High performance computing in data and image processing

A.A. Lukianitsa[1,2], A.G. Shishkin[1,2], F.S. Zaitsev[1,2]

[1]*Fusion Advanced Research Group Ltd., Slovakia.*
[2]*Moscow State University, RF.*
[1]*e-mail: feodor@zajcev.eu*

In the last few years large amounts of data have been collected and stored in massive datasets which needs be processed and analyzed to provide improved understanding of plasma behavior. For example, the amount of image data generated in some plasma applications is growing rapidly as camera resolutions increase, devices get bigger, and the features to be inspected shrink even further.

The time of data processing can be substantially reduced by transferring modules, allowing parallel computing, to video card pipelines. To that end CUDA - a parallel computing architecture developed by Nvidia - can be used. It is based on C programming language with Nvidia extensions and certain restrictions. CUDA gives developers access to the virtual instruction set and memory of the parallel computational elements in CUDA GPUs. We applied artificial neural networks for processing huge amounts of experimental data. Based on our experience we could conclude that CUDA technology allowed to accelerate the training of neural networks in more than 100 times while using relatively cheap video cards nVidia GeForce GT 520 and nVidia GeForce GTX 260. Moreover while analyzing plasma discharge video stream the time required for a single frame processing was reduced by a factor of 40. It holds out a hope of achieving real time data processing in various problems, e.g. feedback control.

Fluid modeling, which describes the discharges based on the number density, mean velocity and mean energy of the charged and neutral species by self-consistent coupling with Maxwell equations, and particle-in-cell/Monte-Carlo (PIC/MC) methods are often used to model plasmas. However, a numerical simulation based on fluid and PIC/MC modeling is very time-consuming, especially for large-scale 2D or 3D computations with more chemical reactions involved. To overcome these difficulties we used parallel a fully implicit numerical solver for gas-discharge fluid modeling equations. In our opinion CUDA technology can be very promising for modeling of various processes by fluid and PIC/MC methods as well.

At present there are a lot of mathematical methods, computer codes and various information and numerical approaches in fusion modeling. The important task is to single out the most advanced and adequate approaches, their modification and standardization. With that aim in mind we developed a universal toolbox ‘Virtual Tokamak” allowing remote usage of research software by usual Web-browser [1,2]. The toolbox allows simulating all principle parts of tokamak and plasma control sytems such as design, plasma diagnostics, magnetic and kinetic systems of plasma control, systems of additional plasma heating, modern plasma behavior systems, divertor. To provide discharge simulation within a reasonable time distributed computations and GRID technologies were used.

In this report we present the high performance computing applications for plasma boundary tracking in video images, search of moving objects in video streams, data mining in huge plasma experimental datasets and distributed computations while modeling plasma discharges within “Virtual Tokamak” framework.

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