CS 475/575 -- Spring Quarter 2024
CHUN-YI, HU

Project #6

OpenCL Linear Regression

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1. **What machine you ran this on**

rabbit.engr.oregonstate.edu

Command: **cat /proc/cpuinfo | less**

```
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 63
model name      : Intel(R) Xeon(R) CPU E5-2630 v3 @ 2.40GHz
stepping        : 2
microcode       : 0x49
cpu MHz         : 1242.041
cache size      : 20480 KB
physical id     : 0
siblings        : 16
core id         : 0
cpu cores       : 8
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 15
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rd
tscp lm constant_tsc arch_perfmon pebs bts rep_good nopl xtopology nonstop_tsc aperfmperf eagerfpu pni pclmulqdq dtes64 monitor ds_cpl vmx smx est tm2 ssse3 sd
bg fma cx16 xtpr pdcm pcid dca sse4_1 sse4_2 x2apic movbe popcnt tsc_deadline_timer aes xsave avx f16c rdrand lahf_lm abm epb invpcid_single ssbd rsb_ctxsw ibr
s ibpb stibp tpr_shadow vnmi flexpriority ept vpid fsgsbase tsc_adjust bmi1 avx2 smep bmi2 erms invpcid cqm xsaveopt cqm_llc cqm_occup_llc dtherm ida arat pln
pts md_clear spec_ctrl intel_stibp flush_l1d
bogomips        : 4800.04
clflush size    : 64
cache_alignment : 64
address sizes   : 46 bits physical, 48 bits virtual
power management:
```

Command: **cat /etc/os-release**

```
rabbit ~/CS575/Project6 1009$ cat /etc/os-release
NAME="CentOS Linux"
VERSION="7 (Core)"
ID="centos"
ID_LIKE="rhel fedora"
VERSION_ID="7"
PRETTY_NAME="CentOS Linux 7 (Core)"
ANSI_COLOR="0;31"
CPE_NAME="cpe:/o:centos:centos:7"
HOME_URL="https://www.centos.org/"
BUG_REPORT_URL="https://bugs.centos.org/"

CENTOS_MANTISBT_PROJECT="CentOS-7"
CENTOS_MANTISBT_PROJECT_VERSION="7"
REDHAT_SUPPORT_PRODUCT="centos"
REDHAT_SUPPORT_PRODUCT_VERSION="7"
```

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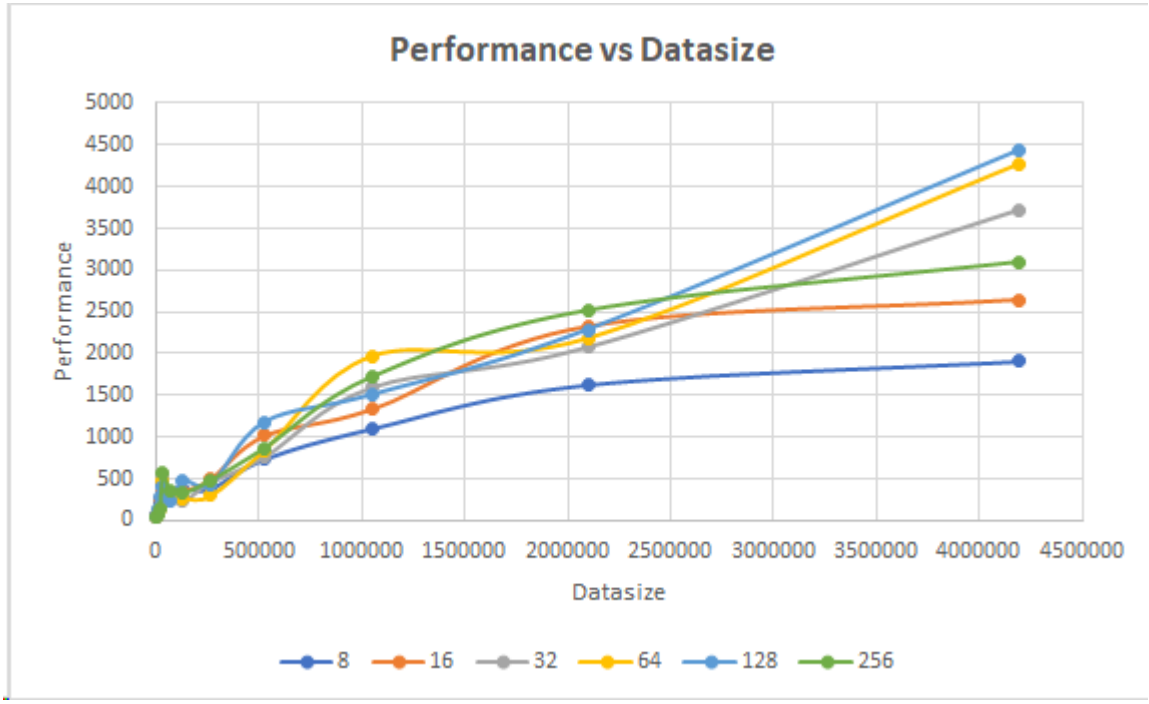
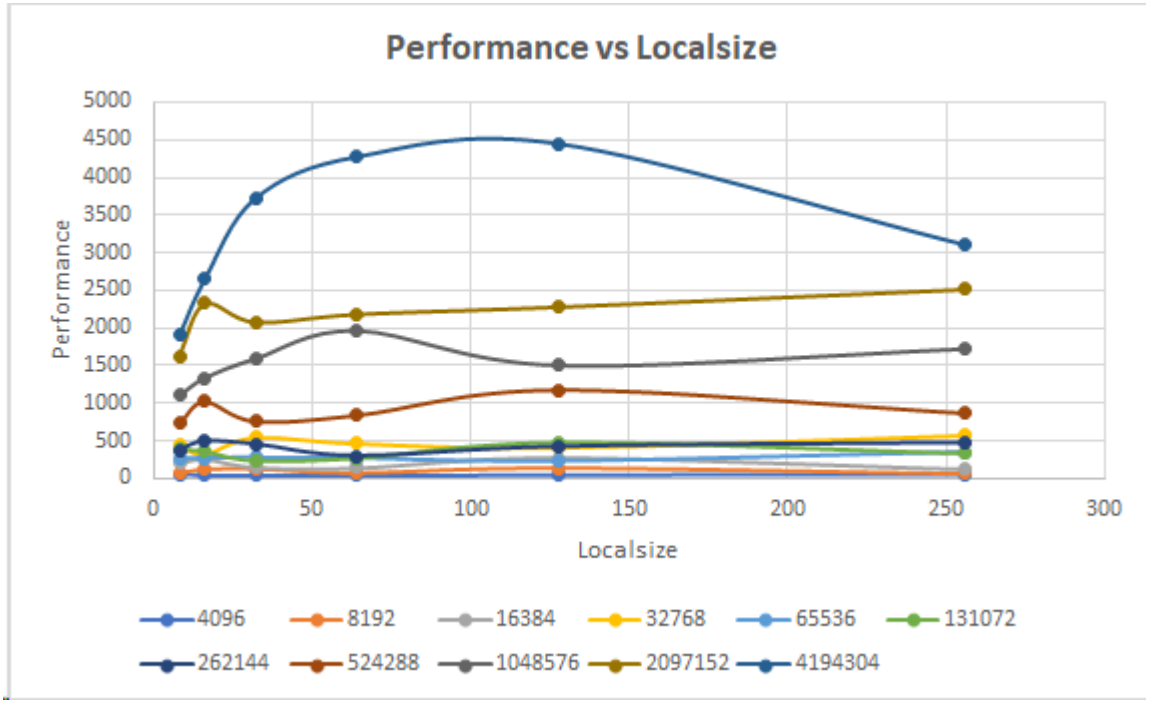
Command: **uname**

```
rabbit ~/CS575/Project6 1009$ uname
Linux
```

2. Show the table and graphs





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I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 6.99 **	
4096	8	34.93
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 6.99 **	
4096	16	50.4
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 6.99 **	
4096	32	29.23
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 6.99 **	
4096	64	40.32
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 6.99 **	
4096	128	34.45
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 6.99 **	
4096	256	69.91
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 6.99 **	
8192	8	107.11
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 6.99 **	
8192	16	83.44
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 6.99 **	
8192	32	80.6
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 6.99 **	
8192	64	84.37
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 6.99 **	
8192	128	90.92
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 6.99 **	
8192	256	98.69
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
16384	8	245.81
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	

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16384	16	149.44
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
16384	32	153.06
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
16384	64	165.31
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
16384	128	138.68
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
16384	256	133.56
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
32768	8	306.62
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
32768	16	514.31
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
32768	32	463.62
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
32768	64	300.63
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
32768	128	387.42
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
32768	256	528.41
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
65536	8	193.1
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
65536	16	253.51
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
65536	32	273.82
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU

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** m = 5.00	b = 7.00 **	
65536	64	293.84
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
65536	128	235.56
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
65536	256	244.08
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
131072	8	273.76
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
131072	16	372.46
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
131072	32	329.58
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
131072	64	365.49
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
131072	128	256.11
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
131072	256	270.09
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
262144	8	484.64
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
262144	16	350.93
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
262144	32	426.86
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
262144	64	460.81
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
262144	128	484.43

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I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
262144	256	448.71
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
524288	8	672.37
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
524288	16	862.78
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
524288	32	878.85
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
524288	64	766.38
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
524288	128	861.6
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
524288	256	924.13
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
1048576	8	917.85
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
1048576	16	1676.36
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
1048576	32	1005.95
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
1048576	64	1615.95
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
1048576	128	1718.68
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.00	b = 7.00 **	
1048576	256	1266.25
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	

2097152	8	1668.24
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
2097152	16	1909.88
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
2097152	32	2558.17
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
2097152	64	2694.49
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
2097152	128	2502.7
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
2097152	256	2647.05
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
4194304	8	1748.72
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
4194304	16	2802.35
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
4194304	32	3305.07
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
4194304	64	3130.65
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
4194304	128	3663.51
I have selected Platform #0	Device #0: Vendor = NVIDIA	Type = CL_DEVICE_TYPE_GPU
** m = 5.01	b = 7.00 **	
4194304	256	3778.95

3. **What patterns are you seeing in the performance curves? What difference does the size of data make? What difference does the size of each work-group make?**

a. The number of data is the major factor to affect the performance, however, the LocalSize can boost the performance when dealing with massive data. In addition, if the LocalSize is 32, 64, or 128, the performance causes barriers which contribute to inefficiency.
b. For the graph(Performance vs LocalSize), the performance is impacted by the number of data directly because massive data will cost more time to compute. When delving into the LocalSize, such as 32, 64, or 128, the curve indicates that the performance leads to the peak because of blocks.
c. For the graph(Performance vs Datasize), the performance is related to the number of data. When the number of data is increasing that the program spends more time to calculate, the number of LocalSize can affect the performance efficiently. However, when LocalSize is 32, 64, or 128 causing insufficient performance, the reason may be lack of the space of calculations with massive data.

4. Why do you think the patterns look this way?

The number of data is the key factor to affect the performance because the memory has the limited space that is unable to compute a tremendous work-group of data at a short time. On the other hand, LocalSize can create barriers to drop down the performance when it reaches specific numbers. However, in this project, the performance has been boosted through GPU's computing instead of CPUs, so GPU has different units and logic of calculations that leads to the development. Undoubtedly, synchronization is also an indispensable characteristic to impact the performance while calculating.