# Question10

June 6, 2021

[1]:
```
from tensorflow import keras
import tensorflow as tf


# read mnist dataset
(train_x, train_y), (test_x, test_y) = keras.datasets.mnist.load_data()
# normalized 0~1
train_x = train_x / 255.0
test_x = test_x / 255.0
# expand dimension
train_x = tf.expand_dims(train_x, 3)
test_x = tf.expand_dims(test_x, 3)
# one-hot encoding
train_y = keras.utils.to_categorical(train_y)
test_y = keras.utils.to_categorical(test_y)
```

[5]:
```
# Lenet-5 model
lenet_5_model = keras.models.Sequential([
    keras.layers.Conv2D(6, kernel_size=5, strides=1,  activation='tanh',␣
 ↪input_shape=train_x[0].shape, padding='same'), #Conv layer 1
    keras.layers.AveragePooling2D(), #Pool layer 2
    keras.layers.Conv2D(16, kernel_size=5, strides=1, activation='tanh',␣
 ↪padding='valid'), #Conv layer 3
    keras.layers.AveragePooling2D(), #Pool layer 4
    keras.layers.Flatten(), #Flatten
    keras.layers.Dense(120, activation='tanh'), #Full layer 5
    keras.layers.Dense(84, activation='tanh'), #Full layer 6
    keras.layers.Dense(10, activation='softmax') # Output layer
])

# build model
lenet_5_model.compile(optimizer='adam', loss='categorical_crossentropy',␣
 ↪metrics=['accuracy'])
# train model
lenet_5_model.fit(train_x, train_y, epochs=5, verbose=1)
# predict label and calculate accuracy
test_loss, test_accuracy = lenet_5_model.evaluate(test_x, test_y)
```

```
print('test loss:', test_loss,'test accuracy:', test_accuracy)
```

```
Epoch 1/5
1875/1875 [==============================] - 16s 8ms/step - loss: 0.2246 -
accuracy: 0.9330
Epoch 2/5
1875/1875 [==============================] - 16s 8ms/step - loss: 0.0844 -
accuracy: 0.9740
Epoch 3/5
1875/1875 [==============================] - 15s 8ms/step - loss: 0.0573 -
accuracy: 0.9828
Epoch 4/5
1875/1875 [==============================] - 16s 8ms/step - loss: 0.0437 -
accuracy: 0.9857
Epoch 5/5
1875/1875 [==============================] - 16s 8ms/step - loss: 0.0356 -
accuracy: 0.9890
313/313 [==============================] - 1s 4ms/step - loss: 0.0456 -
accuracy: 0.9857
test loss: 0.04555569216609001 test accuracy: 0.9857000112533569
```