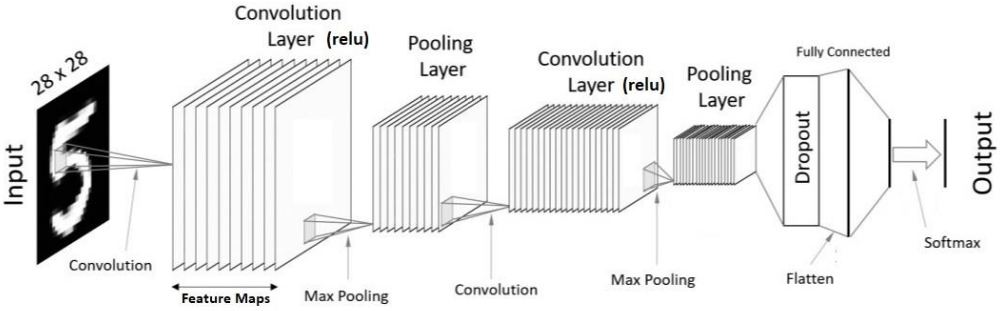
# OASIS ML Group TRAINING 04

## ◆ CNN using PyTorch / from scratch

In this practice, you are going to build two CNN models which one is built from scratch and the other is built by using a useful framework called PyTorch. Please refer to the website which is in training slides for some useful tricks. The MNIST dataset is a common dataset for CNN. The original dataset is in a format that is difficult for beginners to use, so which I provided is used the work of Joseph Redmon to provide the MNIST dataset in a CSV format. **Shout out to Joseph Redmon!**

Follow the hints below to finish it.



### ▫ Practice：

#### ■ Analysis datasets：

The dataset consists of two files：mnist_train.csv, mnist_test.csv

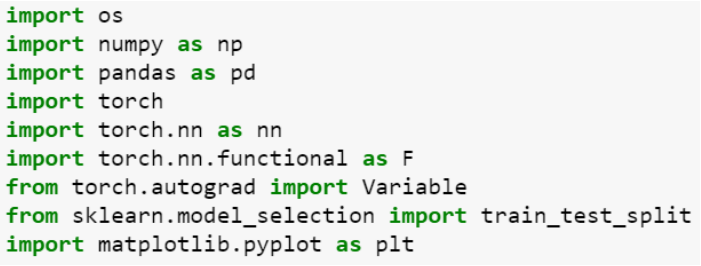
The mnist_train.csv file contains the 60,000 training examples and labels. The mnist_test.csv contains 10,000 test examples and labels. Each row consists of 785 values: the first value is the label (a number from 0 to 9) and the remaining 784 values are the pixel values (a number from 0 to 255).

#### ■ PyTorch：

- Please try to answer what’s PyTorch?
- Why do we want to use it instead of using Python, Numpy …only.

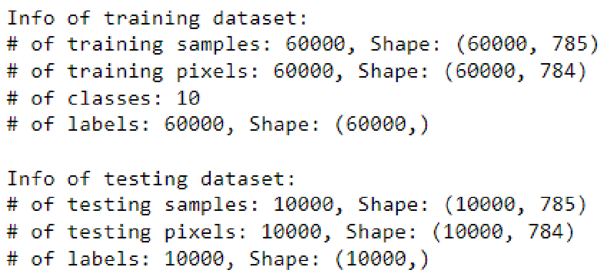
**Hint 01**：Import library you needed.

**For example**： *(Below are **frequently-used** libraries)*



```
import os
import numpy as np
import pandas as pd
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.autograd import Variable
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
```

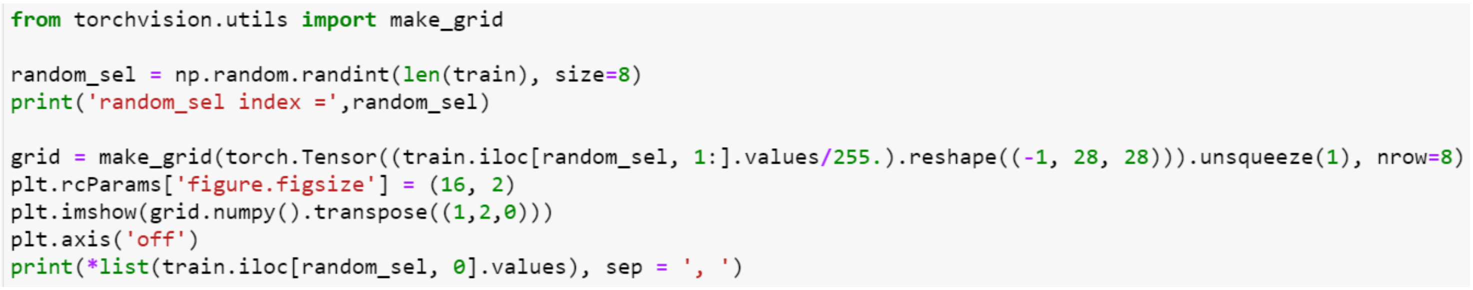
**Hint 02：** Use pandas to read data. After that, I suggest to do datasets information analysis which show below.



```
Info of training dataset:
# of training samples: 60000, Shape: (60000, 785)
# of training pixels: 60000, Shape: (60000, 784)
# of classes: 10
# of labels: 60000, Shape: (60000,)

Info of testing dataset:
# of testing samples: 10000, Shape: (10000, 785)
# of testing pixels: 10000, Shape: (10000, 784)
# of labels: 10000, Shape: (10000,)
```

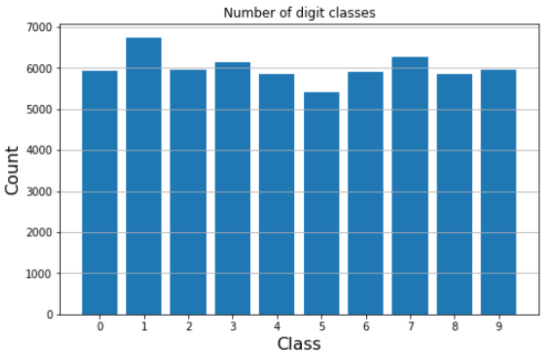
## For hint 3 and hint 4, you are asked to visualize the datasets.

**Hint 03：** Display some images in training datasets through code provided below. In the meantime, try to understand the code.



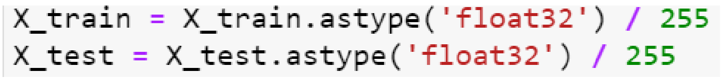
```python
from torchvision.utils import make_grid

random_sel = np.random.randint(len(train), size=8)
print('random_sel index =',random_sel)

grid = make_grid(torch.Tensor((train.iloc[random_sel, 1:].values/255.).reshape((-1, 28, 28))).unsqueeze(1), nrow=8)
plt.rcParams['figure.figsize'] = (16, 2)
plt.imshow(grid.numpy().transpose((1,2,0)))
plt.axis('off')
print(*list(train.iloc[random_sel, 0].values), sep = ', ')
```

**Hint 04：** Show the **histogram** of the classes through code provided below.



**Hint 05：** Doing **normalization** through code provided below.

- Discuss why we need to do normalize?
- Discuss why we need to do “.astype(‘float32’)”?
- Discuss why divide 255?



```python
X_train = X_train.astype('float32') / 255
X_test = X_test.astype('float32') / 255
```

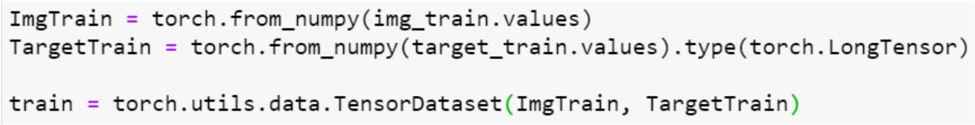
**Hint 06：** Split train datasets to “training” and “validation” by using train_test_split in sklearn. Remember to define test_size and random_state.

**(Recommend test_size = 0.2~0.3)**

**Hint 07**：Use code below to convert datasets to Tensor and package into TensorDataset. Discuss why and what the code means~

(Remind：You will have three kinds of datasets after this step.)

**For example**：

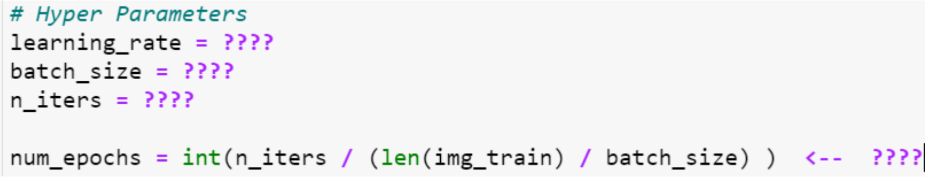


```
ImgTrain = torch.from_numpy(img_train.values)
TargetTrain = torch.from_numpy(target_train.values).type(torch.LongTensor)

train = torch.utils.data.TensorDataset(ImgTrain, TargetTrain)
```

**Hint 08**：Define Hyper-parameters by yourself.

Recommend initial parameters：

learning_rate = 0.01
batch_size = 100
n_iters = 10000



```
# Hyper Parameters
learning_rate = ????
batch_size = ????
n_iters = ????

num_epochs = int(n_iters / (len(img_train) / batch_size) )  <--  ????
```

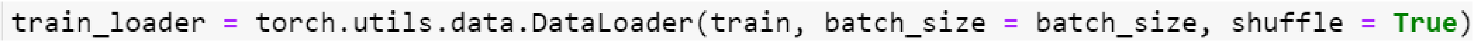
(You can tune by yourself.)

**Hint 09**：Construct Dataloader through code below.

- Discuss what's dataloader?

(Remind： You will have three dataloaders after this step.)

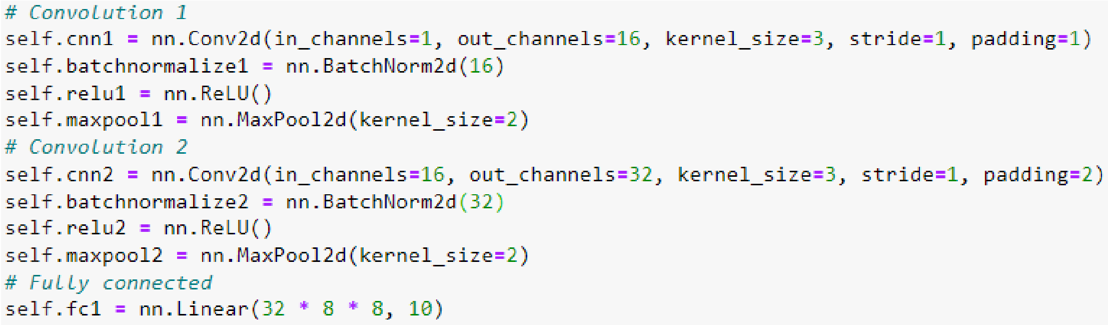
**For example**：



```
train_loader = torch.utils.data.DataLoader(train, batch_size = batch_size, shuffle = True)
```

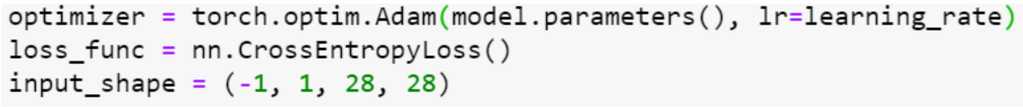
**Hint 10**：**Construct CNN model**.

You will construct a CNN model with Pytorch, and there are the actions of each layer. You should follow these SPEC to finish your CNN model.



```
# Convolution 1
self.cnn1 = nn.Conv2d(in_channels=1, out_channels=16, kernel_size=3, stride=1, padding=1)
self.batchnormalize1 = nn.BatchNorm2d(16)
self.relu1 = nn.ReLU()
self.maxpool1 = nn.MaxPool2d(kernel_size=2)
# Convolution 2
self.cnn2 = nn.Conv2d(in_channels=16, out_channels=32, kernel_size=3, stride=1, padding=2)
self.batchnormalize2 = nn.BatchNorm2d(32)
self.relu2 = nn.ReLU()
self.maxpool2 = nn.MaxPool2d(kernel_size=2)
# Fully connected
self.fc1 = nn.Linear(32 * 8 * 8, 10)
```

**Hint 11**：**Set the optimizer and loss_func**.



```
optimizer = torch.optim.Adam(model.parameters(), lr=learning_rate)
loss_func = nn.CrossEntropyLoss()
input_shape = (-1, 1, 28, 28)
```

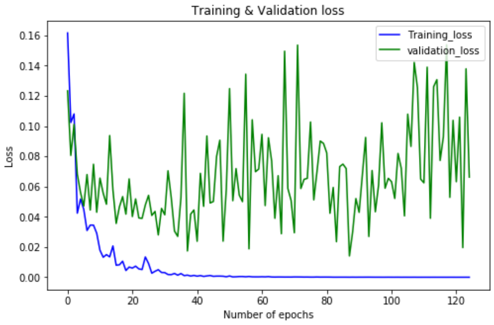
**Hint 12：Define train, evaluation, fit_model,…functions.**

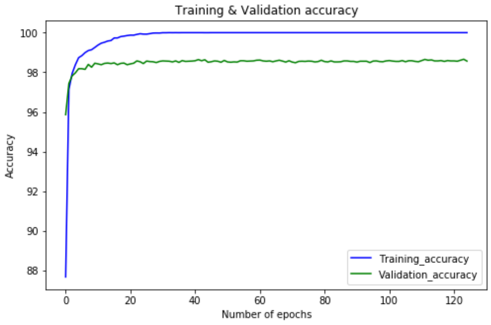
You can define functions to make the training or inference more easily.

**For example：**

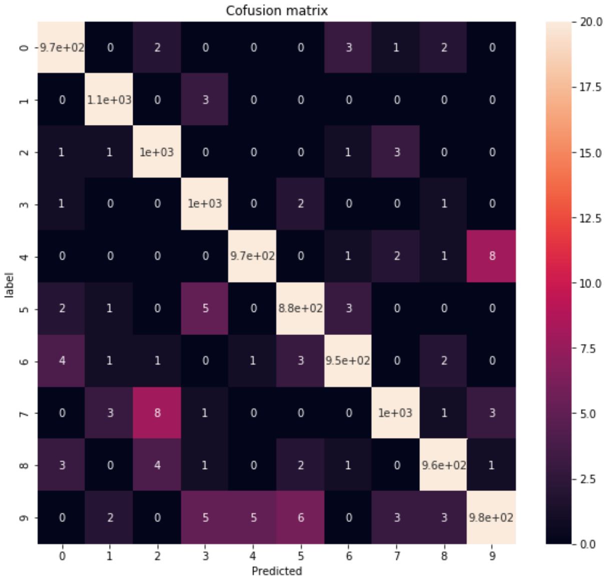
```
def train_model(model, loss_func, optimizer, input_shape, epoch, num_epochs, train_loader, ......):
    ...
    ...
    ...
    return ...
```

**Hint 13：**After training, please show the testing result by using testing dataset. At the same time, please plot “Training & Validation loss curve” and “Training & Validation accuracy curve”.





**Hint 14：**Plot the confusion matrix based on testing data and also print the accuracy of each digits.



**Hint 15：**

After finishing the CNN model which is built with PyTorch, you have to implement it again without using Tensor or Torch packages. You should finish another CNN model **from scratch** which means you can **only use Numpy and other basic packages.** You also have to print the information above and discuss **what is the difference** between these two CNN models.