Problem 4

October 9, 2021

```python
[33]: import torch
      from torch.autograd import Variable
      import torch.nn as nn
      import torch.nn.functional as F

      import torch.optim as optim
      import matplotlib.pyplot as plt

      class Net(nn.Module):
          def __init__(self):
              super(Net, self).__init__()
              self.fc1 = nn.Linear(2,1,bias=False)
          def forward(self, x):
              x = self.fc1(x)
              return x

      net = Net()
      print(net)


      net.fc1.weight = torch.nn.Parameter(torch.tensor([[1., -1.]],
       →requires_grad=True))

      print(list(net.parameters()))

      #input = torch.randn(1,2)
      #out = net(input)


      criterion = nn.MSELoss()
      #def criterion(out, label):
      #    return ((label - out)**2).mean()


      #optimizer = optim.SGD(net.parameters(), lr=0.01, momentum=0.5)
      optimizer = optim.Adam(net.parameters(), lr=0.005)
```

```python
data = torch.tensor([[1.,3.], [2.,6.], [3.,9.]], dtype=torch.float)
target = torch.tensor([[1.],[5.],[13.]], dtype=torch.float)

hist = []


############## Batch GD based update ##############

#for epoch in range(300):
#    optimizer.zero_grad()
#    outputs = net(data)
#    loss = criterion(outputs, target)
#    loss.backward()
#    hist.append(loss)
#    optimizer.step()
#    print("Epoch {} - loss: {}".format(epoch, loss))
##################################################

for epoch in range(300):
    for i, current_data in enumerate(data):
        output = net(current_data)
        loss = criterion(output, target[i])
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()
        #print(i, loss, output, target[i])
        hist.append(loss)
        if (i == 2):
            print("Epoch {} - loss: {}".format(epoch, loss))

### Test the trained network ###
for i, current_data in enumerate(data):
    out = net(current_data)
    print("when x = {}, y = {}".format(current_data, out))

plt.plot(hist, label = "training curve")
```

```
Net(
  (fc1): Linear(in_features=2, out_features=1, bias=False)
)
[Parameter containing:
tensor([[ 1., -1.]], requires_grad=True)]
Epoch 0 - loss: 356.80670166015625
Epoch 1 - loss: 351.81201171875
Epoch 2 - loss: 346.75982666015625
Epoch 3 - loss: 341.71527099609375
Epoch 4 - loss: 336.7008972167969
```

```
Epoch 5 - loss: 331.7275085449219
Epoch 6 - loss: 326.8012390136719
Epoch 7 - loss: 321.9257507324219
Epoch 8 - loss: 317.10369873046875
Epoch 9 - loss: 312.3365478515625
Epoch 10 - loss: 307.6254577636719
Epoch 11 - loss: 302.9710998535156
Epoch 12 - loss: 298.3736877441406
Epoch 13 - loss: 293.83331298828125
Epoch 14 - loss: 289.35003662109375
Epoch 15 - loss: 284.9236145019531
Epoch 16 - loss: 280.5536804199219
Epoch 17 - loss: 276.2398986816406
Epoch 18 - loss: 271.98187255859375
Epoch 19 - loss: 267.7790832519531
Epoch 20 - loss: 263.631103515625
Epoch 21 - loss: 259.53741455078125
Epoch 22 - loss: 255.49746704101562
Epoch 23 - loss: 251.51075744628906
Epoch 24 - loss: 247.57679748535156
Epoch 25 - loss: 243.69503784179688
Epoch 26 - loss: 239.86492919921875
Epoch 27 - loss: 236.08596801757812
Epoch 28 - loss: 232.35768127441406
Epoch 29 - loss: 228.6794891357422
Epoch 30 - loss: 225.05093383789062
Epoch 31 - loss: 221.4714813232422
Epoch 32 - loss: 217.94061279296875
Epoch 33 - loss: 214.4578857421875
Epoch 34 - loss: 211.0228271484375
Epoch 35 - loss: 207.63490295410156
Epoch 36 - loss: 204.293701171875
Epoch 37 - loss: 200.99868774414062
Epoch 38 - loss: 197.7493438720703
Epoch 39 - loss: 194.54531860351562
Epoch 40 - loss: 191.38609313964844
Epoch 41 - loss: 188.2711944580078
Epoch 42 - loss: 185.2001953125
Epoch 43 - loss: 182.1725616455078
Epoch 44 - loss: 179.1879425048828
Epoch 45 - loss: 176.24586486816406
Epoch 46 - loss: 173.34585571289062
Epoch 47 - loss: 170.48744201660156
Epoch 48 - loss: 167.67025756835938
Epoch 49 - loss: 164.89381408691406
Epoch 50 - loss: 162.15773010253906
Epoch 51 - loss: 159.4615020751953
Epoch 52 - loss: 156.80474853515625
```

```
Epoch 53 - loss: 154.18699645996094
Epoch 54 - loss: 151.60787963867188
Epoch 55 - loss: 149.06690979003906
Epoch 56 - loss: 146.56373596191406
Epoch 57 - loss: 144.09788513183594
Epoch 58 - loss: 141.66896057128906
Epoch 59 - loss: 139.2765350341797
Epoch 60 - loss: 136.9202423095703
Epoch 61 - loss: 134.59959411621094
Epoch 62 - loss: 132.3142547607422
Epoch 63 - loss: 130.0637664794922
Epoch 64 - loss: 127.8477554321289
Epoch 65 - loss: 125.66583251953125
Epoch 66 - loss: 123.51757049560547
Epoch 67 - loss: 121.40260314941406
Epoch 68 - loss: 119.32048034667969
Epoch 69 - loss: 117.27088928222656
Epoch 70 - loss: 115.25338745117188
Epoch 71 - loss: 113.26759338378906
Epoch 72 - loss: 111.31314849853516
Epoch 73 - loss: 109.38967895507812
Epoch 74 - loss: 107.49674987792969
Epoch 75 - loss: 105.63402557373047
Epoch 76 - loss: 103.80113220214844
Epoch 77 - loss: 101.9976577758789
Epoch 78 - loss: 100.22328186035156
Epoch 79 - loss: 98.47763061523438
Epoch 80 - loss: 96.76032257080078
Epoch 81 - loss: 95.07099914550781
Epoch 82 - loss: 93.40929412841797
Epoch 83 - loss: 91.77486419677734
Epoch 84 - loss: 90.1673583984375
Epoch 85 - loss: 88.5864028930664
Epoch 86 - loss: 87.03166961669922
Epoch 87 - loss: 85.5028076171875
Epoch 88 - loss: 83.99945831298828
Epoch 89 - loss: 82.52130126953125
Epoch 90 - loss: 81.06797790527344
Epoch 91 - loss: 79.63916778564453
Epoch 92 - loss: 78.2345199584961
Epoch 93 - loss: 76.8537368774414
Epoch 94 - loss: 75.49645233154297
Epoch 95 - loss: 74.16234588623047
Epoch 96 - loss: 72.85110473632812
Epoch 97 - loss: 71.56241607666016
Epoch 98 - loss: 70.29595947265625
Epoch 99 - loss: 69.0514144897461
Epoch 100 - loss: 67.82846069335938
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Epoch 101 - loss: 66.62681579589844
Epoch 102 - loss: 65.4461441040039
Epoch 103 - loss: 64.28614807128906
Epoch 104 - loss: 63.146541595458984
Epoch 105 - loss: 62.02702713012695
Epoch 106 - loss: 60.92728042602539
Epoch 107 - loss: 59.84703826904297
Epoch 108 - loss: 58.786006927490234
Epoch 109 - loss: 57.743896484375
Epoch 110 - loss: 56.72040939331055
Epoch 111 - loss: 55.71527862548828
Epoch 112 - loss: 54.72822189331055
Epoch 113 - loss: 53.758968353271484
Epoch 114 - loss: 52.8072395324707
Epoch 115 - loss: 51.87276840209961
Epoch 116 - loss: 50.955284118652344
Epoch 117 - loss: 50.05453109741211
Epoch 118 - loss: 49.17024612426758
Epoch 119 - loss: 48.30215835571289
Epoch 120 - loss: 47.450035095214844
Epoch 121 - loss: 46.613609313964844
Epoch 122 - loss: 45.79262161254883
Epoch 123 - loss: 44.9868278503418
Epoch 124 - loss: 44.19600296020508
Epoch 125 - loss: 43.419883728027344
Epoch 126 - loss: 42.65823745727539
Epoch 127 - loss: 41.91083526611328
Epoch 128 - loss: 41.17744445800781
Epoch 129 - loss: 40.457828521728516
Epoch 130 - loss: 39.751766204833984
Epoch 131 - loss: 39.05902099609375
Epoch 132 - loss: 38.37937927246094
Epoch 133 - loss: 37.71261215209961
Epoch 134 - loss: 37.058509826660156
Epoch 135 - loss: 36.416873931884766
Epoch 136 - loss: 35.78746032714844
Epoch 137 - loss: 35.17009353637695
Epoch 138 - loss: 34.564544677734375
Epoch 139 - loss: 33.97062683105469
Epoch 140 - loss: 33.388126373291016
Epoch 141 - loss: 32.81685256958008
Epoch 142 - loss: 32.256614685058594
Epoch 143 - loss: 31.707204818725586
Epoch 144 - loss: 31.168453216552734
Epoch 145 - loss: 30.64017105102539
Epoch 146 - loss: 30.12215232849121
Epoch 147 - loss: 29.61423683166504
Epoch 148 - loss: 29.11621856689453
```
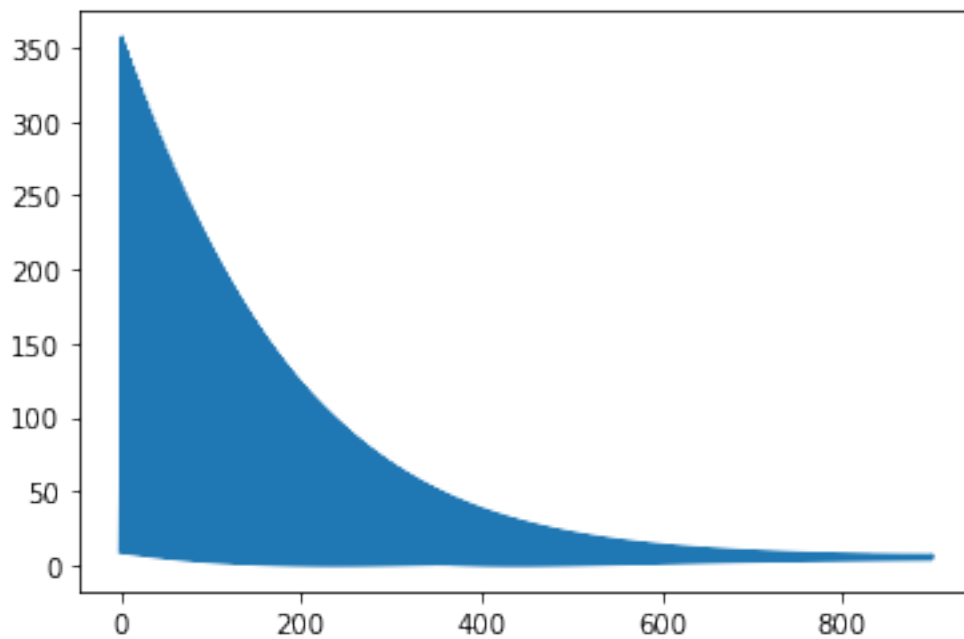
```
Epoch 149 - loss: 28.627958297729492
Epoch 150 - loss: 28.149261474609375
Epoch 151 - loss: 27.679954528808594
Epoch 152 - loss: 27.219865798950195
Epoch 153 - loss: 26.768842697143555
Epoch 154 - loss: 26.326711654663086
Epoch 155 - loss: 25.893312454223633
Epoch 156 - loss: 25.46847915649414
Epoch 157 - loss: 25.052064895629883
Epoch 158 - loss: 24.643917083740234
Epoch 159 - loss: 24.243867874145508
Epoch 160 - loss: 23.851778030395508
Epoch 161 - loss: 23.46749496459961
Epoch 162 - loss: 23.09088706970215
Epoch 163 - loss: 22.721790313720703
Epoch 164 - loss: 22.360076904296875
Epoch 165 - loss: 22.005605697631836
Epoch 166 - loss: 21.658235549926758
Epoch 167 - loss: 21.317848205566406
Epoch 168 - loss: 20.984296798706055
Epoch 169 - loss: 20.657459259033203
Epoch 170 - loss: 20.337194442749023
Epoch 171 - loss: 20.023391723632812
Epoch 172 - loss: 19.71590805053711
Epoch 173 - loss: 19.41465187072754
Epoch 174 - loss: 19.11948585510254
Epoch 175 - loss: 18.83029556274414
Epoch 176 - loss: 18.546964645385742
Epoch 177 - loss: 18.269376754760742
Epoch 178 - loss: 17.997417449951172
Epoch 179 - loss: 17.730981826782227
Epoch 180 - loss: 17.46997833251953
Epoch 181 - loss: 17.21428108215332
Epoch 182 - loss: 16.96379280090332
Epoch 183 - loss: 16.718406677246094
Epoch 184 - loss: 16.47801971435547
Epoch 185 - loss: 16.242549896240234
Epoch 186 - loss: 16.01188850402832
Epoch 187 - loss: 15.785945892333984
Epoch 188 - loss: 15.564610481262207
Epoch 189 - loss: 15.347819328308105
Epoch 190 - loss: 15.13546371459961
Epoch 191 - loss: 14.927462577819824
Epoch 192 - loss: 14.723724365234375
Epoch 193 - loss: 14.524163246154785
Epoch 194 - loss: 14.328700065612793
Epoch 195 - loss: 14.13725757598877
Epoch 196 - loss: 13.949745178222656
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Epoch 197 - loss: 13.766088485717773
Epoch 198 - loss: 13.58620834350586
Epoch 199 - loss: 13.410032272338867
Epoch 200 - loss: 13.237489700317383
Epoch 201 - loss: 13.068485260009766
Epoch 202 - loss: 12.902971267700195
Epoch 203 - loss: 12.740866661071777
Epoch 204 - loss: 12.582108497619629
Epoch 205 - loss: 12.426624298095703
Epoch 206 - loss: 12.274345397949219
Epoch 207 - loss: 12.125216484069824
Epoch 208 - loss: 11.979164123535156
Epoch 209 - loss: 11.8361234664917
Epoch 210 - loss: 11.69604206085205
Epoch 211 - loss: 11.558856010437012
Epoch 212 - loss: 11.424504280090332
Epoch 213 - loss: 11.292937278747559
Epoch 214 - loss: 11.16407585144043
Epoch 215 - loss: 11.037899017333984
Epoch 216 - loss: 10.914329528808594
Epoch 217 - loss: 10.793316841125488
Epoch 218 - loss: 10.674810409545898
Epoch 219 - loss: 10.558762550354004
Epoch 220 - loss: 10.445116996765137
Epoch 221 - loss: 10.333822250366211
Epoch 222 - loss: 10.224837303161621
Epoch 223 - loss: 10.11811637878418
Epoch 224 - loss: 10.013596534729004
Epoch 225 - loss: 9.911253929138184
Epoch 226 - loss: 9.811037063598633
Epoch 227 - loss: 9.712892532348633
Epoch 228 - loss: 9.616791725158691
Epoch 229 - loss: 9.522674560546875
Epoch 230 - loss: 9.430520057678223
Epoch 231 - loss: 9.340282440185547
Epoch 232 - loss: 9.251917839050293
Epoch 233 - loss: 9.16538143157959
Epoch 234 - loss: 9.080655097961426
Epoch 235 - loss: 8.997682571411133
Epoch 236 - loss: 8.916435241699219
Epoch 237 - loss: 8.836883544921875
Epoch 238 - loss: 8.758980751037598
Epoch 239 - loss: 8.682703971862793
Epoch 240 - loss: 8.608020782470703
Epoch 241 - loss: 8.534884452819824
Epoch 242 - loss: 8.463271141052246
Epoch 243 - loss: 8.393146514892578
Epoch 244 - loss: 8.32448673248291
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Epoch 245 - loss: 8.257259368896484
Epoch 246 - loss: 8.191433906555176
Epoch 247 - loss: 8.126981735229492
Epoch 248 - loss: 8.063878059387207
Epoch 249 - loss: 8.00208854675293
Epoch 250 - loss: 7.941590785980225
Epoch 251 - loss: 7.882349967956543
Epoch 252 - loss: 7.8243608474731445
Epoch 253 - loss: 7.767580032348633
Epoch 254 - loss: 7.71198034286499
Epoch 255 - loss: 7.657551288604736
Epoch 256 - loss: 7.604257106781006
Epoch 257 - loss: 7.55208158493042
Epoch 258 - loss: 7.5009942054748535
Epoch 259 - loss: 7.450976371765137
Epoch 260 - loss: 7.402012825012207
Epoch 261 - loss: 7.354079723358154
Epoch 262 - loss: 7.307142734527588
Epoch 263 - loss: 7.2611985206604
Epoch 264 - loss: 7.216219425201416
Epoch 265 - loss: 7.172182083129883
Epoch 266 - loss: 7.129073619842529
Epoch 267 - loss: 7.08687686920166
Epoch 268 - loss: 7.045565128326416
Epoch 269 - loss: 7.005126476287842
Epoch 270 - loss: 6.965543746948242
Epoch 271 - loss: 6.926791191101074
Epoch 272 - loss: 6.888862609863281
Epoch 273 - loss: 6.85173225402832
Epoch 274 - loss: 6.815384387969971
Epoch 275 - loss: 6.779808044433594
Epoch 276 - loss: 6.744984149932861
Epoch 277 - loss: 6.710906982421875
Epoch 278 - loss: 6.677551746368408
Epoch 279 - loss: 6.644899368286133
Epoch 280 - loss: 6.612939834594727
Epoch 281 - loss: 6.581664562225342
Epoch 282 - loss: 6.551053524017334
Epoch 283 - loss: 6.521093845367432
Epoch 284 - loss: 6.491771221160889
Epoch 285 - loss: 6.463077068328857
Epoch 286 - loss: 6.434998035430908
Epoch 287 - loss: 6.4075164794921875
Epoch 288 - loss: 6.3806281089782715
Epoch 289 - loss: 6.354310512542725
Epoch 290 - loss: 6.328561305999756
Epoch 291 - loss: 6.303366661071777
Epoch 292 - loss: 6.278714656829834
```

```
Epoch 293 - loss: 6.2545881271362305
Epoch 294 - loss: 6.230988502502441
Epoch 295 - loss: 6.207890033721924
Epoch 296 - loss: 6.1852898597717285
Epoch 297 - loss: 6.1631855964660645
Epoch 298 - loss: 6.141555309295654
Epoch 299 - loss: 6.120392799377441
when x = tensor([1., 3.]), y = tensor([3.5097], grad_fn=<SqueezeBackward3>)
when x = tensor([2., 6.]), y = tensor([7.0194], grad_fn=<SqueezeBackward3>)
when x = tensor([3., 9.]), y = tensor([10.5291], grad_fn=<SqueezeBackward3>)
```

[33]: [<matplotlib.lines.Line2D at 0x7f128b1ae8b0>]

[ ]: