```
import csv                                                  #for reading data from csv file
import numpy as np
from matplotlib import pyplot                               #for printing images
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.utils.data import TensorDataset                  #for easy iteration of batches
from torch.utils.data import DataLoader
import torch.optim as optim
import matplotlib.pyplot as plt
import pandas as pd
import time
# import torchvision
# import torchvision.transforms as transforms
# import matplotlib.pyplot as plt
# import random
# import tensorflow as tf
# from pathlib import Path
# import requests
# import pickle
# import gzip
import math
from google.colab import drive
from statistics import mean
drive.mount('/content/drive', force_remount=True)
```

```
Mounted at /content/drive
```

```
path = 'drive/My Drive/Kaggle_MNIST_data/'

#loading train data

fields=[]          #taking out the first row which contains headers
y_temp=[]
x_temp=[]

csv_file=open(path+'train.csv', 'r')
csvreader=csv.reader(csv_file)
fields=next(csvreader)

for row in csvreader:

    y_temp.append(row[0])
    x_temp.append(np.asarray(row[1:], dtype=float))

x_train_np=np.asarray(x_temp)
y_train_np=np.asarray(y_temp, dtype=int)

x_train, y_train = map(torch.tensor, (x_train_np, y_train_np))

```

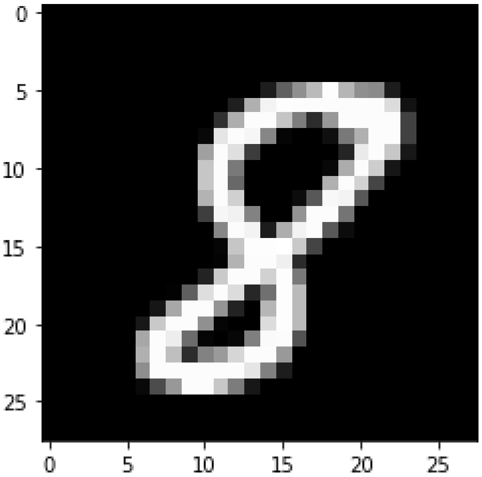
```
print(x_train.shape, y_train.shape)


```

```
torch.Size([42000, 784]) torch.Size([42000])
```

```
#loading test data

csv_file_test=open(path+'test.csv', 'r')
csvreader_test=csv.reader(csv_file_test)

fields_test=[]
x_temp_test=[]

fields_test=next(csvreader_test)

for row in csvreader_test:
    x_temp_test.append(np.asarray(row, dtype=float))

x_test_np=np.asarray(x_temp_test)
x_test=torch.tensor(x_test_np)
```

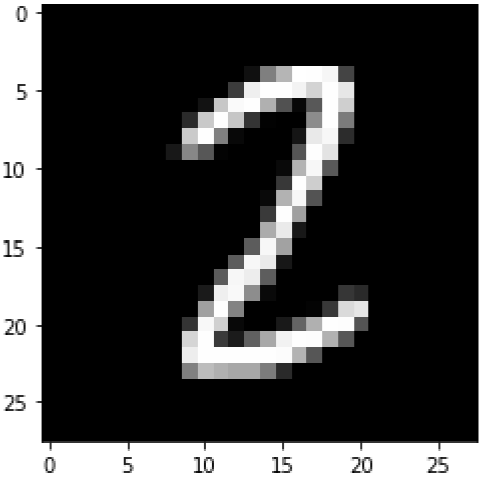
```
#viewing images

#train image view
plt.imshow(x_train[105].reshape(28, 28), cmap='gray')
print('image label: ', y_train[105])

```

```
image label:  tensor(8)
```



```

#test image view
plt.imshow(x_test[102].reshape(28, 28), cmap='gray')
print((x_test.shape))
```

```
torch.Size([28000, 784])
```



```
BatchSize=64
epochs=5
num_classes=10
learning_rate=0.001

# def preprocess(x, y):

#     x=x/255.0
#     x=x.reshape(-1, 1, 28, 28)

#     return x, y

x_train=x_train/255.0
x_train=x_train.reshape(-1, 1, 28, 28)

x_test=x_test/255.0
x_test=x_test.reshape(-1, 1, 28, 28)

train_ds = TensorDataset(x_train, y_train)
test_ds = TensorDataset(x_test)

train_dl = DataLoader(train_ds, batch_size = BatchSize, shuffle=True)
test_dl = DataLoader(test_ds, batch_size = BatchSize, shuffle=False)


# def get_data(train_ds, bs):

#     return DataLoader(train_ds, batch_size=bs, shuffle=True)

# class WrappedDataLoader:

#     def __init__(self, dl, func):
#         self.dl = dl
#         self.func = func

#     def __len__(self):
#         return len(self.dl)
#         return len(self.dl)

#     def __iter__(self):
#         batches = iter(self.dl)
#         for batch in batches:
#             yield(self.func(*batch))
```

```
class CNN_model(nn.Module):

    def __init__(self):

        super().__init__()

        #convs
        self.conv1 = nn.Conv2d(1, 16, kernel_size=5, stride=1, padding=2)
        self.conv2 = nn.Conv2d(16, 32, kernel_size=5, stride=2, padding=2)
        self.conv3 = nn.Conv2d(32, 48, kernel_size=3, stride=1, padding=1)
        self.conv4 = nn.Conv2d(48, 64, kernel_size=3, stride=1, padding=1)

        #linear
        self.fc1 = nn.Linear(64*7*7, 1024)
        self.fc2 = nn.Linear(1024, 10)

        #batch_norm
        self.b_norm1 = nn.BatchNorm2d(16)
        self.b_norm2 = nn.BatchNorm2d(32)
        self.b_norm3 = nn.BatchNorm2d(48)
        self.b_norm4 = nn.BatchNorm2d(64)
        self.b_norm5 = nn.BatchNorm1d(1024)
        self.b_norm6=nn.BatchNorm1d(10)

        #dropouts
        self.drop1 = nn.Dropout2d(p=0.4)
        self.drop2 = nn.Dropout(p=0.4)


        # self.layer1=nn.Sequential(
        #     nn.Conv2d(1, 32, kernel_size=5, stride=1, padding=2),
        #     nn.ReLU(),
        #     nn.MaxPool2d(kernel_size=2, stride=2))

        # self.layer2=nn.Sequential(
        #     nn.Conv2d(32, 64, kernel_size=5, stride=1, padding=2),
        #     nn.ReLU(),
        #     nn.MaxPool2d(kernel_size=2, stride=2))

        # self.drop=nn.Dropout()
        # self.fc1=nn.Linear(7*7*64, 1000)
        # self.fc2=nn.Linear(1000, 10)

    def forward(self, xb):
```

```
xb=xb.view(-1, 1, 28, 28)

#layer 1
out=F.relu(self.conv1(xb))
out=self.b_norm1(out)
out=self.drop1(out)

# print(out.size())

#layer 2
out=F.relu(self.conv2(out))
out=self.b_norm2(out)
# print(out.size())

#layer 3
out=F.relu(self.conv3(out))
out=self.b_norm3(out)
# print(out.size())

#layer 4
out=F.relu(self.conv4(out))
out=self.b_norm4(out)
out=F.avg_pool2d(out, 2, stride=2)
out=self.drop1(out)
# print(out.size())`

out=out.reshape(out.size(0), -1)

#fc1
out=F.relu(self.fc1(out))
out=self.b_norm5(out)
out=self.drop2(out)

#fc2
out=self.fc2(out)
out=self.b_norm6(out)

return out

# out = self.layer1(xb)
# out = self.layer2(out)

# out=out.reshape(out.size(0), -1)

# out=self.drop(out)

# out=self.fc1(out)
# out=self.fc2(out)

return out

```

```
model=CNN_model()

#loss fxn and optimiser

loss_fn=nn.CrossEntropyLoss()
opt=optim.Adam(model.parameters(), lr=learning_rate)
```

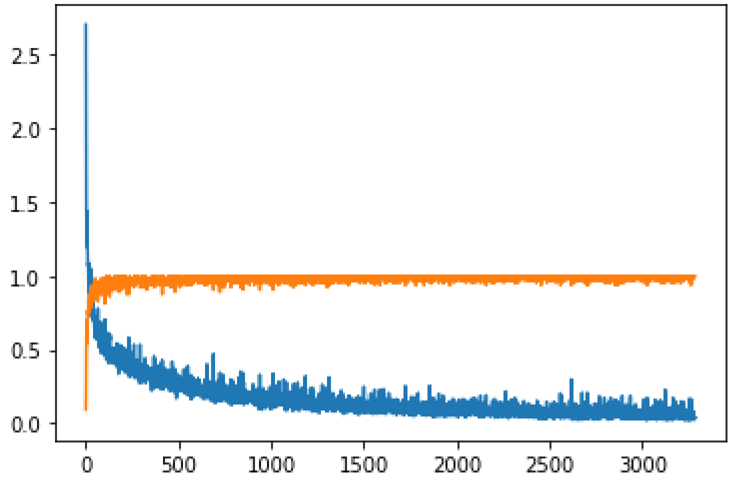
```
# training the model

total_steps=len(train_dl)
losses=[]
acc=[]
for epoch in range(epochs):
    for i, (xb, yb) in enumerate(train_dl):

        y_pred=model(xb.float())
        loss=loss_fn(y_pred, yb)
        losses.append(loss.item())

        opt.zero_grad()
        loss.backward()
        opt.step()

        total=yb.size(0)

        _, prediction = torch.max(y_pred.data, 1)
        correct=(prediction==yb).sum().item()
        acc.append(correct/total)

        if i%100 == 99:

            print('Epoch [{}/{}]   Step [{}/{}]   Loss {}    Accuracy {}'.format(epoch+1, epochs, i+1, total_steps, loss.item


```

```
Epoch [1/5]   Step [100/657]   Loss 0.5072802901268005    Accuracy 93.75
Epoch [1/5]   Step [200/657]   Loss 0.44745591282844543    Accuracy 96.875
Epoch [1/5]   Step [300/657]   Loss 0.3968683183193207    Accuracy 96.875
Epoch [1/5]   Step [400/657]   Loss 0.33709776401519775    Accuracy 96.875
Epoch [1/5]   Step [500/657]   Loss 0.24842308461666107    Accuracy 100.0
Epoch [1/5]   Step [600/657]   Loss 0.2183385044336319    Accuracy 96.875
Epoch [2/5]   Step [100/657]   Loss 0.23371465504169464    Accuracy 98.4375
Epoch [2/5]   Step [200/657]   Loss 0.2234659641981125    Accuracy 96.875
Epoch [2/5]   Step [300/657]   Loss 0.11534883081912994    Accuracy 100.0
Epoch [2/5]   Step [400/657]   Loss 0.15196412801742554    Accuracy 98.4375
Epoch [2/5]   Step [500/657]   Loss 0.17435264587402344    Accuracy 96.875
Epoch [2/5]   Step [600/657]   Loss 0.1981852799654007    Accuracy 95.3125
Epoch [3/5]   Step [100/657]   Loss 0.07437895983457565    Accuracy 100.0
Epoch [3/5]  Step [200/657]  Loss 0.07193994522094727   Accuracy 100.0
Epoch [3/5]  Step [300/657]  Loss 0.0823836550116539   Accuracy 100.0
Epoch [3/5]  Step [400/657]  Loss 0.15408067405223846   Accuracy 98.4375
Epoch [3/5]  Step [500/657]  Loss 0.13243623077869415   Accuracy 96.875
Epoch [3/5]  Step [600/657]  Loss 0.11968963593244553   Accuracy 96.875
Epoch [4/5]  Step [100/657]  Loss 0.05097464099526405   Accuracy 100.0
Epoch [4/5]  Step [200/657]  Loss 0.09880056977272034   Accuracy 98.4375
Epoch [4/5]  Step [300/657]  Loss 0.06091800332069397   Accuracy 100.0
Epoch [4/5]  Step [400/657]  Loss 0.04437074065208435   Accuracy 100.0
Epoch [4/5]  Step [500/657]  Loss 0.1025368869304657   Accuracy 98.4375
Epoch [4/5]  Step [600/657]  Loss 0.04332221299409866   Accuracy 100.0
Epoch [5/5]  Step [100/657]  Loss 0.056743621826171875   Accuracy 100.0
Epoch [5/5]  Step [200/657]  Loss 0.15337294340133667   Accuracy 96.875
Epoch [5/5]  Step [300/657]  Loss 0.055323902517557144   Accuracy 98.4375
Epoch [5/5]  Step [400/657]  Loss 0.051575690507888794   Accuracy 100.0
Epoch [5/5]  Step [500/657]  Loss 0.06951117515563965   Accuracy 98.4375
Epoch [5/5]  Step [600/657]  Loss 0.02482232265174389   Accuracy 100.0
```

```
print(mean(acc))
```

```
0.9786529680365297
```

```
plt.plot(losses)
plt.plot(acc)
plt.show()
```



```
#testing images

test_imgs=x_test.clone().detach()
test_imgs=test_imgs.reshape(test_imgs.shape[0], -1)
print(test_imgs.shape)
# for i, img in enumerate(test_imgs):
#     plt.imshow(img.reshape(28, 28), cmap='gray')
#     plt.show()

```

```
torch.Size([28000, 784])
```

```
model.eval()

with torch.no_grad():

    # print(x_test.shape)
    # print(x_test)

    y_pred_test=model(x_test.float())
    # print(y_pred_test)
    # _, prediction=torch.max(y_pred_test.data, 1)
    prediction=torch.argmax(y_pred_test, axis=1, keepdim=True)
    # print(prediction)

    prediction_np=np.reshape(prediction, prediction.shape[0])
    # print(prediction_np)

    imageID_row=pd.Series(range(1, prediction_np.shape[0]+1), name="ImageId")
    label_row=pd.Series(prediction_np, name="Label")

    sub=pd.concat([imageID_row, label_row], axis=1)
    display(pd.DataFrame(sub))
    # sub.to_csv(path+"1st_Submission.csv", index=False)


    # for xb in test_dl:
    #     pred=model(xb[0].float())
    #     _, prediction = torch.max(pred.data, 1)
    #     print(prediction)
    #     for i, image in enumerate(xb[0]):
    #         # print('Prediction is : ', prediction[i][0])
    #         # plt.imshow(image.reshape(28, 28), cmap='grey')
    #         if i==1:
    #             plt.imshow((image.reshape(28, 28)), cmap='gray')
```

	ImageId	Label
0	1	2
1	2	0
1		
3	4	9
4	5	3
...	...	...
27995	27996	9
27996	27997	7
27997	27998	3
27998	27999	9
27999	28000	2

28000 rows × 2 columns