Multi-core GPU – Fast parallel SAR image generation

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Abstract

This poster presents a design for parallel processing of synthetic aperture radar (SAR) data using multi-core Graphics Processing Units (GP-GPUs). In this design a two-dimensional image is reconstructed from received echo pulses and their corresponding response values. Then the comparative performance of proposed parallel algorithm implementation is tabulated using different set of nvidia GPUs i.e. GT, Tesla and Fermi. Analyzing experimentation results on image of various size 1,024 x 1,024 pixels to 4,096 x 4,096 pixels led us to the conclusion that nvidia Fermi S2050 have maximum performance throughput .

Introduction

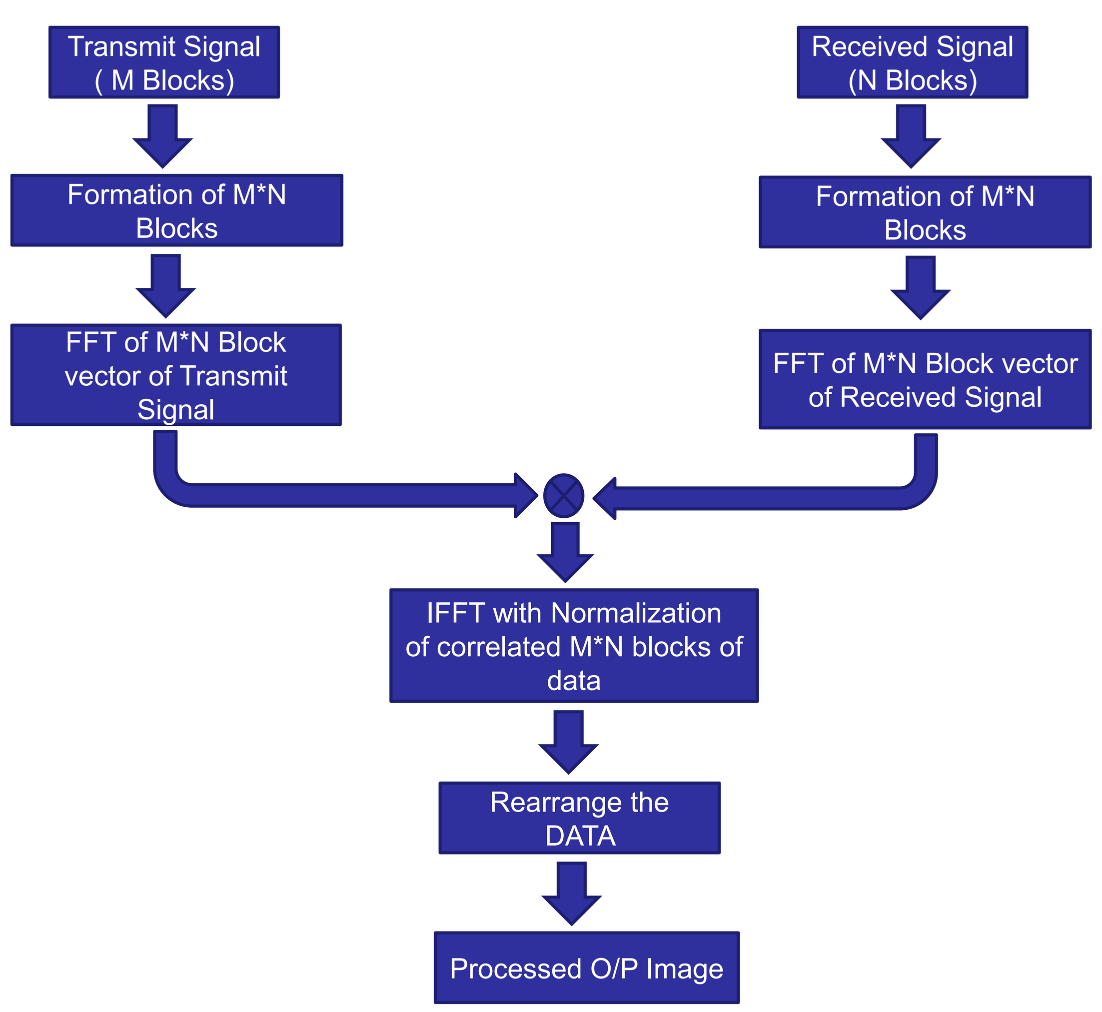
Generating images from Synthetic aperture radar (SAR) video's raw data require complex computations that is tabulated in data sample for RADARSAT-1[1].

In SAR system, fundamental principle is based on matching of received(Rx) signal phase with the transmitted(Tx) signal phase at a stable frequency of transmission. Fast Fourier Transform (FFT) calculation is used to calculate phase of received and transmitted signal.

The modified algorithm that is presented in the paper [2] is implemented by dividing the impulse response of Rx/Tx signal into several blocks of equal length and then computing FFT on each block. It help to process the dimension of range and azimuth in parallel.

Since GP-GPU has huge computational capability which process data in parallel, modified SAR image generation on GPU is implemented. New proposed parallel algorithm helped to achieve faster execution speed for range and azimuth dimension.

Algorithm And Method

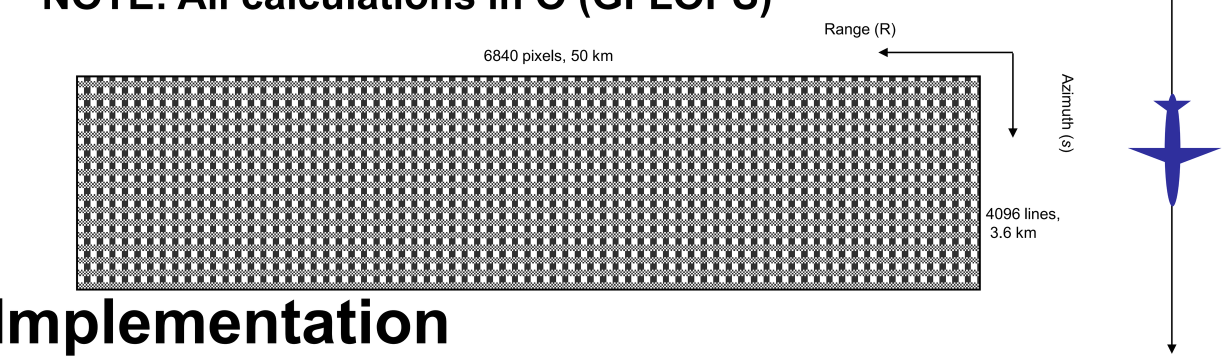


Data Sample

Parameter	Typical Value
Number of range samples	6840
Number of Azimuth samples	4096
Block size (image size)	8192 X 8192
Data size (actual size)	11.27 M samples /sec
Total Computational requirement (range)	1.83 GFLOPS
Total Computational requirement (azimuth)	3.28 GFLOPS
Total load computing requirement	5.11 GFLOPS

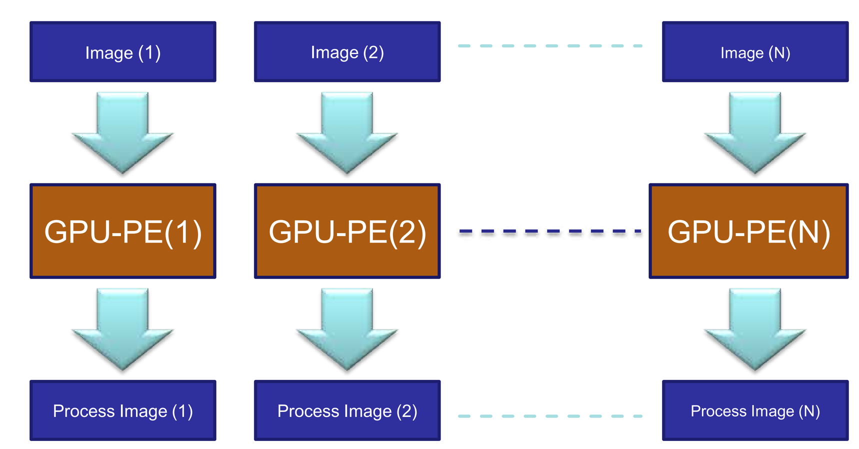
RADAR-SAT-1
Data from C-band Sensor
- 50 km Range
- 3.6 km Azimuth
- 7.2 m Ground Range Resolution
- 5.26 m Azimuth Resolution

NOTE: All calculations in O (GFLOPS)

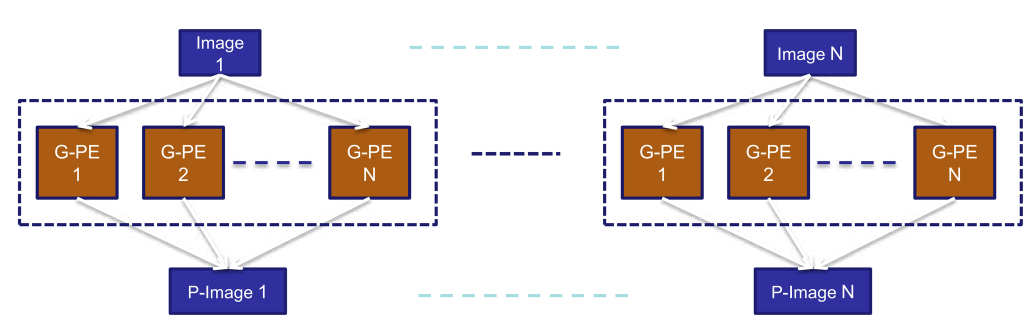


Implementation

Typical Parallel Algorithm



Proposed Parallel Algorithm



Mathematical Model

Exploit Linearity of Correlation process

$$u(n)=\sum_{i=0}^{P-1}u_i(n),\quad iK\le n<(i+1)K-1 \qquad y(n)=\sum_{j=0}^{Q-1}y_j(n),\quad jK\le n<(j+1)K-1$$

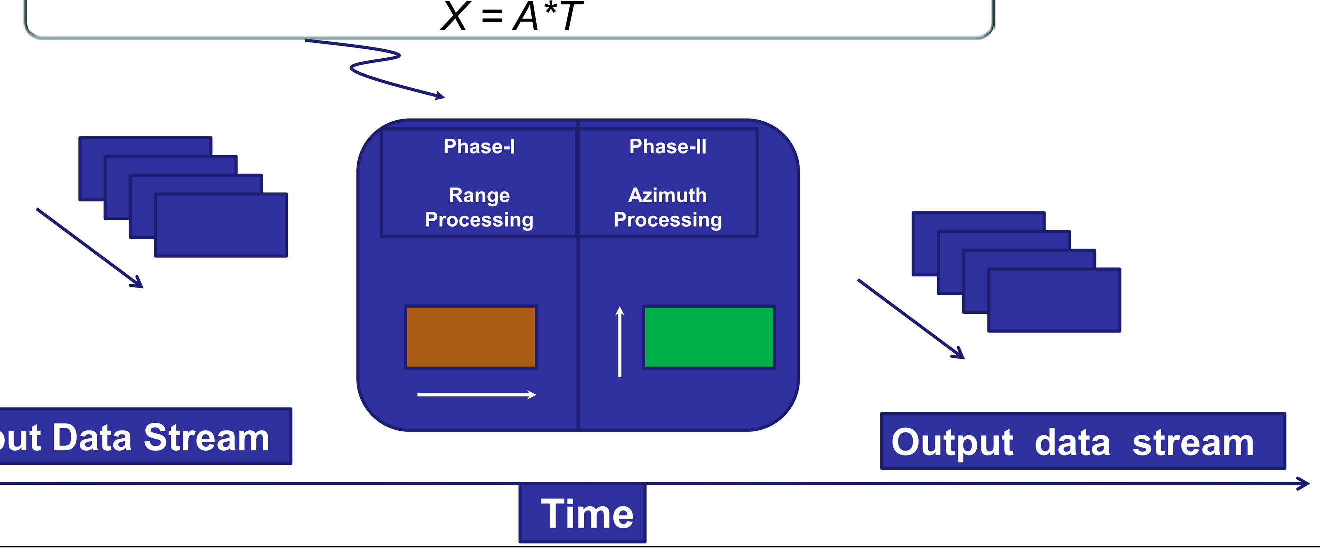
$$r(l)=\sum_{j=0}^{Q-1}\sum_{i=0}^{P-1}\sum_{n=0}^{2K-|l|-2}y_j(n+l)u_i(n),\quad -K\le l<K-1$$

Perform Block Correlation in Transform domain

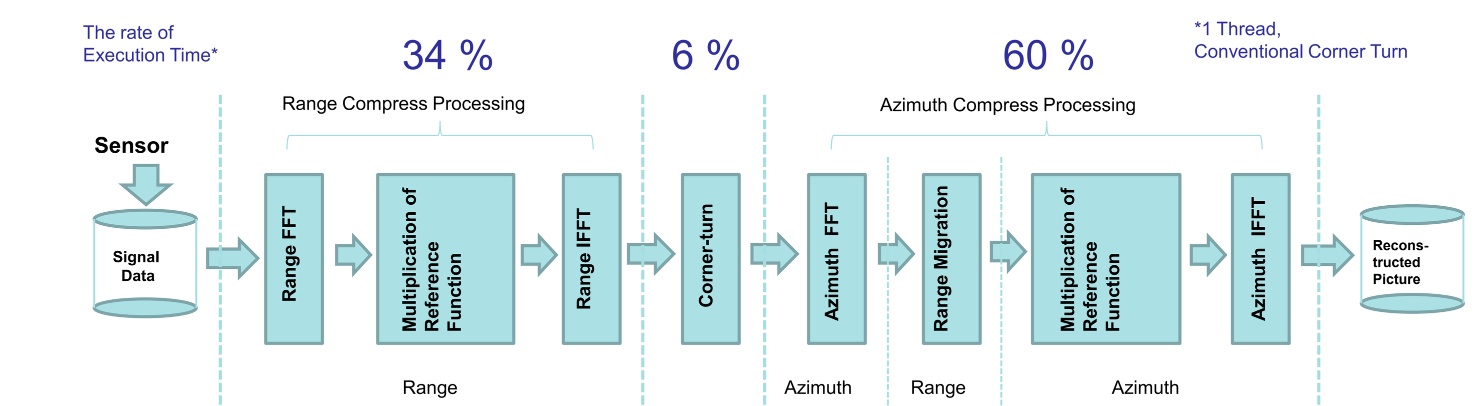
$$r_{ij}(l)=IDFT\left[U_i^*(k)Y_j(k)\right],\quad 0\le k\le(2K-1)$$

Arrange Correlation vector as output of Matrix transform

$$X=A*T$$

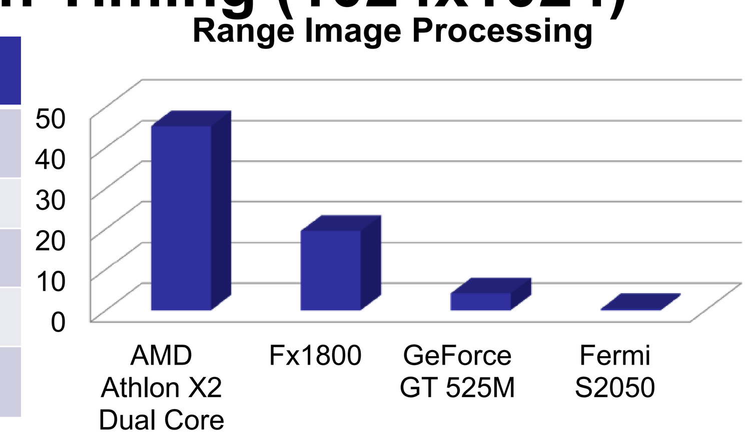


Process distribution to generate SAR



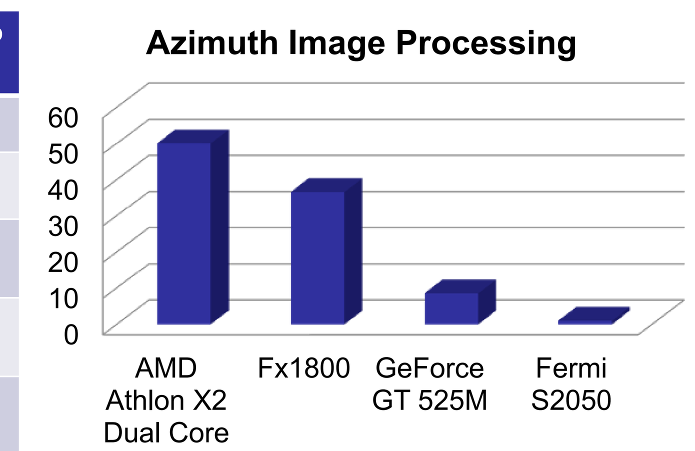
Range Image Generation Timing (1024x1024)

CPU / GPU	Core Details	Time(sec)	Speedup
AMD Athlon X2 Dual Core	1	45.337	1x
Fx1800	64	19.50	2.32x
GeForce GT 525M	96	4.150	10.92x
Tesla GeForce GTX 275	192	1.421	**31.90x**
Fermi S2050 (Multi GPU)	**4x448**	**0.321**	**141.21x**



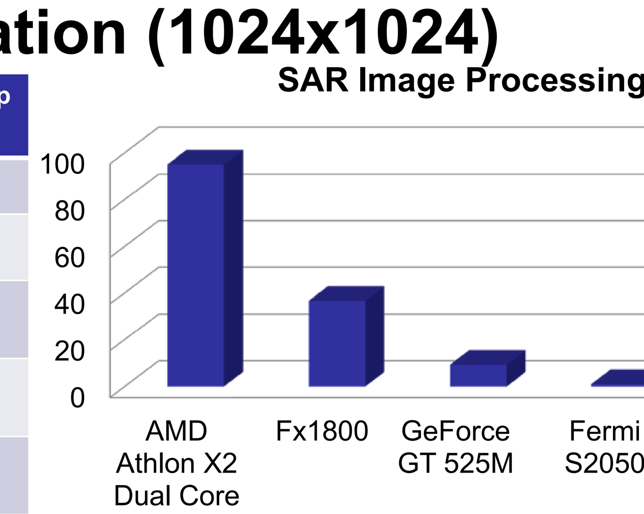
Azimuth Image Generation Timing (1024x1024)

CPU / GPU	Core Details	Time(sec)	Speedup
AMD Athlon X2 Dual Core	1	50.065	1x
Fx1800	64	36.60	1.368x
GeForce GT 525M	96	8.501	5.884x
Tesla GeForce GTX 275	192	3.725	13.44x
Fermi S2050 (Multi GPU)	**4x448**	**0.981**	**51.01x**

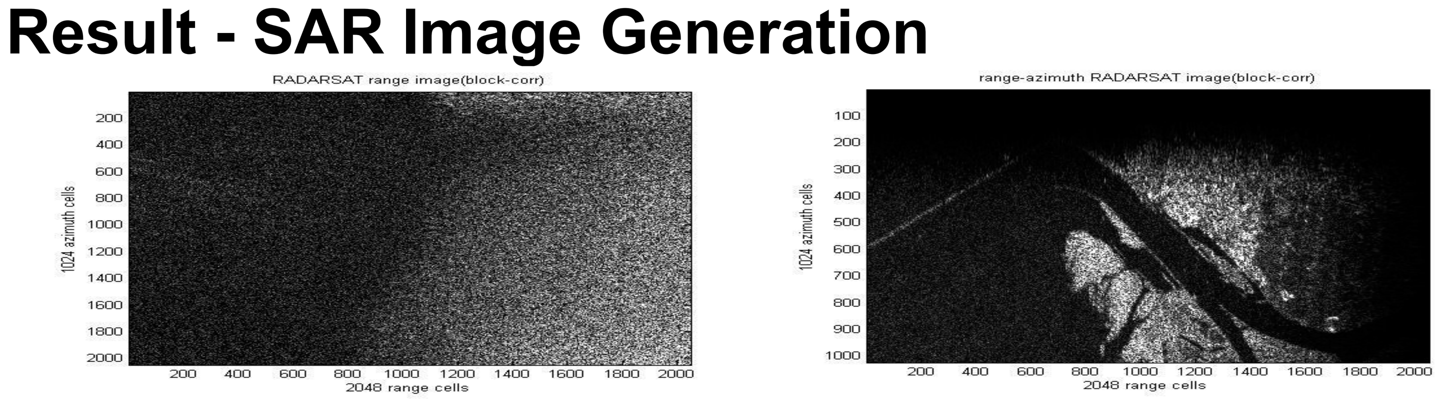


Final SAR Image Generation (1024x1024)

CPU / GPU	Core Details	Time(sec)	Speedup
AMD Athlon X2 Dual Core	1	**95.00**	**1x**
Fx1800	64	**36.60**	**2.6x**
GeForce GT 525M	96	**9.23**	**10.29x**
Tesla GeForce GTX 275	192	**4.4563**	**21.31x**
Fermi S2050 (Multi GPU)	**4x448**	**1.280**	**74.21x**



Result - SAR Image Generation



References

[1] Ian G Cumming and Frank H Wong, *Digital Processing of Synthetic Aperture Data, Artech House, Boston, London, Jan 2005.*

[2] Bhattacharya C, "Parallel processing of satellite-borne SAR data for accurate and efficient image formation," EUSAR 2010, pp. 1046-49, 7-10 June 2010, Aachen, Germany.

[3] NVIDIA Corporation, Compute Unified Device Architecture (CUDA), *http://developer.nvidia.com/object/cuda.html.*

[4] AK Agarwal and et al, "Accelerated SAR image generation on GPGPU platform," APSAR, 2011