```
import torch
import torch.nn as nn
from tqdm.auto import tqdm
import matplotlib.pyplot as plt
from torchsummary import summary
from torchvision import datasets
from torchvision import transforms
from torchvision.transforms import ToTensor
from torch.utils.data import DataLoader


device = "cuda" if torch.cuda.is_available() else "cpu"

# TODO: define train set and test set
transform=transforms.Compose([
        ToTensor(),
        transforms.Normalize(0,1)
        ])
train_set = datasets.MNIST('./Datasets', download=True, train=True, transform=transform)

test_set = datasets.MNIST('./Datasets', download=True, train=False, transform=transform)
```

```
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz to ./Datasets/MNIST/raw/train-images-idx3-ubyte.gz
100%|██████████| 9912422/9912422 [00:00<00:00, 129849028.67it/s]Extracting ./Datasets/MNIST/raw/train-images-idx3-ubyte.gz to ./Datasets


Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz to ./Datasets/MNIST/raw/train-labels-idx1-ubyte.gz
100%|██████████| 28881/28881 [00:00<00:00, 66558073.53it/s]
Extracting ./Datasets/MNIST/raw/train-labels-idx1-ubyte.gz to ./Datasets/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz to ./Datasets/MNIST/raw/t10k-images-idx3-ubyte.gz
100%|██████████| 1648877/1648877 [00:00<00:00, 43790865.55it/s]Extracting ./Datasets/MNIST/raw/t10k-images-idx3-ubyte.gz to ./Datasets/M


Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz to ./Datasets/MNIST/raw/t10k-labels-idx1-ubyte.gz
100%|██████████| 4542/4542 [00:00<00:00, 3891834.27it/s]
Extracting ./Datasets/MNIST/raw/t10k-labels-idx1-ubyte.gz to ./Datasets/MNIST/raw
```

```
# TODO: define dataloader for train and test
train_loader = DataLoader(train_set, batch_size=128, shuffle=True)
test_loader = DataLoader(test_set, batch_size=64, shuffle=True)


class Model(nn.Module):
    def __init__(self):
        super(Model, self).__init__()
        self.conv1 = nn.Conv2d(1, 32, 3, 1)
        self.conv2 = nn.Conv2d(32, 64, 3, 1)
        self.dropout1 = nn.Dropout(0.25)
        self.dropout2 = nn.Dropout(0.5)
        self.fc1 = nn.Linear(9216, 128)
        self.fc2 = nn.Linear(128, 10)
        self.relu = nn.ReLU()
        self.softmax = nn.Softmax(dim=1)
        # TODO: define layers of your model
    def forward(self, x):
        x = self.conv1(x)
        x = self.relu(x)
        x = self.conv2(x)
        x = self.relu(x)
        x = nn.functional.max_pool2d(x, 2)
        x = self.dropout1(x)
        x = torch.flatten(x, 1)
        x = self.fc1(x)
        x = self.relu(x)
        x = self.dropout2(x)
        x = self.fc2(x)
        output = self.softmax(x)
        return output
```

```
# Do not change this cell
def caluculate_acc(data, model, length):
  model.eval()
  acc = 0
  for images, label in data:
    with torch.no_grad():
      images = images.to(device)
      label = label.to(device)
      yp = model(images)
      yp = torch.nn.functional.softmax(yp, dim=1)
      yp = torch.argmax(yp, 1)
      acc += torch.sum(yp == label)
  return acc / length


# Do not change this cell
def train_one_epoch(model, data, optimizer, criterion, length):
  model.train()
  acc = 0
  for images, labels in data:
    imgs = torch.autograd.Variable(images).to(device)
    label = torch.autograd.Variable(labels).to(device)
    optimizer.zero_grad()
    yp = model(imgs)
    loss = criterion(yp, label)
    loss.backward()
    optimizer.step()
    yp = torch.argmax(yp, 1)
    acc += torch.sum(yp == label)
  return loss.item(), acc / length


# TODO: define your model dont forget about device :)
model = Model().to(torch.device(device))

# TODO: define optimizer
optimizer = torch.optim.Adam(model.parameters(), lr=0.003)

# TODO: define loss
criterion = nn.CrossEntropyLoss()

# model summary
summary(model, (1, 28,28), batch_size=128)
```

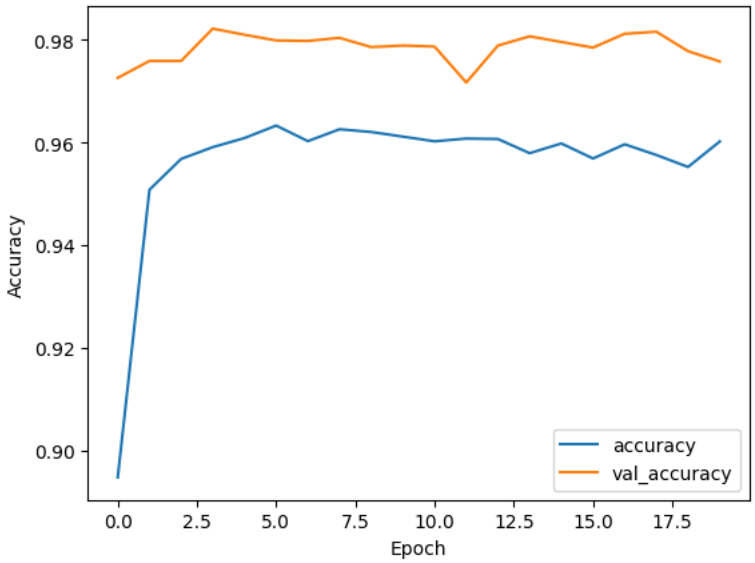
```
----------------------------------------------------------------
        Layer (type)               Output Shape         Param #
================================================================
            Conv2d-1          [128, 32, 26, 26]             320
              ReLU-2          [128, 32, 26, 26]               0
            Conv2d-3          [128, 64, 24, 24]          18,496
              ReLU-4          [128, 64, 24, 24]               0
           Dropout-5          [128, 64, 12, 12]               0
            Linear-6                  [128, 128]       1,179,776
              ReLU-7                  [128, 128]               0
           Dropout-8                  [128, 128]               0
            Linear-9                   [128, 10]           1,290
         Softmax-10                   [128, 10]               0
================================================================
Total params: 1,199,882
Trainable params: 1,199,882
Non-trainable params: 0
----------------------------------------------------------------
Input size (MB): 0.38
Forward/backward pass size (MB): 123.64
Params size (MB): 4.58
Estimated Total Size (MB): 128.60
----------------------------------------------------------------
```

```
# training process
val_accs = []
accs = []
best_acc = 0
for e in tqdm(range(20)):
  accs.append(train_one_epoch(model, train_loader, optimizer, criterion, len(train_set))[1].item())
  val_accs.append(caluculate_acc(test_loader, model, len(test_set)).item())
  if best_acc < val_accs[-1]:
    torch.save(model, "model.h5")
    best_Acc = val_accs[-1]

  # just a way to avoid pverfitting
  if val_accs[-1] > 0.99 and accs[-1] > 0.99:
    break
```

```
100%  20/20 [04:55<00:00, 14.40s/it]
```

```
plt.plot(accs, label='accuracy')
plt.plot(val_accs, label = 'val_accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend(loc='lower right')
plt.show();
```




```
caluculate_acc(test_loader, model, len(test_set)).item(), caluculate_acc(train_loader, model, len(train_set)).item()
```

```
(0.9757999777793884, 0.9764666557312012)
```

+ Code + Text