Conghui He

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Education

Tsinghua University, PhD Candidate in Department of Computer Science and Technology, High Performance Geoscience Computing Group 9/2013 – present

Sun Yat-sen University, Bachelor in Software Engineering 9/2010 – 6/2014

Skills and Interests

General: C/C++, Python, Java, Linux, Bash scripting

Best on C/C++ programming theory and practice

Solid understanding of Linux system management, Bash scripting

High Performance Computing: pthread, OpenMP, MPI, CUDA, FPGA

Skillful in parallel program profiling and optimization

Experienced at ARM/Linux Embedded System designing

Selected Awards

National Scholarship, 2009

IBM Outstanding Student Scholarship, 2010

Sun Yat-sen’s First Prize Student Scholarship, 2011

Fourth Place in ISC12 International Super Computing Challenge, 2012

First place in IEEE/IBM International Smarter Planet Challenge, 2013

Schlumberger Scholarship for Computing Earth Science, 2014

Research Experiences

My research interest includes: Computational Geophysics and Parallel Algorithms. I’m experienced at the parallel algorithms design on modern computer architectures like GPU, multi-core CPU and FPGA processors to solve the computational challenge raised from exploration geophysical applications. Participated projects include:

Accelerate the Market Data Server on Reconfigurable platform 5/2015 - present

Cooperative project with China Financial Futures Exchange (CFFEX), targeted at developing a high performance and low-latency market data server on reconfigurable platform. The system, which is deployed on MAX4 platform, receives/sends trading packets from/to 10Gb Ethernet on FPGA and process them directly on FPGA without any interference from CPU, thus gaining very low latency. Our work on FPGA includes parsing the packets in XTP protocol, maintaining a sorted order book and publishing the reconstructed market data. After careful design and optimizations, our design support more than 200 instruments per FPGA and reach a latency of 4-10us.

Ensemble Full Wave Inversion with Source Encoding 9/2014 – 6/2015

Full wave inversion (FWI) suffers from convergence toward local minima because of the inaccuracy of the initial model and the lack of low frequency data. Noises in seismograms further deteriorate the imaging quality. To relax the dependency on high quality low frequency data, we present an ensemble full wave inversion method with source encoding (EnFWI), which is an ensemble approximation of the total inversion proposed by Tarantola. The method refines the velocity model iteratively by incorporating the observation, while the nonlinear evolution of the covariance is approximated by ensemble covariance. Encoded simultaneous-source FWI (ESSFWI) is applied to improve the representation for the low rank ensemble approximation, and to increase the rate of convergence. Experiments show that EnFWI achieves larger convergence range and better tolerance to data noise with less computational costs than traditional FWI methods.

A Fully-Pipelined Expectation Maximization Hardware Design for Gaussian Mixture Model 4/2014 – 11/2015

Gaussian Mixture Models (GMMs) are powerful tools for probability density modeling and soft clustering. They are widely used in data mining, signal processing and computer vision. In many applications, we need to estimate the parameters of a GMM from data before working with it. This task can be handled by the Expectation-Maximization algorithm for Gaussian Mixture Models (EM-GMM), which is computationally demanding. In this project we present our FPGA-based solution for the EM-GMM algorithm. We propose a pipelined-friendly EM-GMM algorithm, a variant of the original EM-GMM algorithm that can be converted to a fully-pipelined hardware architecture. To further improve the performance, we design a Gaussian probability density function evaluation unit that works with fixed-point arithmetic. We also come up with an idea to convert a large dimension or/and component EM configuration to multiple pieces of smaller dimension or/and component in case of resource limitation. In the experiment, one test case that spends more than 2 minus on a single core CPU only spends hundreds of milliseconds in our data flow engine, enabling it to be a low-latency and high performance application. Our FPGA-based solution also generates accurate-enough results while achieving a maximum of 939 times speedup over a CPU-based solution, and 55 times speedup over a GPU-based solution.

A CPU-GPU Hybrid Parallel Design for Beam Migration 9/2013 - 12/2014

The Kirchhoff beam-stack migration is quite popular in production with both better image quality and faster speed compared to Kirchhoff migration. Meanwhile, continuous HPC developments offer new opportunities for the industry to further enhance the efficiency of beam migration methods. We present a design of a highly efficient GPU-based beam migration. By parallelizing both the ray tracing and the beam mapping kernels with millions of GPU threads and using an asynchronous IO scheme, we derive a parallel beam migration design that fits current CPU-GPU hybrid clusters. Then, we test our GPU-based beam migration on the SEG/EAGE salt model and the SEAM salt model for different generations of GPU architectures, presenting accurate imaging results with 2-6 times speedup compared to a parallel 16-core CPU design.

Accelerating the Global Vegetation-Precipitation Correlation Algorithm 9/2013 - 11/2013

Startup Project for PhD candidate cooperated with a Professor in Remote Sensing field, aiming to accelerate the algorithm taking months to finish. Optimization strategies for it includes modifying the algorithm to reduce I/O accessing by utilizing local buffer, adding a memory pool to reduce frequent memory allocation/destruction, overlapping I/O transferring and computing. It gained 20x speedup in the end.

Reverse Time Migration Implementations on Reconfigurable Platform 3/2013 - 6/2013

Bachelor final year project, accelerating the Reverse Time Migration method on FPGA. The biggest computational challenge is the simulation of acoustic wave equation on a big 3D-mesh. Several algorithms like finite difference method which conduct to a stencil operator was accelerated and researched.

Publications

He, Conghui, Haohuan Fu, Bangtian Liu, Huabin Ruan, Guangwen Yang, Hui Yang, and Are Osen. "A GPU-based Parallel Beam Migration Design." In 2015 SEG Annual Meeting. Society of Exploration Geophysicists, 2015.

He, C., Y. Chen, H. Fu, and G. Yang. "Ensemble Full Wave Inversion with Source Encoding." In 77th EAGE Conference and Exhibition 2015. 2015.

Clinton, Nicholas, Le Yu, Haohuan Fu, Conghui He, and Peng Gong. "Global-Scale Associations of Vegetation Phenology with Rainfall and Temperature at a High Spatio-Temporal Resolution." Remote Sensing 6, no. 8 (2014): 7320-7338.

Social Experiences

Intern of Seismic Imaging R&D Group in Statoil (Beijing) Technology Service Co, Ltd. 7/2014 – 9/2014

President of IEEE Tsinghua Student Branch 9/2013 - 9/2014