33$^{\mathrm{rd}}$ Scottish Fluid Mechanics Meeting

Investigation of parallel computing for jet-surface interaction noise calculations

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28$^{\mathrm{th}}$ May 2020

Abstract

The canonical problem of a jet flow interacting with a plate positioned parallel to the level curves of the streamwise mean flow has received much attention in Aero-acoustics research community as a representation of jet installation effects.

Goldstein et al [1] find that the acoustic spectrum for the round jet scattering problem is given a formula that involves the computation of 4 integrals. However, we found that to achieve a good representation of the turbulence structure this formula should be amended such that a numerical Fourier transform is required. Therefore, the acoustic spectrum now involves the calculation of 5 nested integrals, one of which requires a small step size. Naturally this is computationally expensive on standard desktop computers.

Therefore, we investigate the use of parallel computing in order to speed up the calculations. We compare the use of multiple cores on a CPU to offloading the calculation to a GPU. We investigate the most efficient way to offload to the GPU taking into consideration the cost of data movement between CPU and GPU. Since more accurate representations of the turbulence will require a finer spatial grid, we also consider the effect on speed up as the step size of the integrals is reduced (by increasing the number of iterations).

In general our calculations using the GPU algorithm show considerable reduction in computational time and a much larger reduction than using multiple cores on the CPU. This is particularly evident as the step size is reduced, increasing the utilisation of the GPU to full capacity, and reaching the maximum speed-up of 130. Therefore, this approach is a viable option for design/optimization calculations aimed at characterizing the acoustic signature, especially when using models which accurately represent turbulence and thus require a fine spatial grid.

References

[1] Goldstein, M. E., Leib, S. J., and Afsar, M. Z., "Rapid distortion theory on transversely sheared mean flows of arbitrary cross-section," *J. Fluid Mech.*, Vol. 881, 2019, pp. 551–584.

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