A trade-off analysis between high-order seismic RTM and computational performance tuning.

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ABSTRACT

Among the several methods used in the Oil & Gas geophysical exploration process, the Seismic Method is considered to be the most important one. Among the several numeric methods proposed to solve such differential equations, the Finite Difference (FD) method is one of the most successful. And the Reverse Time Migration (RTM) is one of the main approaches in the seismic processing industry for imaging the subsurface structure of the Earth. The computational costs of Reverse Time Migration kernel are usually quite high, both in relation to the time of execution and to hardware resources demand. A strategy that is frequently employed to decrease the computational costs consists in discretize the wave equation using high-order Finite Difference operators (Holberg, 1987). Thus allowing the increase of the mesh spacing and, consequently, the decrease of the amount of memory and iterations needed to update the wave field over the entire spatial domain. In this context, this work aims to examine the consequences of the variation of the FD operator order over the computational cost of the 3D Acoustic Isotropic RTM kernel. Both the Taylor operators and the operators optimized by the Scaled Binomial Window are assessed, whose discretization orders range from 4th to 36th. The analysis presented in this paper were performed on two computing platforms - Intel Xeon Phi 7120P coprocessor and Intel Xeon E5-2697v2 processor. Since the RTM's performance is strongly influenced by architecture aspects such as cache size, memory bandwidth and processor's clock (Krueger et al., 2013), performance profiling was made over each platform in order to evaluate hardware efficiency and perform computational optimizations. Therefore, this paper seeks to establish possible relations between the order of the operators and the performance of each architecture, in addition to being intended to assist in the decision-making process upon choosing the finite-difference method discretization order. Considering the used dataset and seismic parameters, experiments have shown that the optimized 16th order operator offers the best performance. This one was able to save more than 70% in processing time and saves up to 90% in memory demand. The results also showed the choice of the order of the FD operator should consider aspects such the number of flops (floating-point operations) at the stencil computing, hardware architecture, the domain size and shape.

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