ACCELERATING INSAR RAW DATA SIMULATION ON GPU USING CUDA

Zhang Fan[1]，*Wang Bing-nan*[1, 2]，*Xiang Mao-sheng*[1]

1．National Key Laboratory of Microwave Imaging Technology, Institute of Electronics, Chinese Academy of Sciences, Beijing, 100190, China；2．The Graduate School of Chinese Academy of Sciences, Beijing, 100039, China

1. INTRODUCTION

As the image processing algorithms is relatively mature, the main task of SAR system simulation is to simulate the raw data that contains different actual system errors. With the increased resolution of SAR systems and the demand for InSAR (interferometric SAR) applications, the objects of SAR echo simulation change from point target, surface target into nature three-dimensional terrain, which brings the rapid growth of computation time.

So the OpenMP, MPI, grid computing [1-3] and other high-performance parallel computing technology are used to optimize and accelerate the simulation courses. The three kinds of parallel computing technologies are based on CPU platform, which is designed for the control and logic processing. This design pattern will cost more in construction and maintenance for large-scale parallel computing.

As the improvement of GPU parallel processing capacity and programmability, the combination of GPGPU (general purpose GPU) technology and the classical algorithm has been a hot topic at present GPGPU has been applied to biology, geophysics, medical imaging, image processing and other areas [4-7]. Compared with CPU it achieves acceleration of a dozen to several hundred times. Therefore the paper presents the InSAR raw data parallel simulation algorithm on GPU using CUDA.

2. SCALABLE PRALLEL SAR ECHO SIMULATION

The GPU-based InSAR raw data parallel simulation runs a large number of GPU threads for parallel computation. Each GPU thread calculates the echo of single scattering point at each azimuth time. Although the computing power of each GPU thread is weaker than CPU, the scalable parallel computation maximizes the GPU hardware floating-point operation capacity, and improve the computing speed about 1-2 orders of magnitude finally.

To make use of obvious advantage of GPU parallel computing, the InSAR raw data parallel simulation algorithm on GPU using CUDA is proposed, and the algorithm flow of one channel raw data simulation is as follows:

Step I According to paper[8-10], 3D target is placed in a flat rectangle to build scene geometry model firstly. Secondly geometric characteristics map is calculated using GPU automatic blanking. Thirdly the scattering coefficient map of 3D target is calculated using GRECO algorithm.

Step II According to the system parameter, the linear FM signal is calculated, converted to frequency domain, and transmitted to the GPU memory;

Step III Geometric characteristics map, scattering coefficient maps and geometrical parameters are transferred to the GPU memory and used to calculate the azimuth signals of all the scattering points by CUDA kernels;

Step IV The azimuth signal spectrum is calculated by CUDA's CUFFT library. Then the spectrum multiplication is operated by the CUDA kernels. Finally the whole echo data is achieved by transforming the spectrum product to time domain using the CUFFT inverse Fourier transform. After that, (I) - (IV) are repeated until the end of simulation time. So we can get the other channel InSAR raw data by different geometrical parameters with the algorithm flow.

3. Results

A simple analysis of speed acceleration in three-dimension InSAR raw data simulation will be given in the section. The target elevation information should be consider in three-dimension target raw data simulation. The extra dimension makes the calculation of azimuth signal slant range and look angle increased compared with two-dimension SAR raw data simulation. Therefore, the simulation speed of three-dimension cone and two-dimension flat surface should be compared under the same conditions. In the experiment, scene size is 1024x512, the target area size is 100x100. The imaging results of simulated echo is shown in Figure 1, and the simulation speed experiment results are shown in Table 1.

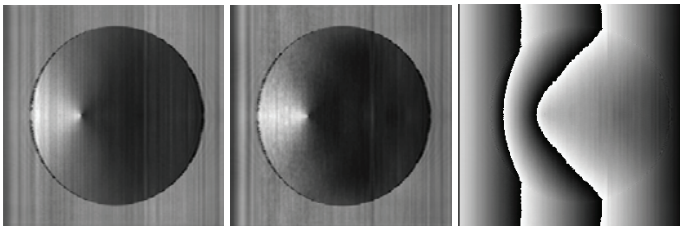

Figure 1 Imageing result of simulated three-dimension cone in different channel and interferometric fringe

Table 1 simulation speed comparison

target	CPU	GPU	speedup
3D	20613ms	703ms	29.32
2D	9531ms	411ms	23.19

As can be seen from Table 1, speed acceleration in three-dimensional simulation is more evident. Compared with two-dimensional echo simulation, the speedup increases about 6 times. It can be seen that the SAR echo fine-grained parallel simulation with CUDA is more suitable for InSAR simulation of three-dimensional targets.

4. Conclusion

The GPU general purpose computing has been more widely used with the development of CUDA architecture. The paper introduces CUDA technology to solve calculation bottleneck of InSAR raw data simulation. The experiments results show that the method is 29 times faster than CPU methods, and have advantages of small space occupier, low electric power consumption and low hardware cost. The method is especially suitable for airborne / spaceborne SAR simulation of large-scale scenes and InSAR simulation. The next step of research will apply CUDA parallel computing technology to spaceborne InSAR echo simulation of real terrain, which assists the spaceborne InSAR system design and validation.

4. REFERENCES

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