CIS6930: Programming on Massive Parallel Systems

GPU Project 2: A better version of SDH computing program

Submitted by – Ghalib Saleem

I have decided to implement the algorithm 3 from the paper, Algorithms and Framework for Computing 2-body Statistics on GPUs by Napath Pitaksirianan, Zhila Nouri, and Yi-Cheng Tu for the implementation of this project. The paper describes a series of techniques for achieving high performance in dealing with a group of problems that share similar computing patterns as the SDH problem.

Algorithm 3: SDH with Output Privatization

Local Var: t (Thread id), b (Block id)
Global Var: B (Block size), M (total number of blocks)

```
1: SHMOut ← Initialize shared memory to zero
2: reg ← the t-th datum of b-th input data block
3: for i = b + 1 to M do
4:    R ← the i-th input data block loaded to cache
5:    syncthreads()
6:    for j = 0 to B do
7:       d ← DisFunction(reg, R[j])
8:       atomicAdd(SHMOut[d] , 1)
9:    end for
10: end for
11: L ← the b-th input data block loaded to cache
12: syncthreads()
13: for i = t + 1 to B do
14:    d ← DisFunction(reg, L[i])
15:    atomicAdd(SHMOut[d] , 1)
16: end for
17: syncthreads()
18: Output[b][t] ← SHMOut[t]
```

The reason I chose the Algorithm 3 is the use of shared memory for the values of distance function. As we all know shared memory is faster than the local memory and Global memory and has lower latency. The privatization algorithm creates a private copy of the output and stores it so it tends to be utilized by the subset of threads.

After completion and execution of my code, the minimum total running time of the kernel for three execution with different input that I was able to achieve is:

Note: - GPU Old is Brute force and GPU Algo 3 is result of privatization.

Output 1

Number of Samples: 10000	**Bucket Width:** 1000	**Block Size:** 64
Kernel time: 93.46391 ms		

```
(base) ghalibsaleem@Ghalib-linux:~/Documents/USF/Cuda/proj2-ghalibsaleem$ nvcc proj2-ghalibsaleem.cu -o test
(base) ghalibsaleem@Ghalib-linux:~/Documents/USF/Cuda/proj2-ghalibsaleem$ ./test 10000 1000 64

************************************ GPU Old ******************************************
Running time for GPU Old version: 0.000010

00:           16288 |          108733 |          275806 |          501165 |          767139 |
05:         1061461 |         1367080 |         1678079 |         1979292 |         2259514 |
10:         2510674 |         2730531 |         2906757 |         3039978 |         3120712 |
15:         3146650 |         3112938 |         3027899 |         2882944 |         2685905 |
20:         2426248 |         2110178 |         1743897 |         1356172 |         1021851 |
25:          749569 |          530258 |          358306 |          230657 |          138568 |
30:           76914 |           39502 |           19368 |            8666 |            3661 |
35:            1254 |             326 |              50 |              10 |               0
 T:49995000



************************************ GPU Algo 3******************************************
Running time for GPU new version: 0.000016

00:           16288 |          108733 |          275806 |          501165 |          767139 |
05:         1061461 |         1367080 |         1678079 |         1979292 |         2259514 |
10:         2510674 |         2730531 |         2906757 |         3039978 |         3120712 |
15:         3146650 |         3112938 |         3027899 |         2882944 |         2685905 |
20:         2426248 |         2110178 |         1743897 |         1356172 |         1021851 |
25:          749569 |          530258 |          358306 |          230657 |          138568 |
30:           76914 |           39502 |           19368 |            8666 |            3661 |
35:            1254 |             326 |              50 |              10 |               0
 T:49995000

**********Time to generate:: 93.46391 ms***********
```

Output 2

Number of Samples: 10000	**Bucket Width:** 500	**Block Size:** 32
Kernel time: 74.97648 ms		

```
(base) ghalibsaleem@Ghalib-linux:~/Documents/USF/Cuda/proj2-ghalibsaleem$ ./test 10000 500 32

************************************ GPU Old ******************************************
Running time for GPU Old version: 0.000008

00:           2076 |          14212 |          37870 |          70863 |         113190 |
05:         162616 |         219792 |         281373 |         348231 |         418908 |
10:         492542 |         568919 |         643293 |         723787 |         799933 |
15:         878146 |         953657 |        1025635 |        1097551 |        1161963 |
20:        1225131 |        1285543 |        1340874 |        1389657 |        1435607 |
25:        1471150 |        1505326 |        1534652 |        1554499 |        1566213 |
30:        1574002 |        1572648 |        1562633 |        1550305 |        1527753 |
35:        1500146 |        1463004 |        1419940 |        1372128 |        1313777 |
40:        1249134 |        1177114 |        1097835 |        1012343 |         920271 |
45:         823626 |         723835 |         632337 |         548947 |         472904 |
50:         405296 |         344273 |         289347 |         240911 |         197652 |
55:         160654 |         129093 |         101564 |          78499 |          60069 |
60:          44360 |          32554 |          23054 |          16448 |          11533 |
65:           7835 |           5295 |           3371 |           2289 |           1372 |
70:            804 |            450 |            222 |            104 |             34 |
75:             16 |              8 |              2 |              0 |              0
 T:49995000


************************************ GPU Algo 3******************************************
Running time for GPU new version: 0.000016

00:           2076 |          14212 |          37870 |          70863 |         113190 |
05:         162616 |         219792 |         281373 |         348231 |         418908 |
10:         492542 |         568919 |         643293 |         723787 |         799933 |
15:         878146 |         953657 |        1025635 |        1097551 |        1161963 |
20:        1225131 |        1285543 |        1340874 |        1389657 |        1435607 |
25:        1471150 |        1505326 |        1534652 |        1554499 |        1566213 |
30:        1574002 |        1572648 |        1562633 |        1550305 |        1527753 |
35:        1500146 |        1463004 |        1419940 |        1372128 |        1313777 |
40:        1249134 |        1177114 |        1097835 |        1012343 |         920271 |
45:         823626 |         723835 |         632337 |         548947 |         472904 |
50:         405296 |         344273 |         289347 |         240911 |         197652 |
55:         160654 |         129093 |         101564 |          78499 |          60069 |
60:          44360 |          32554 |          23054 |          16448 |          11533 |
65:           7835 |           5295 |           3371 |           2289 |           1372 |
70:            804 |            450 |            222 |            104 |             34 |
75:             16 |              8 |              2 |              0 |              0
 T:49995000

**********Time to generate:: 74.97648 ms***********
```

Output 3

Number of Samples: 100000	**Bucket Width:** 1000	**Block Size:** 64
Kernel time: 6902.37646 ms		

```
(base) ghalibsaleem@Ghalib-linux:~/Documents/USF/Cuda/proj2-ghalibsaleem$ ./test 100000 1000 64

************************************ GPU Old ****************************************
Running time for GPU Old version: 0.000010

00:         1640289 |        10843080 |        27544198 |        50026816 |        76708211 |
05:       106121559 |       136910632 |       167848146 |       197868797 |       225955796 |
10:       251328500 |       273244161 |       291068479 |       304327905 |       312470075 |
15:       315193417 |       312331390 |       303639589 |       289084180 |       268815791 |
20:       242887739 |       211519683 |       174891328 |       135536901 |       101644679 |
25:        74102047 |        52073269 |        34966533 |        22219570 |        13192634 |
30:         7249346 |         3683809 |         1759328 |          789152 |          317736 |
35:          109694 |           29703 |            5342 |             491 |               5
 T:4999950000


************************************ GPU Algo 3****************************************
Running time for GPU new version: 0.000050

00:         1640289 |        10843080 |        27544198 |        50026816 |        76708211 |
05:       106121559 |       136910632 |       167848146 |       197868797 |       225955796 |
10:       251328500 |       273244161 |       291068479 |       304327905 |       312470075 |
15:       315193417 |       312331390 |       303639589 |       289084180 |       268815791 |
20:       242887739 |       211519683 |       174891328 |       135536901 |       101644679 |
25:        74102047 |        52073269 |        34966533 |        22219570 |        13192634 |
30:         7249346 |         3683809 |         1759328 |          789152 |          317736 |
35:          109694 |           29703 |            5342 |             491 |               5
 T:4999950000

**********Time to generate:: 6902.37646 ms***********
```