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Net Id: vd283

Problem Build a FC layer-based neural network to recognize handwritten digits .(NN structure- 784-200-50-10)

Q1: Using the NumPy

Q2: Using Pytorch or other in-Built Frameworks

Code , Discussion and Output(Note Separate Code Files are attached also for testing)

(Q2)_Part 2: Output

```
C:\Users\vikhyat\data_structures_algo\deep_learning_homework>python nn_part2.py
-------------------------Training and Testing using Neural Network-----------------  :
C:\Users\vikhyat\AppData\Local\Programs\Python\Python37\lib\site-packages\torch\nn\modules\container.py:100: UserWarning: Implicit dimension choice for softmax has been deprecated. Change the call to include dim
=X as an argument.
  input = module(input)
The loss is :  -0.80729892578125
The success_rate is :  83.41
The loss is :  -0.8370771484375
The success_rate is :  85.11
The loss is :  -0.9037685546875
The success_rate is :  91.71
The loss is :  -0.91907861328125
The success_rate is :  93.17
The loss is :  -0.92746943359375
The success_rate is :  93.84
The loss is :  -0.93371572265625
The success_rate is :  94.45
The loss is :  -0.9373806640625
The success_rate is :  94.89
The loss is :  -0.9434142578125
The success_rate is :  95.33
The loss is :  -0.94624853515625
The success_rate is :  95.59
The loss is :  -0.9489859375
The success_rate is :  95.82
The loss is :  -0.9525298828125
The success_rate is :  96.14
The loss is :  -0.95251943359375
The success_rate is :  96.2
Total Time takan to train finally at such accuracy :  224.91852283477783
```

Description:

- ✓ Layers as suggested(784-200-50-10)
- ✓ Learning Rate: 0.01
- ✓ Number of epochs=12
- ✓ Momentum used to fasten the training and hence optimisation
- ✓ Cross entropy loss used
- ✓ Achieved more than 96 percent accuracy in about 3 minutes using the above model as target set was for 95 percent

Note :

a. The code has been attached(nn_part2_vd283.py)
b. Please take care of the data in the same file etc for proper execution

Q1:-

Part 3 (Using the batch based method for training with several optimisations of momentum , reularisation error) :

Using Numpy:

```
C:\Users\vikhyat\data_structures_algo\deep_learning_homework>python nn_part3.py
The Total average loss after the epoch number  0 is :  1.34605915976958802
The Total average loss after the epoch number  1 is :  0.5211988734654709
The Total average loss after the epoch number  2 is :  0.36518327105380083
The Total average loss after the epoch number  3 is :  0.28367188869999016
The Total average loss after the epoch number  4 is :  0.22552029754277828
The Total average loss after the epoch number  5 is :  0.1816339393686411
The Total average loss after the epoch number  6 is :  0.14854695709213922
The Total average loss after the epoch number  7 is :  0.12606105804484005
The Total average loss after the epoch number  8 is :  0.10591229768404455
The Total average loss after the epoch number  9 is :  0.09419987002470027
Training accuracy :  0.9743
Training Time taken:  38.8444926738739
```

Description:

- ✓ Layers as suggested(784-200-50-10)
- ✓ Learning Rate: 0.01
- ✓ Number of epochs=10
- ✓ Momentum used to fasten the training and hence optimisation parameter=0.8
- ✓ Regularisation error has also been added with parameter
- ✓ Cross entropy loss used

Achieved more than 97 percent accuracy in just 38 seconds using the above model as target set was for 95 percent

Note :

a. The code has been attached.(nn_part3_vd283.py)
b. Please take care of the data in the same file etc for proper execution
c. Note that I have transposed the images of size 784 in the colums not as rows so much W matrices sizes will be like this only.
d. Layers of relu , softmax etc used as asked in the neural networks requirements

Part 1:

In this , I have done is the plain vanila – NUMPY based Neural Network:-

Where there is :

a. Regularistaion error added for optimisation
b. Whole Training batch is used in One epoch so it is not the Batch based training
c. Structure is same
d. Learning Rate: 0.01
e. Regularistaion parameter : 1e-3
f. Total 500 iterations have been tried
g. Above 96 percent accuracy achieved.

Note :

a. The code has been attached.(nn_part1_vd283.py)
b. Please take care of the data in the same file etc for proper execution
c. Note that I have transposed the images of size 784 in the colums not as rows so much W matrices sizes will be like this only.
d. Layers of relu , softmax etc used as asked in the neural networks requirements
e. Note : As suggested I will use the further optimistaions like moving avearges , RMS Prop , Drop Outs , Adams Optimisation etc on it with batch Normalisation etc to make it better.
f. Note This is my observation only that learning rate is still high as some jitters in loss patern are seen so – In further projects where we have to do deep analysis then I will come forward with that.
g. Further its trace has been attached.


```
The Total loss in these  498  iterations is :  0.11653542107016293
The Total loss in these  499  iterations is :  0.11636491575379192
Training accuracy :  0.9652
Training Time taken:  686.9028334617615
Testing Time taken:  0.1478290557861328

C:\Users\vikhyat\data_structures_algo\deep_learning_homework>
```

Thanks professor that in such quick time learn so much about deep learning/neural network , I have really learnt a lot.I personally request Professor to provide the feedback for this homework. Thanks again.

Trace:

C:\Users\vikhyat\data_structures_algo\deep_learning_homework>python nn_part1.py

The Total loss in these 0 iterations is : 2.3072621842095367

The Total loss in these 1 iterations is : 2.2772959366218464

The Total loss in these 2 iterations is : 2.2480381763375616

The Total loss in these 3 iterations is : 2.216407784333007

The Total loss in these 4 iterations is : 2.179919570653319

The Total loss in these 5 iterations is : 2.136448539443011

The Total loss in these 6 iterations is : 2.0839830031687794

The Total loss in these 7 iterations is : 2.0207405637297855

The Total loss in these 8 iterations is : 1.9452677190392749

The Total loss in these 9 iterations is : 1.856293609462743

The Total loss in these 10 iterations is : 1.7530803607121572

The Total loss in these 11 iterations is : 1.636161730424199

The Total loss in these 12 iterations is : 1.508514850593647

The Total loss in these 13 iterations is : 1.376122024236836

The Total loss in these 14 iterations is : 1.2470986662892867

The Total loss in these 15 iterations is : 1.1291114011162688

The Total loss in these 16 iterations is : 1.026950545435767

The Total loss in these 17 iterations is : 0.9424469342938476

The Total loss in these 18 iterations is : 0.8844054896131262

The Total loss in these 19 iterations is : 0.9949911597438221

The Total loss in these 20 iterations is : 2.3501395359947774

The Total loss in these 21 iterations is : 2.7727780000689215

The Total loss in these 22 iterations is : 2.365452173093601

The Total loss in these 23 iterations is : 1.724744982676587

The Total loss in these 24 iterations is : 1.5061714521058667

The Total loss in these 25 iterations is : 1.2974869967435443

The Total loss in these 26 iterations is : 1.12572217857574

The Total loss in these 27 iterations is : 0.9889654079114194

The Total loss in these 28 iterations is : 0.8842498533300809

The Total loss in these 29 iterations is : 0.8034649013803127

The Total loss in these 30 iterations is : 0.742291309546154

The Total loss in these 31 iterations is : 0.6951157726396716

The Total loss in these 32 iterations is : 0.6569096813505519

The Total loss in these 33 iterations is : 0.6255196359301465

The Total loss in these 34 iterations is : 0.6014288025523833

The Total loss in these 35 iterations is : 0.5958857502383645

The Total loss in these 36 iterations is : 0.68094526370787

The Total loss in these 37 iterations is : 1.2357782427603987

The Total loss in these 38 iterations is : 1.6553432938011348

The Total loss in these 39 iterations is : 0.9062698948899125

The Total loss in these 40 iterations is : 0.6708990715429843

The Total loss in these 41 iterations is : 0.591000070032827

The Total loss in these 42 iterations is : 0.5520920002497405

The Total loss in these 43 iterations is : 0.5257185083250246

The Total loss in these 44 iterations is : 0.505738386459662

The Total loss in these 45 iterations is : 0.4898798485694904

The Total loss in these 46 iterations is : 0.4773454602915049

The Total loss in these 47 iterations is : 0.46790172314340495

The Total loss in these 48 iterations is : 0.46285175278688656

The Total loss in these 49 iterations is : 0.4652845468611694

The Total loss in these 50 iterations is : 0.48491098336886923

The Total loss in these 51 iterations is : 0.540382739302381

The Total loss in these 52 iterations is : 0.6605760681103587

The Total loss in these 53 iterations is : 0.7621963886836574

The Total loss in these 54 iterations is : 0.7074167491351286

The Total loss in these 55 iterations is : 0.5213442250326171

The Total loss in these 56 iterations is : 0.4431456150686585

The Total loss in these 57 iterations is : 0.4213448879688484

The Total loss in these 58 iterations is : 0.40953778447918276

The Total loss in these 59 iterations is : 0.40134197335881927

The Total loss in these 60 iterations is : 0.3947167152328633

The Total loss in these 61 iterations is : 0.38896636519283295

The Total loss in these 62 iterations is : 0.3838706257452824

The Total loss in these 63 iterations is : 0.3792519779746831

The Total loss in these 64 iterations is : 0.37503514152077827

The Total loss in these 65 iterations is : 0.3711526140968364

The Total loss in these 66 iterations is : 0.36754962660972784

The Total loss in these 67 iterations is : 0.36421893684409934

The Total loss in these 68 iterations is : 0.36112494135289724

The Total loss in these 69 iterations is : 0.35827104607835725

The Total loss in these 70 iterations is : 0.355669356007157

The Total loss in these 71 iterations is : 0.35337495307161154

The Total loss in these 72 iterations is : 0.35141749403107697

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The Total loss in these 80 iterations is : 0.38379015260654203

The Total loss in these 81 iterations is : 0.40547399569759807

The Total loss in these 82 iterations is : 0.43024507472959905

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The Total loss in these 84 iterations is : 0.46162120713255406

The Total loss in these 85 iterations is : 0.43842830292656987

The Total loss in these 86 iterations is : 0.3978719797547037

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The Total loss in these 88 iterations is : 0.33360260492972527

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The Total loss in these 301 iterations is : 0.1625447820077953

The Total loss in these 302 iterations is : 0.1622211253499752

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The Total loss in these 317 iterations is : 0.15752462348137242

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The Total loss in these 319 iterations is : 0.1569200225584976

The Total loss in these 320 iterations is : 0.1566197369262634

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The Total loss in these 322 iterations is : 0.15602293934511957

The Total loss in these 323 iterations is : 0.15572651818012476

The Total loss in these 324 iterations is : 0.15543089803502547

The Total loss in these 325 iterations is : 0.1551366391116815

The Total loss in these 326 iterations is : 0.15484373354068623

The Total loss in these 327 iterations is : 0.1545519956434919

The Total loss in these 328 iterations is : 0.15426159030439596

The Total loss in these 329 iterations is : 0.1539726322839046

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