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Implementation of NTSS Algorithm to three dimensional Particle Image Velocimetry for fluid flow using GPU

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Abstract

Particle Image Velocimetry (PIV) is a non-invasive optical technique used to measure and visualize the whole-area velocity map of a real flow. This flow is seeded with particles of similar properties like viscosity, density of fluid etc. There are many PIV algorithm reported and their use depends upon the problem to be solved. In this paper, a PIV algorithm viz. the New Three Step Search (NTSS) Algorithm which is the improved version of Three Step Search algorithm has been chosen. NTSS is developed in the range of image compression, is to be presented for the quick vector following. There are two PIV images, over which we are applying NTSS algorithm using cross correlation method. Furthermore, NTSS is implemented as serial and parallel computation. There are different software that implement the PIV viz. MatPIV, OpenPIV, OpenCV and GeoPIV et al. In this project open source OpenPIV software has been chosen as implementation.

Keywords: PIV, PyCUDA, OpenPIV, CUDA.

1. Introduction

PIV is basically used where high visibility, low aerodynamics-diameter particles are needed to follow high-acceleration flows. Particle Image Velocimetry is used to find displacement between two images and also to find the actual position with maximum value using cross-correlation method. It is a measure of likeness of two arrangements as an element of the dislodging of one in respect to the other. This is otherwise called a sliding spot item or sliding inward item. It is ordinarily utilized for scanning a long flag for a shorter, known component. It has applications in design acknowledgement, single molecule investigation, electron tomography, averaging, cryptanalysis, and neurophysiology. For continuous function J_1 and J_2

$$R(s) = \int J_1(X)\, J_2(X+S)dx$$

Where,

J_1, J_2 = Sub area

x = Interrogation window

s = Shift between the images

Different software are available as implementation of PIV, like MatPIV, OpenPIV, OpenCV, and GeoPIV et al. In this project, we have used the software Open Source Particle Image Velocimetry (OpenPIV). It is a free, open source software. There are many algorithms that are available as part of OpenPIV. The test results show that the proposed algorithm is suitable for parallel implementation on CPU–GPUs model and has good scalability both in the problem size and in the number of GPUs used.

Particle Image Velocimetry

Particle Image Velocimetry (PIV) is a non-invasive optical technique used to measure and visualize the whole-area velocity map of a real flow. The experimental set-up of a PIV system typically consists of several sub systems. The application of PIV is that the tracer particles have to be added to the flow.

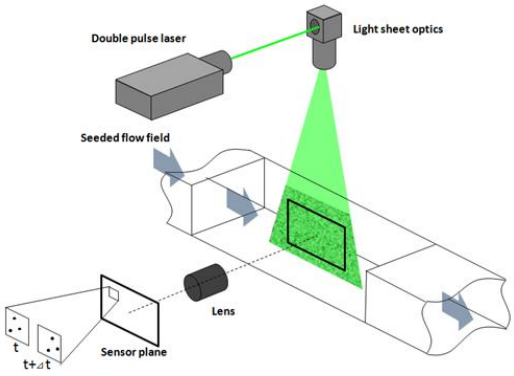

Fig1: principle of PIV

The particles should to be as little as conceivable with the goal that they can nearly be taken after the stream. The diagram will shows the working of PIV. Arrangement, even 3D Particle Image Velocimetry (PIV) is an optical, laser based estimation and perception system utilized as a part of research, industry and education. It is a Velocimetry system and, with suitable calculations, could reveal additionally other stream properties. PIV can measure 2D or, if it is in stereo, speed fields in plane.

New Three Step Search (NTSS) Algorithm

It is an advanced type of three step search calculation. In the initial step, it manages close by displacement all the more sufficiently by an inside based constraint. TSS is determined by making the inquiry adjusting to the

movement vector separate, and a midway stop innovation to distinguish the calculation test. The advantages of NTSS is that it is approved and tried for translational and straight forward shear stream cases. The impediments of NTSS are that most extreme development is bound to 7 pixels.

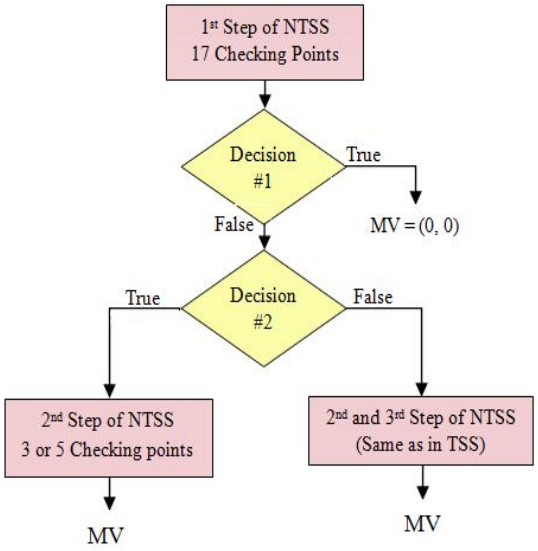

Fig 2: Algorithm of NTSS

2 .Literature Review

S.K.Kim et al say that Particle Image Velocimetry technique (PIV) is basically developed by measuring whole flow field, the use of both Qualitatively and quantitatively. Particle Image Velocimetry requires utilization of fast and reliable, computer based techniques for following various particles suspended in a flow field. The NTSS algorithm is the advanced version of Three Step Search (TSS) algorithm, NTSS had been generally utilized as the motion estimation technique in low bit rate video compression application, attributed to its straightforward implementation and capability Since the use of full search block matching (FSBM) with FFT has practically identical speed and better precisions, PIV with NTSS is not popular in two dimensional PIV. In three dimensional PIV estimations, the immense calculation request is anticipated. Therefore according to S.K. there is a need to revisit the use of NTSS. With the three dimensional synthetic images, NTSS algorithm is validated for translational and straightforward flow cases. Here, the NTSS algorithm is connected to the standard images offered by the Visual Society of Japan. The impediment of NTSS is that the maximum movement is confined to 7 pixels. Finally, as New Three Step Search(NTSS) is the modification of Three dimensional Step Search, developed in the range of image compression, is to be presented for the quick vector following in three step search dimensional PIV from the utilization of new three step search to converted and simple shear flow cases, while practically find the accuracy in New Three Step Search and full search block estimation is almost similar but also finding the gain is calculation time by New Three Step Search is best.

3.GPU Implementation

Graphic Processing Unit (GPU) were developed primarily to performs the computation for computer graphics mainly texture mapping, shading and rendering polygons etc. These GPU have become highly parallel and multi-threaded and much efficient in handling the processes with large amount of data. CPUs consist single Control Unit and ALU whereas GPU incorporates multiple Control Units and ALUs. In this project, Nvidia Geforce GTX 980 Ti GPU, having 2816 CUDA cores and 6 GB RAM is employed.

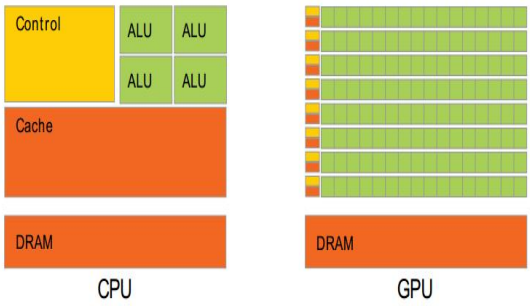

Fig.3: CPU vs. GPU

Compute Unified Device Architecture (CUDA) is a parallel programming architecture for using GPU for directly programming the shaders of underlying GPU. Massively parallel processing over hundreds GPU cores makes it exceptionally compelling at accomplishing huge parallel processing performance. CUDA is a parallel computing platform and programming model invented by NVIDIA.

Figure 4: Nvidia GeForce GTX 980 TI

PyCUDA

PyCUDA is a Library used for accessing the CUDA capabilities of a GPU from Python programming language. PyCUDA gives you simple, Pythonic access to NVidia's CUDA parallel calculation API. A few wrappers of the CUDA API as of now exist–so why the requirement for PyCUDA. PyCUDA has compiled the CUDA source code and uploaded it. PyCUDA is a python programming environment for CUDA, object clean-up attached to lifetime of items. There are different packages that are required for installation of PyCUDA. PyCUDA' base layer

is written in C++. Also for all intents and purposes it is free.

4. OpenPIV

OpenPIV is written in python language. OpenPIV is an exertion of Scientists to convey a device for the investigation of PIV pictures utilizing cutting edge calculations. OpenPIV is released under open source license which means that the source code is freely available for users to study, copy, modify and improve. OpenPIV has been implemented in many languages but due to its simplicity, development is done on Python. OpenPIV is not just the PIV picture examination programming. There are different types of source code that will be provided in OpenPIV of the flow. OpenPIV is the best way to access the PIV images. OpenPIV is good to evaluate PIV images, acquired with frame-stride or continuous, time-resolved PIV system.

5.Proposed work

The main application of Particle Image Velocimetry is that the fluid velocity measurement for fluid dynamics characterization we can say that the air flowing around a car or an aircraft, water running through hydroelectric turbine ,blood flow etc. In this research work the hardware work is done on GPU(Graphic Processing Unit) and CPU(Control Processing Unit). Now a days, GPU are most preferred over CPU based computation. Efforts are done to utilize GPU based acceleration technique for faster post-processing post PIV images.

6.Conclusion

Particle Image Velocimetry find a displacement between two images and its also find the actual position with maximum value using cross -correlation method. PIV From the application of NTSS to translation and simple shear flow cases, while accuracy in NTSS is better than other algorithm but not finding the actual output. It deal with small displacement more effectively. Comparison with other three dimension PIV algorithm will be the next work. Now a days GPU based computation are most preferred over CPU due to parallel processing available on GPU. Effort has been done to utilize GPU based acceleration techniques for faster post-processing of PIV images.

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