CS575(Introduction To Parallel Programming)
Project 7B

Project Title : Autocorrelation using CPU OpenMP, CPU SIMD, and GPU {OpenCL or CUDA}(Project 7B)

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The code for CPU OpenMP, CPU SIMD and GPU OpenCL was run on the DGX system for the final results for making the graph and bar chart. The additional test which is the GPU OpenCL Reduction was also run on the DGX system.

In the Zip file,
Project7.bash and Project7.cpp are for the OpenMP 1 thread and n threads.
Project7smd.bash and Project7smd.cpp are for the SIMD.
Project7cln.cl, Project7cln.cpp and submitn.bash are for the OpenCL without Reduction. (“n” represents “normal”)
Project7cl.cl, Project7cl.cpp and submit.bash are for the OpenCL with Reduction.

The results from the Sums[1] to Sums[512] are

65714.640625,56250.253906,74983.554688,69584.882812,72806.578125,68815.015625,64611.453125,50654.968750,66498.078125,54632.628906,57564.343750,53866.570312,51863.937500,57208.886719,38789.738281,70471.335
938,57995.265625,47065.578125,37750.140625,50747.925781,48695.976562,41677.742188,37895.097656,38128.863281,28218.945312,34063.542969,36536.304688,27512.732422,15850.123047,19402.771484,35640.382812,24682
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,-20086.982344,-17155.750000,-24140.986250,-32104.082031,-32835.574219,-41169.710938,-36128.398438,-40985.980469,-30000.546875,-35843.312500,-47834.558594,-54251.312500,-39240.730469,-52322.441406,-52298.
984375,-62629.339844,-46070.597656,-48190.136719,-56357.097656,-47569.710938,-50194.941406,-58208.582031,-57033.164062,-63793.699219,-69903.953125,-62870.105469,-58715.531250,-57681.976562,-67855.609375,-
57007.855469,-61616.960938,-66365.132812,-69078.257812,-58680.437500,-77704.812500,-66296.210938,-54655.007812,-58983.855469,-67470.679688,-61201.949219,-59452.078125,-54489.273438,-54099.398438,-54524.34
7656,-46528.269531,-52642.906250,-49664.789062,-54750.074219,-46755.550781,-46317.703125,-47863.792969,-47151.167969,-52662.789062,-35396.007812,-44594.691406,-45516.917969,-48238.445312,-15095.520508,-28
934.753906,-36615.078125,-21613.103516,-35151.656250,-26882.195312,-32267.255859,-14164.615234,-19345.501953,-15551.242188,-3350.602783,-4344.016602,-7645.084961,-7825.727539,-5308.773926,1908.219360,4165
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9.019531,44684.585938,53033.167969,56462.222656,45851.796875,49740.410156,45105.988281,45080.761719,42886.773438,52269.589844,55465.812500,54043.101562,59130.468750,55174.945312,51211.160156,67530.960938,
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062,54820.484375,54138.812500,46422.976562,52582.816406,50320.753906,50703.089844,58189.050781,61541.703125,47194.066406,55805.359375,49217.992188,51835.234375,41696.472656,43158.882812,48874.625000,44890
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,-58073.710938,-38445.609375,-34810.730469,-34354.750000,-37033.351562,-39377.964844,-29391.029297,-35179.339844,-23286.046875,-25076.009766,-28252.093750,-33967.507812,-18772.687500,-19734.763672,-13749.
607422,-17037.794922,-13726.080078,-4444.363281,-9883.735352,-10432.674805,-3820.030273,-1237.571045,12135.875977,1723.175293,6393.126465,8200.410156,6854.067871,3639.074951,18312.910156,29461.478516,1699
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7655.375000,-73118.976562,-73107.304688,-59861.781250,-69914.921875,-64577.582031,-70276.265625,-80746.281250,-55016.664062,-62592.050781,-59953.363281,-61237.015625,-60951.093750,-55921.210938,-62996.000
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89.033203,-32187.943359,-26350.953125,-34123.171875,-17315.517578,-24362.900391,-21994.427734,-9505.400391,-9290.668945,-28999.546875,3156.358154,-13061.954102,-9803.797852,-4563.844238,5818.685059,5713.5
52246,15661.094727,7679.560547,17258.535156,4598.836426,9417.934570,24587.583984,17733.515625,25300.080078,17782.585938,33701.187500,27722.519531,41186.175781,33670.164062,33115.507812,45431.351562,46715.
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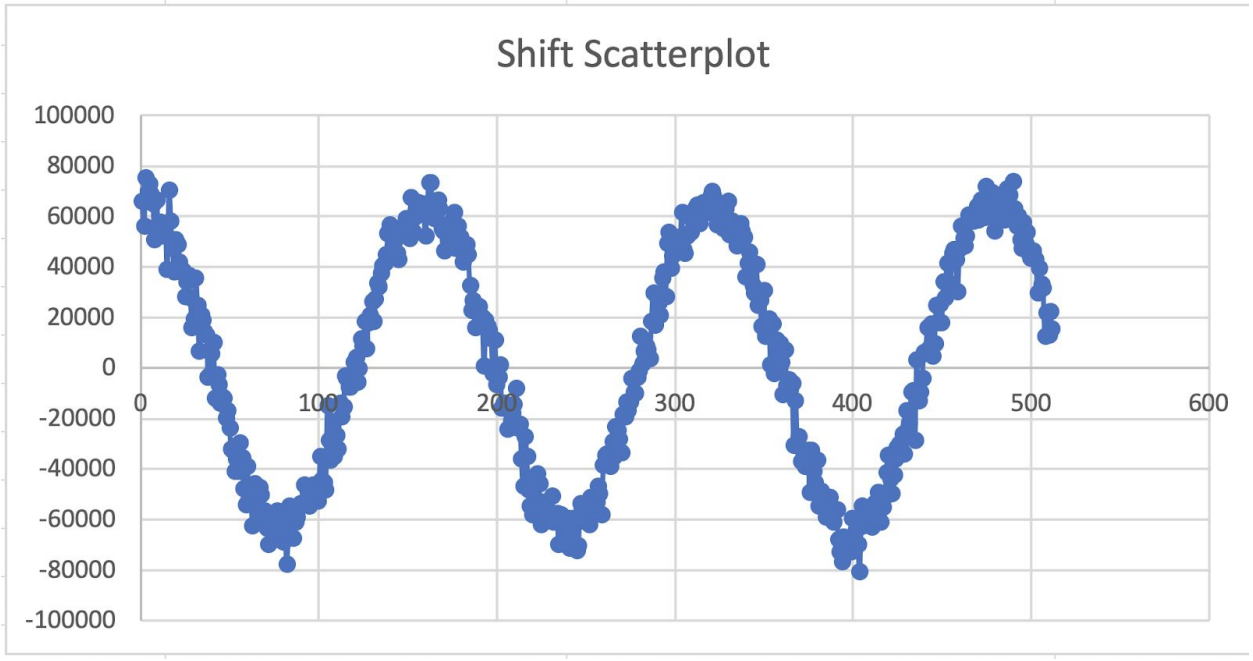
494.621094,59447.207031,71931.250000,66948.851562,61805.652344,69259.179688,64419.421875,54078.753906,62151.644531,61996.781250,64492.468750,65811.945312,58315.863281,62458.710938,70895.835938,68093.25000
0,61067.484375,73754.164062,63017.054688,55942.515625,60060.597656,50378.558594,47044.824219,57362.906250,49089.472656,53328.234375,44917.656250,43325.222656,46239.882812,43225.468750,42830.648438,29369.1
19141,39178.105469,32838.812500,31561.484375,12393.739258,21795.785156,13027.322266,22156.294922,15506.144531,

The shift scatterplot is



The hidden sine-wave period is around 160.

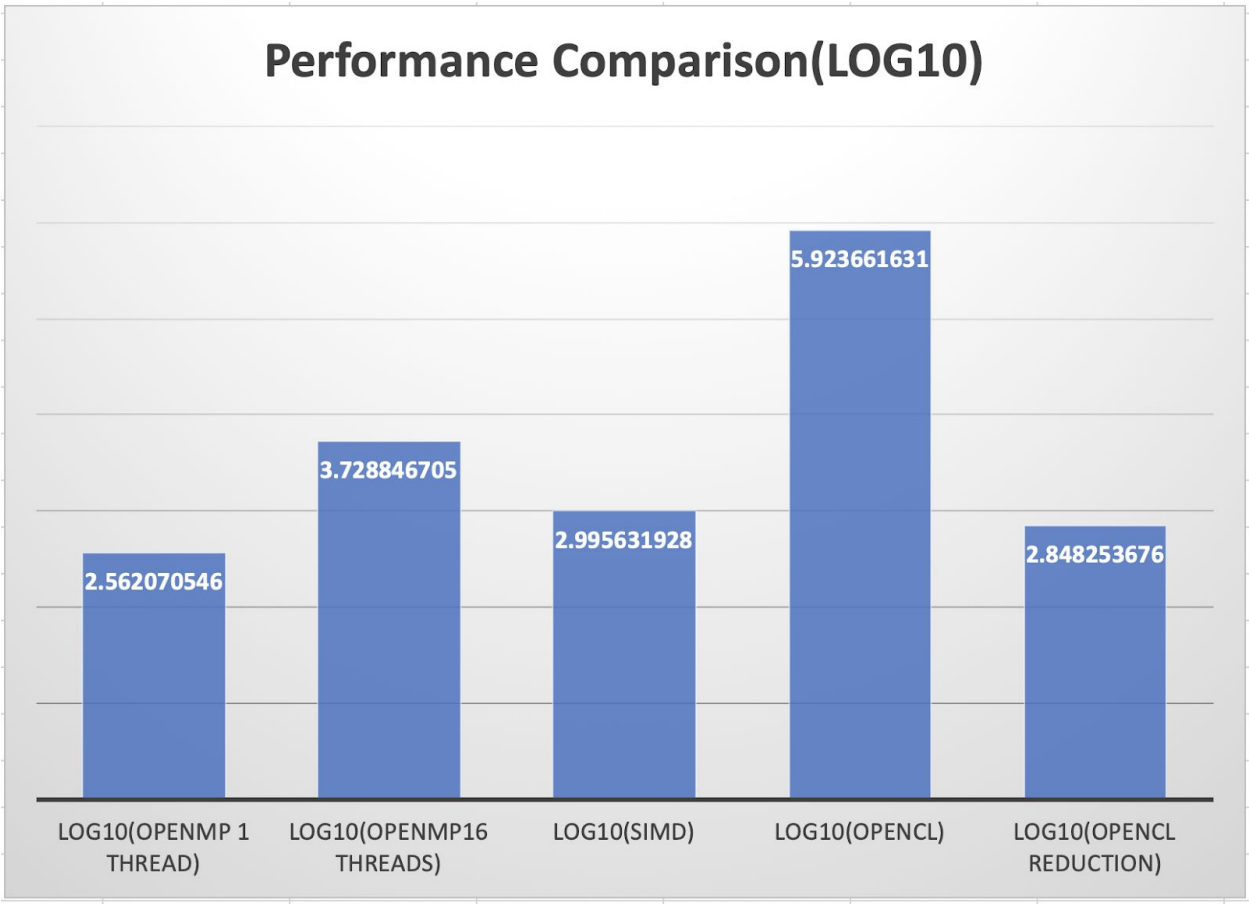
The performance results in Log10 are

Log10(Openmp 1 Thread)	Log10(Openmp16 Threads)	Log10(SIMD)	Log10(Opencl)	Log10(Opencl Reduction)
2.562070546	3.728846705	2.995631928	5.923661631	2.848253676

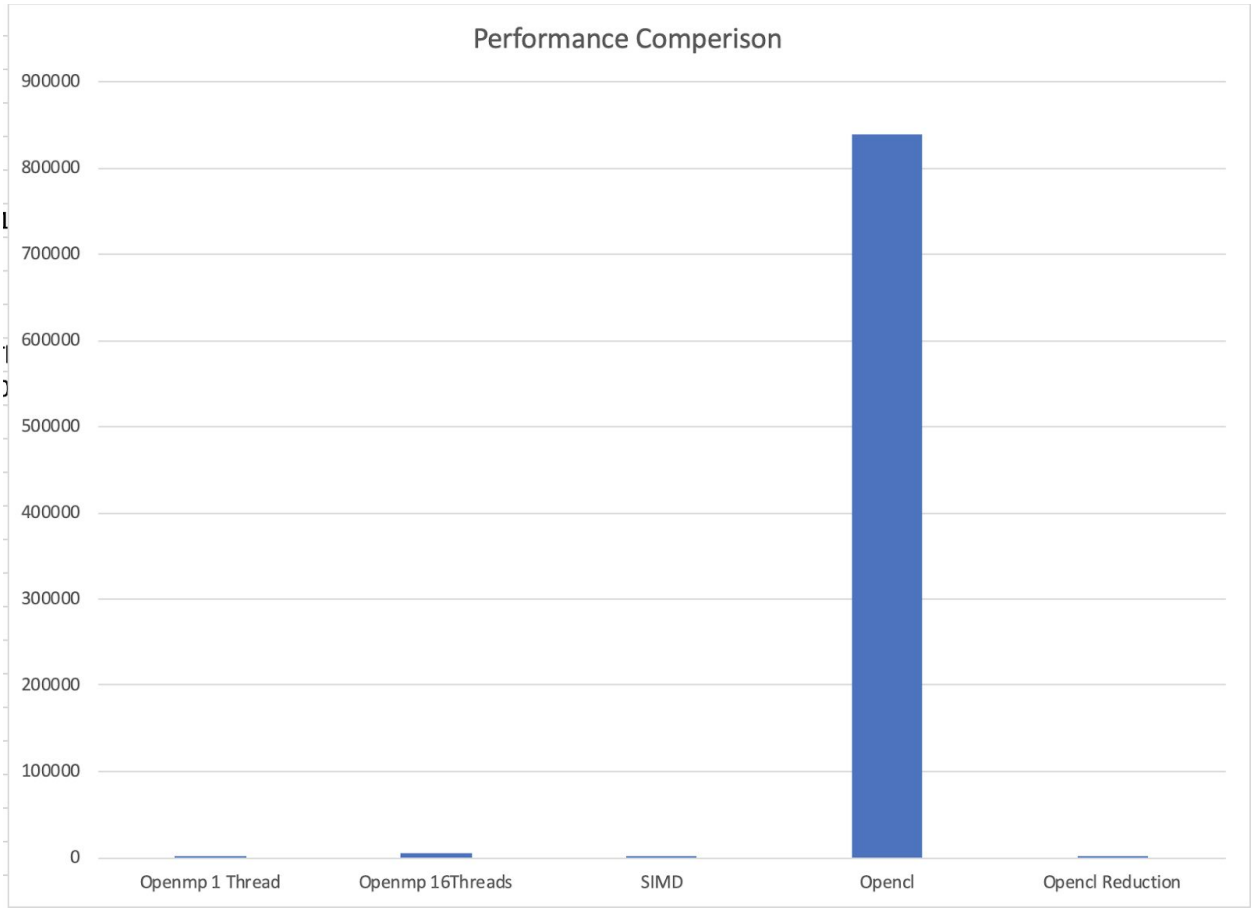
The original performance results are

Openmp 1 Thread	Openmp 16Threads	SIMD	Opencl	Opencl Reduction
364.8132019	5356.075684	989.9925537	838806.1983	705.1048079

The Performance Bar Chart with the Log10 value is



The Performance Bar Chart with the original value is



The very last result is for the OpenCL Reduction, which is not required to do for the Project 7B .

The OpenCL is the fastest. The OpenMP 16 threads is the second fastest. The SIMD is the third and the OpenMP 1 thread is fourth without considering the reduction test. The test for the GPU OpenCL is by far faster than other tests apparently. The cause is that the every calculation for the Size(32768) was done on the individual thread at the same time while the 32768 calculations are done only one after another in the OpenMP 1 thread test and the same number of calculations are done at the rate of 16 calculations at a time in the OpenMP 16 threads test,resulting in the fact that the OpenCL test would be approximately 32768 times faster than the OpenMP 1 thread test and approximately (32768/16)=2048 times faster than the OpenMP 16 threads if there was no overhead. In the same way, four float values were loaded and four calculations were done at a time in the SIMD test,which means that it would be nearly (32768/4)=8192 times slower than the OpenCL test ,(16/4)=4

times slower than the OpenMP 16 threads test and 4 times faster than the OpenMP 1 thread test if there was no overhead.

The OpenCL with Reduction test is slower than the OpenCL without reduction test. There are two reasons I can think of for this. The first is that FMA(Fused Multiply-Add) was not used in the OpenCL with Reduction while it was used in the OpenCL without Reduction. The second is that the loop for the shift is in the .cpp file CPU side and the Kernel function is in the loop, which means that the Kernel function needs to be called 32768 times to be run at the GPU side, and there might be more overhead or more data transmission time for that.