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Practical 10 - CNN

In [2]:
```
## here we will working with MNSIT dataset
from keras.datasets import mnist
from keras.utils.np_utils import to_categorical
```

In [6]:
```
## load data

(X_train,y_train),(X_test,y_test) = mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-data
sets/mnist.npz
11493376/11490434 [==============================] - 2s 0us/step
```

In [7]:
```
print(X_train.shape)  ## 60000 images of 28*28
print(X_test.shape)   ## 10000 images of 28*28
```

```
(60000, 28, 28)
(10000, 28, 28)
```

In [8]:
```
print(y_train.shape)
print(y_test.shape)
```

```
(60000,)
(10000,)
```

In [9]:
```
print(y_train[:10])
```

```
[5 0 4 1 9 2 1 3 1 4]
```

In [11]:
```
# type(y_train)
```

In [14]:
```
X_train = X_train.reshape(60000,28,28,1)
X_test  = X_test.reshape(10000,28,28,1)
y_train=to_categorical(y_train)
y_test=to_categorical(y_test)
```

In [16]:
```
y_train ## converted into categorical , one hot encoded format
```

Out[16]:
```
array([[0., 0., 0., ..., 0., 0., 0.],
       [1., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 1., 0.]], dtype=float32)
```

In [17]:
```
## train our model
```

In [18]:
```
from keras.models import Sequential
from keras.layers import Flatten,Conv2D,Dense
```

In [20]:
```
## build model

model = Sequential()
model.add(Conv2D(30,kernel_size=3,activation='relu',input_shape=(28,28,1)))
model.add(Conv2D(15,kernel_size=3,activation='relu'))
model.add(Flatten())
model.add(Dense(10,activation="softmax"))
```

In [21]:
```
model.compile(optimizer = 'adam',loss='categorical_crossentropy',metrics=["acc
uracy"])
```

In [22]:
```
model.summary()
```

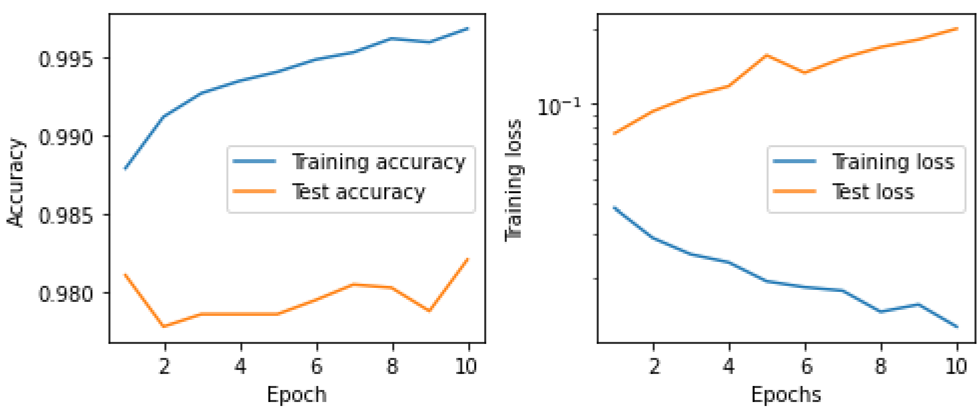
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 26, 26, 30)        300
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 24, 24, 15)        4065
_________________________________________________________________
flatten (Flatten)            (None, 8640)              0
_________________________________________________________________
dense (Dense)                (None, 10)                86410
=================================================================
Total params: 90,775
Trainable params: 90,775
Non-trainable params: 0
_________________________________________________________________
```

In [24]:
```
m1 = model.fit(X_train,y_train,validation_data=(X_test,y_test),epochs=10)  ##
 1st model
```

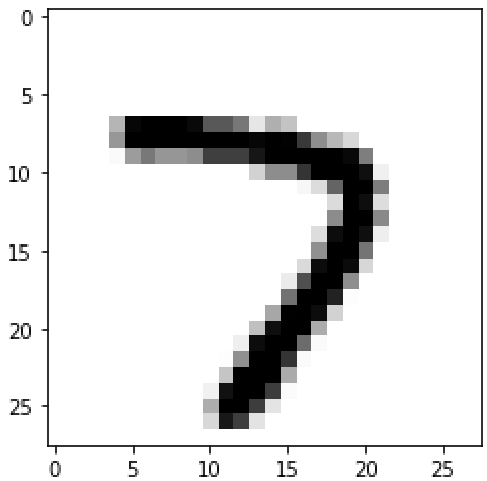
```
Epoch 1/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0380 - acc
uracy: 0.9879 - val_loss: 0.0761 - val_accuracy: 0.9811
Epoch 2/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0289 - acc
uracy: 0.9912 - val_loss: 0.0933 - val_accuracy: 0.9778
Epoch 3/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0248 - acc
uracy: 0.9927 - val_loss: 0.1073 - val_accuracy: 0.9786
Epoch 4/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0230 - acc
uracy: 0.9935 - val_loss: 0.1178 - val_accuracy: 0.9786
Epoch 5/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0193 - acc
uracy: 0.9941 - val_loss: 0.1572 - val_accuracy: 0.9786
Epoch 6/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0183 - acc
uracy: 0.9949 - val_loss: 0.1336 - val_accuracy: 0.9795
Epoch 7/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0177 - acc
uracy: 0.9954 - val_loss: 0.1531 - val_accuracy: 0.9805
Epoch 8/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0145 - acc
uracy: 0.9962 - val_loss: 0.1695 - val_accuracy: 0.9803
Epoch 9/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0155 - acc
uracy: 0.9960 - val_loss: 0.1820 - val_accuracy: 0.9788
Epoch 10/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0126 - acc
uracy: 0.9969 - val_loss: 0.2013 - val_accuracy: 0.9821
```

In [26]:

```
#Plot the train/test accuracy and train/test loss
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np

plt.figure(figsize=(7,3))

plt.subplot(1,2,1)
train_acc = m1.history['accuracy'];
test_acc = m1.history['val_accuracy'];

nepochs = len(train_acc);
sns.lineplot(x=np.arange(1,nepochs+1), y=train_acc, label='Training accuracy'
);
sns.lineplot(x=np.arange(1,nepochs+1), y=test_acc, label='Test accuracy');
plt.xlabel('Epoch');
plt.ylabel('Accuracy');

plt.subplot(1,2,2)
train_loss = m1.history['loss']
test_loss = m1.history['val_loss']
sns.lineplot(x=np.arange(1,nepochs+1), y=train_loss, label='Training loss');
sns.lineplot(x=np.arange(1,nepochs+1), y=test_loss, label='Test loss');
plt.yscale('log')
plt.xlabel('Epochs')
plt.ylabel('Training loss')
plt.tight_layout()
```



In [27]:
```
plt.imshow(X_test[17].reshape(28,28), cmap='binary');
```



In [32]:
```
# print(model.predict(X_test[[17]]))
print()
print('The number with max probability is')
print(np.argmax(model.predict(X_test[[17]])))
```

```
The number with max probability is
7
```

In [67]:
```
model2=Sequential()
model2.add(Conv2D(30,kernel_size=(3,3),activation='relu',input_shape=(28,28,1
)))
model2.add(Conv2D(64,kernel_size=(3,3),activation="relu"))
model2.add(Conv2D(15,kernel_size=(3,3),activation='relu'))
model2.add(Flatten())
model2.add(Dense(10,activation="softmax"))
```

In [68]:
```
model2.compile(optimizer = 'adam',loss='categorical_crossentropy',metrics=["ac
curacy"])
```

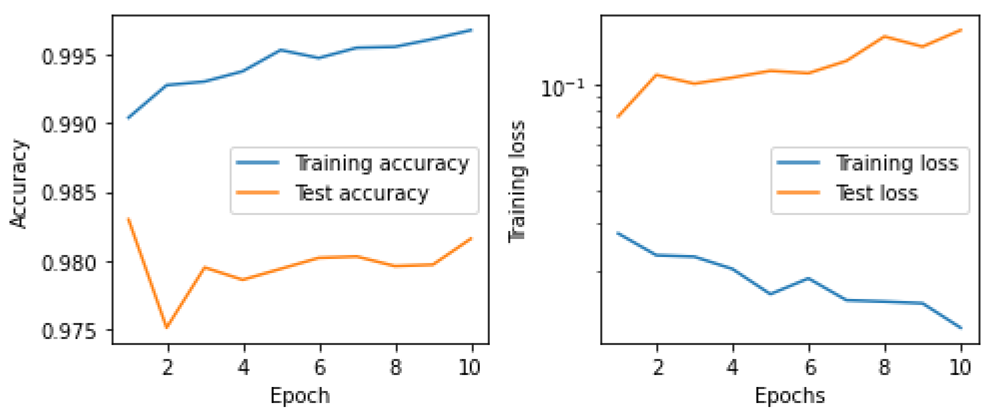
In [69]:
```
model2.summary()
```

```
Model: "sequential_6"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_15 (Conv2D)           (None, 26, 26, 30)        300       
_________________________________________________________________
conv2d_16 (Conv2D)           (None, 24, 24, 64)        17344     
_________________________________________________________________
conv2d_17 (Conv2D)           (None, 22, 22, 15)        8655      
_________________________________________________________________
flatten_6 (Flatten)          (None, 7260)              0         
_________________________________________________________________
dense_6 (Dense)              (None, 10)                72610     
=================================================================
Total params: 98,909
Trainable params: 98,909
Non-trainable params: 0
_________________________________________________________________
```

In [71]:
```
m2 = model2.fit(X_train,y_train,validation_data=(X_test,y_test),epochs=10)   ## 2nd model
```

```
Epoch 1/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0276 - accuracy: 0.9904 - val_loss: 0.0760 - val_accuracy: 0.9830
Epoch 2/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0228 - accuracy: 0.9928 - val_loss: 0.1091 - val_accuracy: 0.9751
Epoch 3/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0225 - accuracy: 0.9930 - val_loss: 0.1011 - val_accuracy: 0.9795
Epoch 4/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0203 - accuracy: 0.9938 - val_loss: 0.1065 - val_accuracy: 0.9786
Epoch 5/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0163 - accuracy: 0.9953 - val_loss: 0.1131 - val_accuracy: 0.9794
Epoch 6/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0187 - accuracy: 0.9948 - val_loss: 0.1107 - val_accuracy: 0.9802
Epoch 7/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0154 - accuracy: 0.9955 - val_loss: 0.1233 - val_accuracy: 0.9803
Epoch 8/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0153 - accuracy: 0.9956 - val_loss: 0.1524 - val_accuracy: 0.9796
Epoch 9/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0150 - accuracy: 0.9961 - val_loss: 0.1395 - val_accuracy: 0.9797
Epoch 10/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0121 - accuracy: 0.9968 - val_loss: 0.1610 - val_accuracy: 0.9816
```

In [72]:
```python
#Plot the train/test accuracy and train/test Loss
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np

plt.figure(figsize=(7,3))

plt.subplot(1,2,1)
train_acc = m2.history['accuracy'];
test_acc = m2.history['val_accuracy'];

nepochs = len(train_acc);
sns.lineplot(x=np.arange(1,nepochs+1), y=train_acc, label='Training accuracy'
);
sns.lineplot(x=np.arange(1,nepochs+1), y=test_acc, label='Test accuracy');
plt.xlabel('Epoch');
plt.ylabel('Accuracy');

plt.subplot(1,2,2)
train_loss = m2.history['loss']
test_loss = m2.history['val_loss']
sns.lineplot(x=np.arange(1,nepochs+1), y=train_loss, label='Training loss');
sns.lineplot(x=np.arange(1,nepochs+1), y=test_loss, label='Test loss');
plt.yscale('log')
plt.xlabel('Epochs')
plt.ylabel('Training loss')
plt.tight_layout()
```



In [ ]:
```python
## thus we tweaked first model and were able to get some slight improvement in
accuracy
```