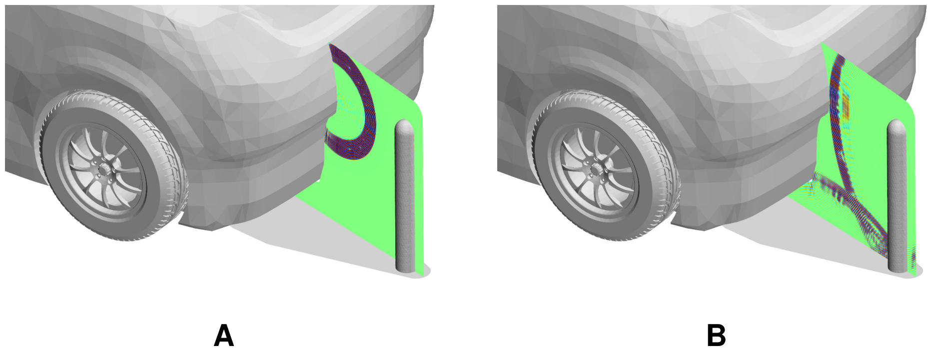

Figure 2. Rear parking sensor simulations. **A** – Outgoing ultrasonic outgoing waves; **B** – Reflected waves by obstacle and ground floor.