地球物理学报 » 2012, Vol. 55 » Issue (12) :4069-4077 doi:10.6038/j.issn.0001-5733.2012.12.019

引用本文(Citation):
陈召曦, 孟小红, 郭良辉, 刘国峰.基于GPU并行的重力、重力梯度三维正演快速计算及反演策略. 地球物理学报, 2012,55(12): 4069-4077,doi: 10.6038/j.issn.0001-5733.2012.12.019

CHEN Zhao-Xi, MENG Xiao-Hong, GUO Liang-Hui, LIU Guo-Feng.Three-dimensional fast forward modeling and the inversion strategy for large scale gravity and gravimetry data based on GPU.Chinese J.Geophys. (in Chinese),2012,55(12): 4069-4077,doi: 10.6038/j.issn.0001-5733.2012.12.019

基于GPU并行的重力、重力梯度三维正演快速计算及反演策略

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Three-dimensional fast forward modeling and the inversion strategy for large scale gravity and gravimetry data based on G

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摘要

利用NVIDIA CUDA编程平台,实现了基于GPU并行的重力、重力梯度三维快速正演计算方法.采用当前在重力数据约束反演或联合反演中流行的物性模型(密度大小不同、规则排列的长方体单元)作为地下剖分单元,对任意三维复杂模型体均可用很多物性模型进行组合近似,利用解析方法计算出所有物性模型在计算点的异常值并累加求和,得到整个模型体在某一计算点引起的重力(或重力梯度)值.针对精细的复杂模型体产生的问题,采用GPU并行计算技术,主要包括线程有效索引与优化的并行归约技术进行高效计算.在显卡型号为NVIDIA Quadro 2000相对于单线程CPU程序,重力和重力梯度U_{xx}、U_{xy}正演计算可以分别达到60与50倍的加速.本文还讨论了GPU并行计算在两种反演方法中的策略,为快速三维反演技术提供了借鉴.

关键词 GPU, CUDA, 正演计算, 重力, 重力梯度, 加速比

Abstract:

NVIDIA CUDA, the massively parallel programming platform of GPUs, is used to calculate the forward modeling of scalar and tensor gravimetry data. The model is subdivided into a large number of regular blocks with fixed size and unknown density values. The gravimetry anomalies at the surface points can be summed by the anomaly of each block computed by an analytical method. In order to improve the approximation, the subsurface should be divided into a larger number of voxels. We adopt GPU parallel method for forward calculation because the traditional CPU program is time-consuming,which includes two main issues: the index presentation and optimized parallel reduction. The result shows that the forward calculation by GPU has correct results and an improved efficiency, which have achieved an acceleration of a factor of 60 for gravity data and 50 for gravimetry data. This can provide the basis for 3D inverse problem. In addition, we discuss the strategies of the 3D property inversion using GPU, providing the examples for the 3D property inversion of potential field data sets.

Keywords GPU, CUDA, Forward modeling, Gravity, Gravimetry data, Speedup ratio

Received 2012-04-10;

Fund: