CS3450
Kevin Paganini
3/7/2023
Lab 1: Predicting Runtimes

Predict Relative Runtime from GPU Specs

The NVIDIA V100 has a nominal double-precision throughput of 16.4 single-precision (float) TFLOPS. (floating point operations per second). The T4 has a throughput of 8.1 single-precision. In your report, record what ratio you expect between the times these two systems will take to train a neural network. Briefly explain your reasoning. Assume that only one GPU is used on each node. I don't know of an authoritative source defining what counts as a FLOP, but this Stack Overflow answer has the ring of truth for me (Dr. Yoder).

FLOPs amount of time it takes to do one addition and multiplication.

Answer: Since the V100 has double the throughput as the T4, I would expect it to be able to train roughly doubly as fast.

Experimentally Determine the Runtime from Running One Epoch

T4 Node two CPUs:
Job 107186: 24.4 minutes

```
paganinik@dh-mgmt2:~$ tail -f slurm-107186.out
Processing batch: 1-157
loss_D 0.619, loss_G 1.373, 27.7 examples/sec on cpu (40448.0 examples in 1460.2 seconds during this epoch)
Processing batch: 1-158
loss_D 0.620, loss_G 1.373, 27.7 examples/sec on cpu (40597.0 examples in 1465.4 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.620, loss_G 1.373, 1465.8 sec/epoch on cpu
Num epochs: 1
Total training time: 1465.8 seconds
Started at: Tue, 07 Mar 2023 20:29:42 local
Ended at: Tue, 07 Mar 2023 20:54:08 local
```

T4 Node 16 CPUs:
Job 107482: 512 seconds

```
paganinik@dh-mgmt2:~$ tail -f slurm-107482.out
Processing batch: 1-157
loss_D 0.651, loss_G 1.184, 79.2 examples/sec on cpu (40448.0 examples in 510.5 seconds during this epoch)
Processing batch: 1-158
loss_D 0.651, loss_G 1.190, 79.3 examples/sec on cpu (40597.0 examples in 512.2 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.651, loss_G 1.190, 512.5 sec/epoch on cpu
Num epochs: 1
Total training time: 512.5 seconds
Started at: Thu, 09 Mar 2023 11:33:06 local
Ended at: Thu, 09 Mar 2023 11:41:39 local
```

T4 Node with GPU and eight CPUs

Job 107456: 86 seconds

```
paganinik@dh-mgmt2:~$ tail -f slurm-107456.out
Processing batch: 1-157
loss_D 0.631, loss_G 1.335, 474.0 examples/sec on cuda:0 (40448.0 examples in 85.3 seconds during this epoch)
Processing batch: 1-158
loss_D 0.630, loss_G 1.332, 473.7 examples/sec on cuda:0 (40597.0 examples in 85.7 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.630, loss_G 1.332, 86.0 sec/epoch on cuda:0
Num epochs: 1
Total training time: 86.0 seconds
Started at: Thu, 09 Mar 2023 11:27:09 local
Ended at: Thu, 09 Mar 2023 11:28:35 local
```

Running on a DGX Node with a GPU (and eight CPUs)

Job 107474: 36.8 seconds

```
paganinik@dh-mgmt2:~$ tail -f slurm-107474.out
Processing batch: 1-157
loss_D 0.638, loss_G 1.304, 1114.7 examples/sec on cuda:0 (40448.0 examples in 36.3 seconds during this epoch)
Processing batch: 1-158
loss_D 0.638, loss_G 1.303, 1116.0 examples/sec on cuda:0 (40597.0 examples in 36.4 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.638, loss_G 1.303, 36.8 sec/epoch on cuda:0
Num epochs: 1
Total training time: 36.8 seconds
Started at: Thu, 09 Mar 2023 10:31:04 local
Ended at: Thu, 09 Mar 2023 10:31:41 local
```

Predict the Runtime for 20 epochs

T4 Node two CPUs: 8.1 hours

T4 Node 16 CPUs: 2.85 hours

T4 Node with GPU (and eight CPUs): 28.67 minutes

Running on a DGX Node with a GPU (and eight CPUs): 12.3 minutes

Experimentally Determine the Runtime from Running 20 Epochs

T4 Node two CPUs: 8.8 hours

Job 107507:

```
paganinik@dh-mgmt2:~$ tail -f slurm-107507.out
Processing batch: 20-157
loss_D 0.021, loss_G 7.409, 27.7 examples/sec on cpu (40448.0 examples in 1459.6 seconds during this epoch)
Processing batch: 20-158
loss_D 0.021, loss_G 7.410, 27.7 examples/sec on cpu (40597.0 examples in 1464.8 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.021, loss_G 7.410, 1582.5 sec/epoch on cpu
Num epochs: 20
Total training time: 31650.5 seconds
Started at: Thu, 09 Mar 2023 11:47:20 local
Ended at: Thu, 09 Mar 2023 20:34:50 local
```

T4 Node 16 CPUs: 3.25 hours

Job 107643:

```
paganinik@dh-mgmt2:~$ tail -f slurm-107643.out
Processing batch: 20-157
loss_D 0.034, loss_G 7.003, 70.8 examples/sec on cpu (40448.0 examples in 571.4 seconds during this epoch)
Processing batch: 20-158
loss_D 0.034, loss_G 7.007, 70.8 examples/sec on cpu (40597.0 examples in 573.3 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.034, loss_G 7.007, 583.7 sec/epoch on cpu
Num epochs: 20
Total training time: 11675.0 seconds
Started at: Thu, 09 Mar 2023 12:27:21 local
Ended at: Thu, 09 Mar 2023 15:41:56 local
```

T4 Node with GPU (and eight CPUs): 25.75 minutes

Job 107522:

```
paganinik@dh-mgmt2:~$ tail -f slurm-107522.out
Processing batch: 20-157
loss_D 0.020, loss_G 7.718, 532.6 examples/sec on cuda:0 (40448.0 examples in 75.9 seconds during this epoch)
Processing batch: 20-158
loss_D 0.021, loss_G 7.719, 532.1 examples/sec on cuda:0 (40597.0 examples in 76.3 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.021, loss_G 7.719, 77.3 sec/epoch on cuda:0
Num epochs: 20
Total training time: 1546.3 seconds
Started at: Thu, 09 Mar 2023 12:01:53 local
Ended at: Thu, 09 Mar 2023 12:27:39 local
```

Running on a DGX Node with a GPU (and eight CPUs): 10.8 minutes

Job 107524:

```
paganinik@dh-mgmt2:~$ tail -f slurm-107524.out
Processing batch: 20-157
loss_D 0.068, loss_G 6.594, 1444.9 examples/sec on cuda:0 (40448.0 examples in 28.0 seconds during this epoch)
Processing batch: 20-158
loss_D 0.068, loss_G 6.594, 1445.5 examples/sec on cuda:0 (40597.0 examples in 28.1 seconds during this epoch)
<Figure size 500x500 with 2 Axes>
loss_D 0.068, loss_G 6.594, 32.6 sec/epoch on cuda:0
Num epochs: 20
Total training time: 652.9 seconds
Started at: Thu, 09 Mar 2023 11:02:03 local
Ended at: Thu, 09 Mar 2023 11:12:56 local
```

Full table of runtimes:

Epochs	2 CPUs	16 CPUs	T4 + 8 CPUs	V100 + 8 CPUs
1	24.4 minutes	8.5 minutes	86 seconds	36.8 seconds
20 (predicted)	8.1 hours	2.85 hours	28.67 minutes	12.3 minutes
20 (actual)	8.8 hours (26.4 minutes per epoch)	3.25 hours (9.75 minutes per epoch)	25.75 minutes (1.3 minutes per epoch)	10.8 minutes (32.65 seconds per epoch)

Discussion

Include a concluding discussion in your report. How closely did your predictions match the reality? Explain any differences. Also, be sure to discuss how the relative speed between the DGX and the T4 compared with your predictions.

I predicted that the V100 would roughly be double as fast as the T4. The actual ratio experimentally found is T4 / V100 = 86 seconds / 36.8 seconds = 2.34, (25.75 / 10.8 = 2.38). So, the experimentally found relative training time is actually slower (in terms of the T4) than what was predicted. This is most likely due to other processes running on the teaching node whilst I was running my experiment. If all things were held equal for both the T4 and V100, I believe that the ratio of training times would be closer to 2.

Both the training sessions that only used CPU's took longer than I anticipated. Both training sessions using GPU's took shorter than expected. I think part of the reason why the CPU jobs took longer than expected is because both of them ran for longer, so they probably started running into traffic from other users. The GPU jobs ran for a lot shorter so they had a lot less chance to run into network traffic. Even though the estimates weren't exact they would all be very good to use when trying to provide a ball park estimate for a training session, with a certain number of epochs.