```
C:\Users\Marko\anaconda3\python.exe C:/Users/Marko/Desktop/PSIML2022/graph-transformer-psiml/main.py
wandb: Currently logged in as: njmarko. Use `wandb login --relogin` to force relogin
wandb: Tracking run with wandb version 0.13.1
wandb: Run data is saved locally in C:\Users\Marko\Desktop\PSIML2022\graph-transformer-psiml\wandb\run-20220808_022452-pp98c6v4
wandb: Run `wandb offline` to turn off syncing.
wandb: Syncing run crisp-yogurt-1
wandb:  View project at https://wandb.ai/njmarko/MNIST
wandb:  View run at https://wandb.ai/njmarko/MNIST/runs/pp98c6v4
Epoch: 1
[    0/50000 (  0%)]  Loss: 2.3753
Execution time: 4.225025415420532
[25000/50000 ( 50%)]  Loss: 0.9496
Execution time: 107.98920750617981
Accuracy: 62.34%

Average validation loss: 0.3280  Accuracy: 8998/10000 (89.98%)

Epoch: 2
[    0/50000 (  0%)]  Loss: 0.3133
Execution time: 1.3070425987243652
[25000/50000 ( 50%)]  Loss: 0.2864
```

```
22 Execution time: 119.99837470054626
23 Accuracy: 92.10%
24
25 Average validation loss: 0.2250  Accuracy
   : 9312/10000 (93.12%)
26
27 Epoch: 3
28 [    0/50000 (  0%)]  Loss: 0.1972
29 Execution time: 1.141212249603271
30 [25000/50000 ( 50%)]  Loss: 0.2174
31 Execution time: 106.35244297981262
32 Accuracy: 94.50%
33
34 Average validation loss: 0.1433  Accuracy
   : 9567/10000 (95.67%)
35
36 Epoch: 4
37 [    0/50000 (  0%)]  Loss: 0.1702
38 Execution time: 1.1261963844299316
39 [25000/50000 ( 50%)]  Loss: 0.2600
40 Execution time: 110.64022064208984
41 Accuracy: 95.62%
42
43 Average validation loss: 0.1315  Accuracy
   : 9606/10000 (96.06%)
44
45 Epoch: 5
46 [    0/50000 (  0%)]  Loss: 0.1531
47 Execution time: 1.1753606796264648
48 [25000/50000 ( 50%)]  Loss: 0.2116
49 Execution time: 106.17156934738159
50 Accuracy: 96.27%
51
```

```
52 Average validation loss: 0.1302  Accuracy
   : 9582/10000 (95.82%)
53
54 Epoch: 6
55 [    0/50000 (  0%)]  Loss: 0.1679
56 Execution time: 1.121169090270996
57 [25000/50000 ( 50%)]  Loss: 0.1241
58 Execution time: 106.16841983795166
59 Accuracy: 96.82%
60
61 Average validation loss: 0.1009  Accuracy
   : 9702/10000 (97.02%)
62
63 Epoch: 7
64 [    0/50000 (  0%)]  Loss: 0.0462
65 Execution time: 1.178670883178711
66 [25000/50000 ( 50%)]  Loss: 0.0663
67 Execution time: 106.10663628578186
68 Accuracy: 97.72%
69
70 Average validation loss: 0.0836  Accuracy
   : 9751/10000 (97.51%)
71
72 Epoch: 8
73 [    0/50000 (  0%)]  Loss: 0.0235
74 Execution time: 1.156041622161865 2
75 [25000/50000 ( 50%)]  Loss: 0.0617
76 Execution time: 105.86152267456055
77 Accuracy: 98.24%
78
79 Average validation loss: 0.0855  Accuracy
   : 9757/10000 (97.57%)
80
```

```
Epoch: 9
[    0/50000 (  0%)]  Loss: 0.0642
Execution time: 1.1696171760559082
[25000/50000 ( 50%)]  Loss: 0.0264
Execution time: 106.55971670150757
Accuracy: 98.66%

Average validation loss: 0.0709  Accuracy: 9801/10000 (98.01%)

Epoch: 10
[    0/50000 (  0%)]  Loss: 0.0445
Execution time: 1.1109998226165771
[25000/50000 ( 50%)]  Loss: 0.0161
Execution time: 105.75596165657043
Accuracy: 99.17%

Average validation loss: 0.0662  Accuracy: 9829/10000 (98.29%)

Epoch: 11
[    0/50000 (  0%)]  Loss: 0.0074
Execution time: 1.120924472808838
[25000/50000 ( 50%)]  Loss: 0.0138
Execution time: 106.46969032287598
Accuracy: 99.20%

Average validation loss: 0.0749  Accuracy: 9807/10000 (98.07%)

Epoch: 12
[    0/50000 (  0%)]  Loss: 0.0343
Execution time: 1.285039424896240
```

```
111 [25000/50000 ( 50%)]  Loss: 0.0232
112 Execution time: 106.1396918296814
113 Accuracy: 98.83%
114
115 Average validation loss: 0.0843  Accuracy
    : 9771/10000 (97.71%)
116
117 Epoch: 13
118 [    0/50000 (  0%)]  Loss: 0.0194
119 Execution time: 1.17995285987854
120 [25000/50000 ( 50%)]  Loss: 0.0547
121 Execution time: 106.7394151687622
122 Accuracy: 98.23%
123
124 Average validation loss: 0.0879  Accuracy
    : 9734/10000 (97.34%)
125
126 Epoch: 14
127 [    0/50000 (  0%)]  Loss: 0.0622
128 Execution time: 1.0866062641143799
129 [25000/50000 ( 50%)]  Loss: 0.0326
130 Execution time: 105.96093511581421
131 Accuracy: 98.17%
132
133 Average validation loss: 0.1065  Accuracy
    : 9703/10000 (97.03%)
134
135 Epoch: 15
136 [    0/50000 (  0%)]  Loss: 0.0628
137 Execution time: 1.115727424621582
138 [25000/50000 ( 50%)]  Loss: 0.0862
139 Execution time: 105.45809078216553
140 Accuracy: 97.94%
```

```
141
142 Average validation loss: 0.1036  Accuracy
    : 9696/10000 (96.96%)
143
144 Epoch: 16
145 [    0/50000 (  0%)]  Loss: 0.0609
146 Execution time: 1.2929949760437012
147 [25000/50000 ( 50%)]  Loss: 0.0510
148 Execution time: 133.53248929977417
149 Accuracy: 98.24%
150
151 Average validation loss: 0.0955  Accuracy
    : 9741/10000 (97.41%)
152
153 Epoch: 17
154 [    0/50000 (  0%)]  Loss: 0.0433
155 Execution time: 1.2101540565490723
156 [25000/50000 ( 50%)]  Loss: 0.0334
157 Execution time: 105.49013686180115
158 Accuracy: 98.68%
159
160 Average validation loss: 0.0771  Accuracy
    : 9796/10000 (97.96%)
161
162 Epoch: 18
163 [    0/50000 (  0%)]  Loss: 0.0396
164 Execution time: 1.1893651485443115
165 [25000/50000 ( 50%)]  Loss: 0.0431
166 Execution time: 109.78957676887512
167 Accuracy: 99.24%
168
169 Average validation loss: 0.0640  Accuracy
    : 9836/10000 (98.36%)
```

```
170
171 Epoch: 19
172 [    0/50000 (  0%)]  Loss: 0.0136
173 Execution time: 1.1782257556915283
174 [25000/50000 ( 50%)]  Loss: 0.0127
175 Execution time: 105.99137473106384
176 Accuracy: 99.54%
177
178 Average validation loss: 0.0670  Accuracy
    : 9841/10000 (98.41%)
179
180 Epoch: 20
181 [    0/50000 (  0%)]  Loss: 0.0061
182 Execution time: 1.1189544200897217
183 [25000/50000 ( 50%)]  Loss: 0.0017
184 Execution time: 105.99375343322754
185 Accuracy: 99.80%
186
187 Average validation loss: 0.0631  Accuracy
    : 9851/10000 (98.51%)
188
189 Epoch: 21
190 [    0/50000 (  0%)]  Loss: 0.0027
191 Execution time: 1.1629595756530762
192 [25000/50000 ( 50%)]  Loss: 0.0050
193 Execution time: 106.12245202064514
194 Accuracy: 99.84%
195
196 Average validation loss: 0.0661  Accuracy
    : 9852/10000 (98.52%)
197
198 Epoch: 22
199 [    0/50000 (  0%)]  Loss: 0.0025
```

```
200 Execution time: 1.1716349124908447
201 [25000/50000 ( 50%)]  Loss: 0.0017
202 Execution time: 105.9075813293457
203 Accuracy: 99.58%
204
205 Average validation loss: 0.0804  Accuracy
    : 9812/10000 (98.12%)
206
207 Epoch: 23
208 [    0/50000 (  0%)]  Loss: 0.0470
209 Execution time: 1.128035068511963
210 [25000/50000 ( 50%)]  Loss: 0.0368
211 Execution time: 106.07592582702637
212 Accuracy: 98.88%
213
214 Average validation loss: 0.1218  Accuracy
    : 9695/10000 (96.95%)
215
216 Epoch: 24
217 [    0/50000 (  0%)]  Loss: 0.0794
218 Execution time: 1.124781847000122
219 [25000/50000 ( 50%)]  Loss: 0.0647
220 Execution time: 106.00075149536133
221 Accuracy: 98.51%
222
223 Average validation loss: 0.1011  Accuracy
    : 9729/10000 (97.29%)
224
225 Epoch: 25
226 [    0/50000 (  0%)]  Loss: 0.0429
227 Execution time: 1.2182452678680 42
228 [25000/50000 ( 50%)]  Loss: 0.0274
229 Execution time: 105.89058256149292
```

```
230 Accuracy: 98.54%
231
232 Average validation loss: 0.0960  Accuracy
    : 9759/10000 (97.59%)
233
234 Epoch: 26
235 [    0/50000 (  0%)]  Loss: 0.0774
236 Execution time: 1.147000789642334
237 [25000/50000 ( 50%)]  Loss: 0.0563
238 Execution time: 105.52384305000305
239 Accuracy: 98.56%
240
241 Average validation loss: 0.0844  Accuracy
    : 9762/10000 (97.62%)
242
243 Epoch: 27
244 [    0/50000 (  0%)]  Loss: 0.0031
245 Execution time: 1.118954420089721 7
246 [25000/50000 ( 50%)]  Loss: 0.0397
247 Execution time: 106.5278263092041
248 Accuracy: 99.29%
249
250 Average validation loss: 0.0759  Accuracy
    : 9817/10000 (98.17%)
251
252 Epoch: 28
253 [    0/50000 (  0%)]  Loss: 0.0019
254 Execution time: 1.1811494827270508
255 [25000/50000 ( 50%)]  Loss: 0.0347
256 Execution time: 105.52149319648743
257 Accuracy: 99.51%
258
259 Average validation loss: 0.0650  Accuracy
```

```
259 : 9860/10000 (98.60%)
260
261 Epoch: 29
262 [    0/50000 (  0%)]  Loss: 0.0259
263 Execution time: 1.0980074405670166
264 [25000/50000 ( 50%)]  Loss: 0.0157
265 Execution time: 105.85231065750122
266 Accuracy: 99.80%
267
268 Average validation loss: 0.0609  Accuracy
    : 9873/10000 (98.73%)
269
270 Epoch: 30
271 [    0/50000 (  0%)]  Loss: 0.0287
272 Execution time: 1.1186399459838867
273 [25000/50000 ( 50%)]  Loss: 0.0089
274 Execution time: 110.23469090461731
275 Accuracy: 99.91%
276
277 Average validation loss: 0.0632  Accuracy
    : 9878/10000 (98.78%)
278
279 Epoch: 31
280 [    0/50000 (  0%)]  Loss: 0.0035
281 Execution time: 1.1879081726074219
282 [25000/50000 ( 50%)]  Loss: 0.0016
283 Execution time: 106.32115960121155
284 Accuracy: 99.95%
285
286 Average validation loss: 0.0641  Accuracy
    : 9865/10000 (98.65%)
287
288 Epoch: 32
```

```
289 [    0/50000 (  0%)]  Loss: 0.0007
290 Execution time: 1.1090083122253418
291 [25000/50000 ( 50%)]  Loss: 0.0005
292 Execution time: 106.60549187660217
293 Accuracy: 99.91%
294
295 Average validation loss: 0.0773  Accuracy
    : 9836/10000 (98.36%)
296
297 Epoch: 33
298 [    0/50000 (  0%)]  Loss: 0.0165
299 Execution time: 1.187152624130249
300 [25000/50000 ( 50%)]  Loss: 0.0281
301 Execution time: 106.91513681411743
302 Accuracy: 99.13%
303
304 Average validation loss: 0.0911  Accuracy
    : 9776/10000 (97.76%)
305
306 Epoch: 34
307 [    0/50000 (  0%)]  Loss: 0.0286
308 Execution time: 1.0720467567443848
309 [25000/50000 ( 50%)]  Loss: 0.0130
310 Execution time: 106.26481056213379
311 Accuracy: 98.88%
312
313 Average validation loss: 0.0883  Accuracy
    : 9776/10000 (97.76%)
314
315 Epoch: 35
316 [    0/50000 (  0%)]  Loss: 0.0125
317 Execution time: 1.1035544872283936
318 [25000/50000 ( 50%)]  Loss: 0.0501
```

```
319 Execution time: 105.97989130020142
320 Accuracy: 98.60%
321
322 Average validation loss: 0.1036  Accuracy
    : 9724/10000 (97.24%)
323
324 Epoch: 36
325 [    0/50000 (  0%)]  Loss: 0.0602
326 Execution time: 1.157832384109497
327 [25000/50000 ( 50%)]  Loss: 0.0195
328 Execution time: 106.54508709907532
329 Accuracy: 98.86%
330
331 Average validation loss: 0.0760  Accuracy
    : 9824/10000 (98.24%)
332
333 Epoch: 37
334 [    0/50000 (  0%)]  Loss: 0.0285
335 Execution time: 1.1124558448791504
336 [25000/50000 ( 50%)]  Loss: 0.0137
337 Execution time: 106.50986933708191
338 Accuracy: 99.39%
339
340 Average validation loss: 0.0838  Accuracy
    : 9809/10000 (98.09%)
341
342 Epoch: 38
343 [    0/50000 (  0%)]  Loss: 0.0300
344 Execution time: 1.1400096416473389
345 [25000/50000 ( 50%)]  Loss: 0.0049
346 Execution time: 106.10755467414856
347 Accuracy: 99.60%
348
```

```
Average validation loss: 0.0729  Accuracy: 9847/10000 (98.47%)

Epoch: 39
[    0/50000 (  0%)]  Loss: 0.0004
Execution time: 1.1086740493774414
[25000/50000 ( 50%)]  Loss: 0.0013
Execution time: 107.03735303878784
Accuracy: 99.85%

Average validation loss: 0.0665  Accuracy: 9862/10000 (98.62%)

Epoch: 40
[    0/50000 (  0%)]  Loss: 0.0010
Execution time: 1.1129989624023438
[25000/50000 ( 50%)]  Loss: 0.0035
Execution time: 106.19556021690369
Accuracy: 99.92%

Average validation loss: 0.0656  Accuracy: 9864/10000 (98.64%)

Epoch: 41
[    0/50000 (  0%)]  Loss: 0.0001
Execution time: 1.107642412185669
[25000/50000 ( 50%)]  Loss: 0.0006
Execution time: 106.08087611198425
Accuracy: 99.95%

Average validation loss: 0.0666  Accuracy: 9866/10000 (98.66%)

```

```
Epoch: 42
[    0/50000 (  0%)]  Loss: 0.0003
Execution time: 1.1359994411468506
[25000/50000 ( 50%)]  Loss: 0.0044
Execution time: 106.22545123100281
Accuracy: 99.93%

Average validation loss: 0.0770  Accuracy: 9852/10000 (98.52%)

Epoch: 43
[    0/50000 (  0%)]  Loss: 0.0225
Execution time: 1.0939967632293701
[25000/50000 ( 50%)]  Loss: 0.0041
Execution time: 106.1336658000946
Accuracy: 99.42%

Average validation loss: 0.0984  Accuracy: 9795/10000 (97.95%)

Epoch: 44
[    0/50000 (  0%)]  Loss: 0.0215
Execution time: 1.1483302116394043
[25000/50000 ( 50%)]  Loss: 0.0046
Execution time: 107.61529183387756
Accuracy: 99.07%

Average validation loss: 0.0902  Accuracy: 9795/10000 (97.95%)

Epoch: 45
[    0/50000 (  0%)]  Loss: 0.0272
Execution time: 1.1599979400634766
```

```
408 [25000/50000 ( 50%)]  Loss: 0.0061
409 Execution time: 106.82790994644165
410 Accuracy: 98.89%
411
412 Average validation loss: 0.0926  Accuracy
    : 9785/10000 (97.85%)
413
414 Epoch: 46
415 [    0/50000 (  0%)]  Loss: 0.0339
416 Execution time: 1.1077518463134766
417 [25000/50000 ( 50%)]  Loss: 0.0255
418 Execution time: 109.9880599975586
419 Accuracy: 98.96%
420
421 Average validation loss: 0.0907  Accuracy
    : 9783/10000 (97.83%)
422
423 Epoch: 47
424 [    0/50000 (  0%)]  Loss: 0.0416
425 Execution time: 1.131248950958252
426 [25000/50000 ( 50%)]  Loss: 0.0111
427 Execution time: 105.91382622718811
428 Accuracy: 99.43%
429
430 Average validation loss: 0.0670  Accuracy
    : 9852/10000 (98.52%)
431
432 Epoch: 48
433 [    0/50000 (  0%)]  Loss: 0.0022
434 Execution time: 1.1659996509552002
435 [25000/50000 ( 50%)]  Loss: 0.0150
436 Execution time: 106.64353156089783
437 Accuracy: 99.78%
```

```
438
439 Average validation loss: 0.0702  Accuracy
    : 9853/10000 (98.53%)
440
441 Epoch: 49
442 [    0/50000 (  0%)]  Loss: 0.0077
443 Execution time: 1.1149213314056396
444 [25000/50000 ( 50%)]  Loss: 0.0005
445 Execution time: 106.27554154396057
446 Accuracy: 99.91%
447
448 Average validation loss: 0.0707  Accuracy
    : 9870/10000 (98.70%)
449
450 Epoch: 50
451 [    0/50000 (  0%)]  Loss: 0.0006
452 Execution time: 1.1358489990234375
453 [25000/50000 ( 50%)]  Loss: 0.0011
454 Execution time: 106.13030409812927
455 Accuracy: 99.94%
456
457 Average validation loss: 0.0694  Accuracy
    : 9875/10000 (98.75%)
458
459 models/MNIST-gat/train-MNIST-30-acc98.
    77999877929688
460
461 Test loss: 0.0535  Accuracy: 9872/10000 (
    98.72%)  Precision: 0.99  Recall: 0.99
462
463 Confusion matrix:
464  [[ 975    1    1    0    0    0    1
    1    1    0]
```

```
465  [   0 1132    1    0    0    0    1    1
       0    0]
466  [   2    0 1021    1    2    0    0    4
       2    0]
467  [   0    0    2  994    0    5    0    4
       2    3]
468  [   2    0    0    0  968    0    4    1
       1    6]
469  [   1    0    0   10    0  873    3    1
       2    2]
470  [   6    2    2    1    4    0  942    0
       1    0]
471  [   0    3    7    1    0    0    0 1013
       1    3]
472  [   2    0    2    1    1    2    1    1
     961    3]
473  [   2    2    0    3    5    1    0    3
       0  993]]
474 Execution time: 12747.21 seconds
475 wandb: Waiting for W&B process to finish
    ... (success).
476 wandb
    :

477 wandb:
478 wandb: Run history:
479 wandb: train_accuracy
    ▁▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇
480 wandb: train_f1_score
    ▁▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇▇
481 wandb:     train_loss
    ▇▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁
482 wandb:   val_accuracy
```

wandb: val_f1_score

wandb: val_loss

```
wandb:
wandb: Run summary:
wandb: train_accuracy 99.94199
wandb: train_f1_score 1.0
wandb:     train_loss 0.00114
wandb:   val_accuracy 98.75
wandb:   val_f1_score 0.9875
wandb:       val_loss 11.80244
wandb:
wandb: Synced crisp-yogurt-1: https://
    wandb.ai/njmarko/MNIST/runs/pp98c6v4
wandb: Synced 6 W&B file(s), 0 media file
    (s), 0 artifact file(s) and 0 other file(
    s)
wandb: Find logs at: .\wandb\run-
    20220808_022452-pp98c6v4\logs

Process finished with exit code 0
```