8th Biennial International Conference
& Exposition on Petroleum Geophysics

"HYDERABAD 2010"

P-268

Surface-related multiple elimination with multiple prediction on GPU

Ying Shi, Hong Liu and Bo Li*
Institute of Geology and Geophysics, Chinese Academy of Sciences

Summary

Surface-related multiple prediction by SRME call for much space convolution computation, which show matrix multiplication at each frequency component. In the abstract, we exploit the computation advantage of GPU to calculate matrix multiplication. We arrange concentrated matrix multiplication on GPU to accelerate surface-related prediction, and other computation on CPU sequentially. Surface-related multiple will be suppressed by cooperated and parallel computation on GPU/CPU, which improve computation efficiency for surface-related multiple prediction greatly. Shot data and complex Pluto synthetic data model are tested by the proposed method. Comparison result show the application of GPU computation technology accelerates multiple prediction greatly.

Introduction

Compare with moveout method, wave equation based multiple attenuation method process complex surface well. So since SRME technology appear, the data driven multiple suppression method play an important role on seismic data processing. The method need not presuming condition and surface geology structure, and it suits to complex earth especially. However, a lot of spatial convolution computation spends much calculation time, which shows matrix multiplication on every frequency component. The success of GPU (graphics processing unit) general computation technology in seismic pre-stack time migration (Li, et al., 2009) shows GPU can play much important role in seismic data processing.

In the abstract, we introduce GPU general computation technology to SRME method, and suppress surface-related multiple by cooperated and parallel computation on GPU/CPU. We finish matrix multiplication on GPU to accelerate computation and other computation on CPU sequentially. The method improves prediction efficiency greatly, which can save much computation time and show more advantage on large data set. By GPU technology, The proposed method will provide much chance for surface-related multiples elimination development. SRME will show more prospect in petroleum seismic data processing field.

Theoretically, more advantage will appear if we introduce GPU technology to 3D multiple prediction, because 3D multiple prediction call for the same dense sampling in both x and y direction. That shows much computation needed to be finished .Multiple suppress with 2D data will be discuss in this abstract.

Theoretical Aspect

Surface-related multiple elimination (SRME)

Surface-related multiple elimination based on wave equation can be implemented by series expansion (Verschuur and Berkhout, 1992) or iteration (Berkhout and verschuur, 1997, Verschuur and Berkhout, 1997) method. The method consists of two steps, multiple prediction and adaptive subtraction (Weglein, et al., 1997). SRME Series expansion and iteration method is as shown in equation (1) and (2), (3) respectively. From the expressions, we note that either series expansion or iteration method needs matrix multiplications.

$$P_0 = P - A(f)P^2 + A^2(f)P^3 - A^3(f)P^4 + \ldots \quad (1)$$

$$P_0^{(i+1)} = P - A(f)P_0^{\,i}P \quad (2)$$

$$P_0^{(0)} = P \quad (3)$$

where P , P_0 , $A(f)$ and i are total wavefiled with multiples, multiple-free data, inverse source wavelet and iteration number respectively.

In the abstract, we use series expansion method to suppress surface-related multiple on Pluto synthetic data and iteration method to suppress surface-related multiple on shot data. We replace primary with seismic data itself (total wavefield) in series expansion, also we start the first iteration with initial estimation from seismic data itself in the iteration method.

During prediction, we use GPU to implement matrix multiplication, i.e., multiple prediction. During subtraction, there are many methods which can be adopted, such as minimum energy method, expanded multichannel matching filters for seismic multiple attenuation, pattern recognition method, adaptive multiple subtraction based on constrained independent component analysis, and so on. In the abstract, we use minimum energy method for subtraction. Which are done by the assumption that the total amount of energy in seismic data is minimum after multiples are attenuated.

Matrix multiplication by GPU

GPU processes strong programmable and float computation ability. It can execute hundreds of processes simultaneously. So GPU suit to parallel and dense numerical computation greatly. GPU general computation can be implemented by CUDA (Compute Unified Device Architecture) language. CUDA extend C language by kernel function.

In the abstract, in order to improve multiples prediction efficiency, we transfer matrix multiplication calculation to GPU device, and attenuate surface-related multiples by cooperated and parallel computation on GPU/CPU. We arrange sequential code on CPU, and matrix multiplication code on GPU. The multiprocessor is divided into some blocks, and every block is divided into some threads, using the threads to implement parallel computation. During matrix multiplication, for saving much global memories bandwidth, fast shared memories are also used.

Due to strong computation ability from GPU, the method in the paper can predict multiple from large data set with high efficiency. The larger data, the more advantage can be shown.

Examples

The two following tests are done. Figure 2 tests shot record with multiples, which are attenuated by the iteration implement of SRME. Figure 3 tests Pluto model with multiples, which are attenuated by the series expansion implement of SRME.

Figure 2(a) show synthetic shot record with one-order and two-order surface-related multiples; (b) show predicted multiples by GPU; (c) show Multiples suppression result after three iterations. GPU test platform is GeForce GTS 250. The other computation environment is CPU with 3.0GHZ main frequency. For each iteration, the matrix multiplication on CPU spends 6396s, but that only need 73s on GPU.

The applicability of the proposed method is also examined by using 2D Pluto synthetic data set, which is supplied by SMAART Joint Venture Consortium to test multiple attenuation effect. The model contains three salts and strong one-order and two-order surface multiples. The test platform is GPU NVIDIA Tesla C1060, and its compucation abiliby and main frequency are 1.3 and 1.30GHz respectively. The maximal thread is 512 in a block, and Warp block size is 32 threads. The other computation environment is four cores CPU node with 2.5GHZ main frequency. The matrix multiplication on CPU spend 14934s, but that only need 213s on GPU. There is a seventyfold improvement for computation efficiency. Figure 3 shows application effect on GPU. Figure 3(a) show Pluto synthetic data with multiples. Figure 3(b) shows predicted multiples by GPU. Figure 3(c) shows multiples suppression result by adaptive minimum energy.

Conclusions

We introduce GPU computation technology to multiple prediction by SRME in the paper. Surface-related multiple will be suppressed by cooperated and parallel computation on GPU/CPU. We transfer concentrated matrix multiplication to GPU to accelerate surface-related prediction, and other computation are finished by CPU sequentially, which improve multiple prediction efficiency greatly when we suppress multiple by traditional SRME method. Tests show it is better idea to introduce GPU technology to SRME method. Surface-related multiple

prediction algorithm by GPU provide technology basis for 3D SRME industry development.

Acknowledgments

This research was supported by the Project of National Natural Science Foundation of China (grant No. 40830424), the Project of National 863 Plan of China (grant No.2006AA09A102-08), the Project of National 973 Plan of China (grant No. 2007CB20960).

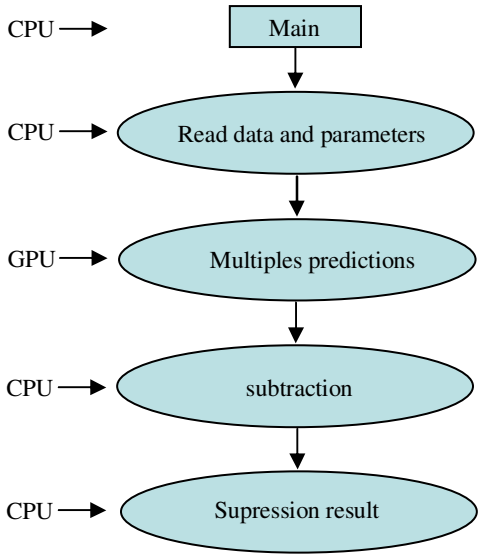


Figure 1: Workflow of surface-related multiple suppression.

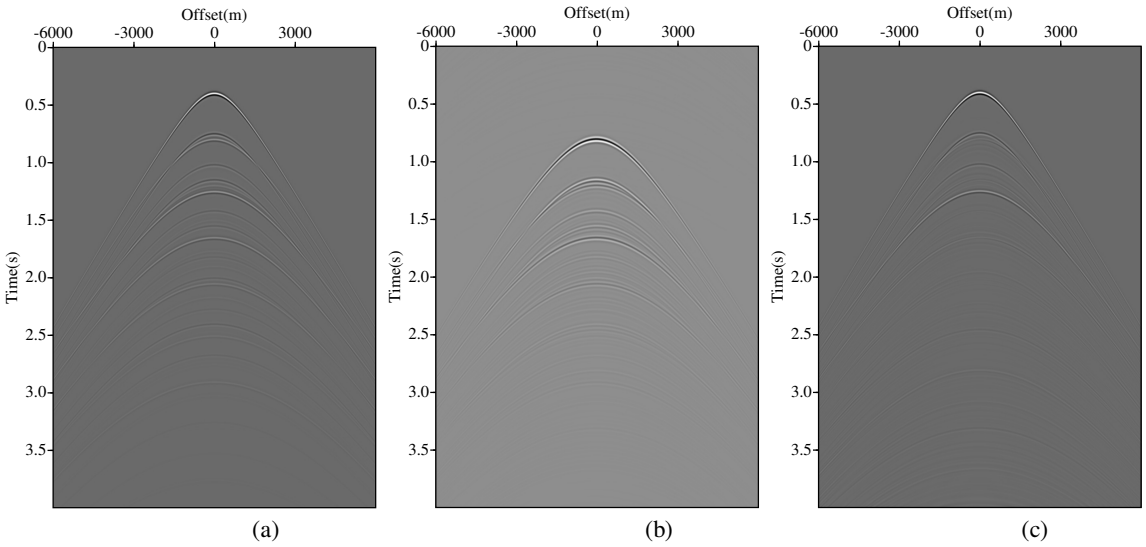
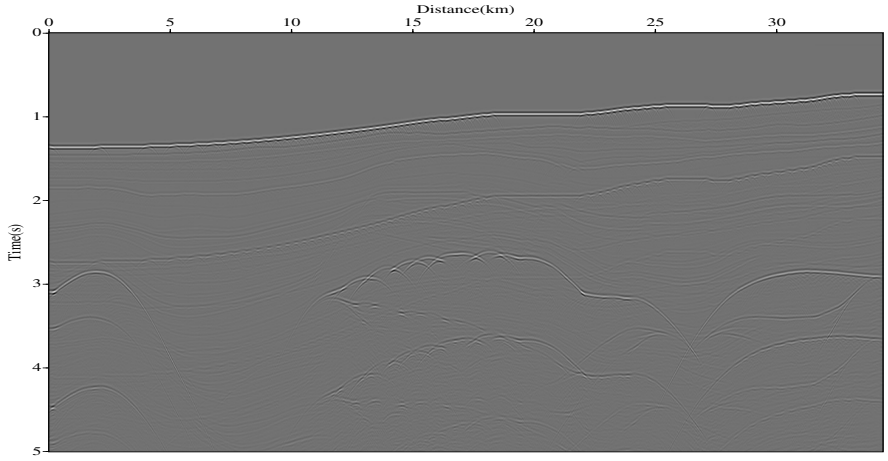


Figure 1: Surface-related suppression on shot data. (a) Shot record with surface-related multiples; (b) Predicted multiples by GPU; (c) Multiples suppression result.



(a)

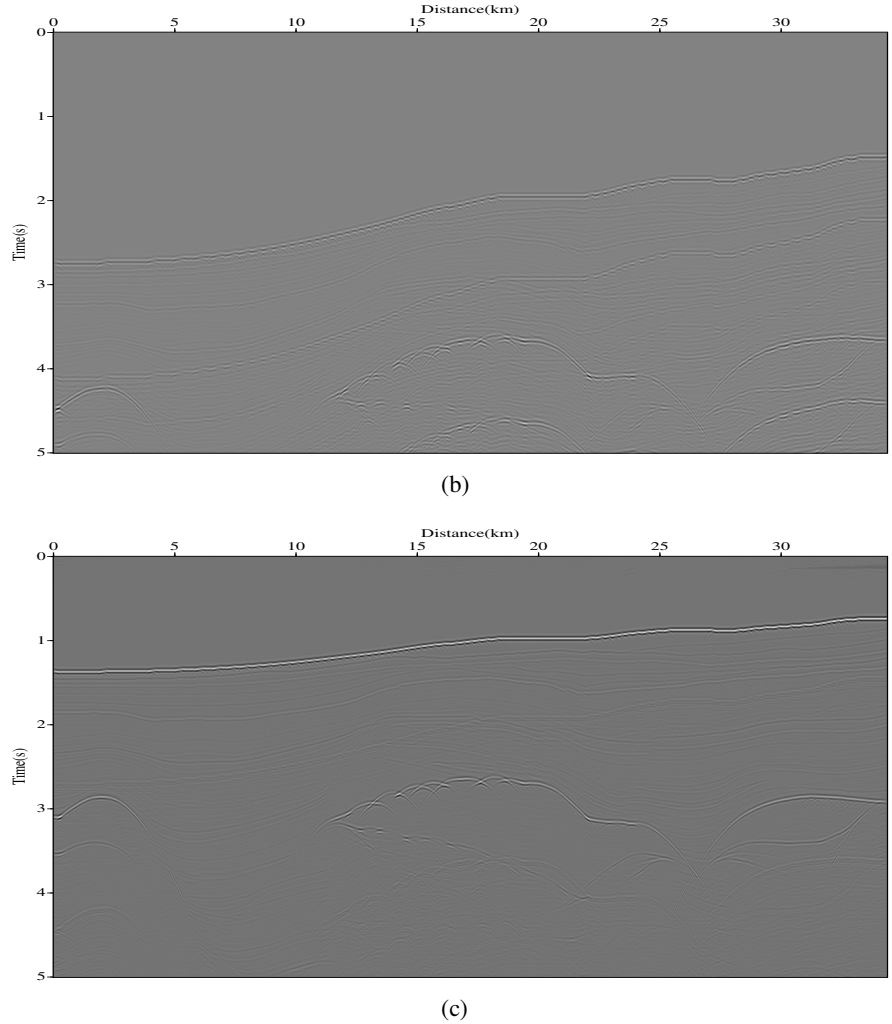


Figure 2: Surface-related suppression on Pluto synthetic data. (a) Pluto synthetic data with multiples; (b) Predicted multiples by GPU; (c) Multiples suppression result.

References

Li B, Liu G F, Liu H. A method of using GPU to accelerate seismic pre-stack time migration. Chinese J. Geophys. (in Chinese), 2009,52(1):245-252

Weglein, A.B., F.A. Gasparotto, P.M. Carvalho, and R.H. Stolt. An inverse scattering series method for attenuating multiples in seismic reflection data. Geophysics, 1997, 62(6): 1975–1989

Verschuur D J, Berkhout A J. Adaptive surface-related

multiple elimination. Geophysics, 1992, 57(9): 1166–1177

Verschuur D J, Berkhout A J. Estimation of multiple scattering by iterative inversion, part Ⅱ: Practical aspects and examples. Geophysics, 1997, 62(5): 1596–1611

Berkhout A J, Verschuur D J. Estimation of multiple scattering by iterative inversion, part Ⅰ: Theoretical considerations. Geophysics, 1997, 62(5): 1586–1595