

Assignment HPC2

Title :-

Parallel computing using CUDA

Problem Statement :-

Vector and Matrix operations

Design parallel algorithm to

1. Add two large vectors
2. Multiply vector and matrix

3. Multiply two ~~two~~ $N \times N$ arrays using n^2 processors.

Objective :-

Learn parallel decomposition of problem

Learn parallel computing using CUDA.

Software and Hardware required :

1. OS : Linux or windows
2. google colab
3. Atavidea Nvidia GPU
4. CUDA API

Outcomes :

Students will be able to decompose problem into subproblems, to learn how to use GPU to learn to solve subproblems using threads on GPU cores.

Theory:-

Dividing computation into smaller computation and assigning with to different processors for parallel execution are the two key steps in design of parallel algorithm.

The process of dividing computation into smaller parts some or all of which may potentially be executed in parallel is called decomposition tasks. are programmer defined units of computation into which the main computation is subdivided by means of decomposition.

Simutaneous execution of multiple tasks is the key to reducing the time required to solve the entire problem. Tasks can be of arbitrary size but once defined, they are regarded as individual units of computation. The tasks into which a problem is decomposed may not all be of same size

In addition of two vectors ,we have to add ith element from first array with ith element of second array we can alllocate this each to distinct thread. Some using thing can be done for the product of two vector.

There can be 3 cases for addition of two vectors using CUDA.

1. n blocks and one thread per block
2. 1 blocks and n thread -in the block
3. m blocks and n thread per block.

Mathematical model

Let S be the system set

$$S = \{ s; e; x; y; F_{me}; DD; NDD; F_C; SC \}$$

s = start state

e = end state

x = set of inputs

$x = \{ x_1 \}$ where x_1 is element of vector or matrix

where

x_1 = Elements of vector

y = output set (sum of product of element of vector / matrix)

F_{me} is set of main functions

$$F_{me} = \{ f_1, f_2, f_3 \}$$

Where,

f_1 = decomposition function

f_2 = function to find sum / product

f_3 = function to merge results.

DD = Deterministic Data

vector / Matrix of Elements.

NDD = Non deterministic Data

F_C = Failure case

No failure case identified for the application

Test cases:-

i) vector addition:-

For $n = 8$.

$$\begin{array}{cccccccc} 6 & 4 & 2 & 9 & 1 & 3 & 2 & 1 \\ 7 & 3 & 7 & 1 & 6 & 7 & 5 & 4 \end{array}$$

Result is.

$$\begin{array}{cccccccc} 13 & 7 & 9 & 10 & 7 & 10 & 7 & 5 \end{array}$$

Teacher Signature _____

2) Vector Matrix multiplication

Vector

$$4 \quad 3 \quad 2 \quad 4$$

Matrix.

$$\begin{matrix} 2 & 4 & 3 & 1 & 2 \\ 2 & 3 & 4 & 3 & 4 \\ 4 & 3 & 1 & 3 & 1 \\ 1 & 4 & 1 & 2 & 2 \end{matrix}$$

Result

$$20 \quad 47 \quad 30 \quad 35 \quad 30$$

3) Matrix to Matrix multiplication

$$\begin{matrix} 4 & 7 & 4 & 6 \\ 8 & 6 & 7 & 3 \end{matrix}$$

Result:

$$\begin{matrix} 65 & 45 \\ 75 & 66 \end{matrix}$$

Conclusion:-

In this way, vector addition, vector matrix multiplication & matrix matrix multiplication is performed with less time complexity using GPU and CUDA programming.