

```
In [ ]: pip -q install tensorflow keras
Note: you may need to restart the kernel to use updated packages.

In [ ]: #Importing libs
from sklearn.preprocessing import LabelBinarizer
from sklearn.metrics import classification_report
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.datasets import mnist, cifar10
from tensorflow.keras import backend as K
import matplotlib.pyplot as plt
import numpy as np
import argparse

2023-09-26 11:03:37.321604: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not find cuda drivers on your machine, GPU will not be used.
2023-09-26 11:03:39.690302: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not find cuda drivers on your machine, GPU will not be used.
2023-09-26 11:03:39.698886: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlow binary is optimized to use available CPU instructions in performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.
2023-09-26 11:03:44.312229: W tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not find TensorRT

In [ ]: #grab the MNIST dataset
print("[INFO] accessing MNIST...")
((trainX, trainY), (testX, testY)) = mnist.load_data()

[INFO] accessing MNIST...

In [ ]: #MNIST

# each image in the MNIST dataset is represented as a 28x28x1
# image, but in order to apply a standard neural network we must
# first "flatten" the image to be simple list of 28x28=784 pixels
trainX = trainX.reshape((trainX.shape[0], 784))
xtest_nonreshape = testX.reshape((testX.shape[0], 28, 28))
testX = testX.reshape((testX.shape[0], 28 * 28 * 1))

In [ ]: trainX.shape

Out[ ]: (60000, 784)

In [ ]: #CIFAR10

# each image in the CIFAR10 dataset is represented as a 32x32x3
# image, but in order to apply a standard neural network we must
# first "flatten" the image to be simple list of 32x32= pixels
trainX = trainX.reshape((trainX.shape[0], 32 * 32 * 3))
#xtest_nonreshape = testX.reshape((testX.shape[0], 32, 32))
testX = testX.reshape((testX.shape[0], 32 * 32 * 3))
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In [ ]: # scale data to the range of [0, 1]
trainX = trainX.astype("float32") / 255.0
testX = testX.astype("float32") / 255.0

In [ ]: # convert the labels from integers to vectors
lb = LabelBinarizer()
trainY = lb.fit_transform(trainY)
testY = lb.transform(testY)

In [ ]: #MNIST

# define the 784-256-128-10 architecture using Keras
model = Sequential()
model.add(Dense(256, input_shape=(784,), activation="sigmoid"))
model.add(Dense(128, activation="sigmoid"))
model.add(Dense(10, activation="softmax"))

In [ ]: #CIFAR10

# define the 784-256-128-10 architecture using Keras
model = Sequential()
model.add(Dense(256, input_shape=(3072,), activation="sigmoid"))
model.add(Dense(128, activation="sigmoid"))
model.add(Dense(10, activation="softmax"))

In [ ]: # train the model using SGD
print("[INFO] training network...")
sgd = SGD(0.01)
model.compile(loss="categorical_crossentropy", optimizer=sgd,
metrics=["accuracy"])
H = model.fit(trainX, trainY, validation_data=(testX, testY), epochs=200,
```

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[INFO] training network...
Epoch 1/200
469/469 [=====] - 2s 2ms/step - loss: 2.2851 - accuracy: 0.1625 - val_loss: 2.2478 - val_accuracy: 0.3316
Epoch 2/200
469/469 [=====] - 1s 2ms/step - loss: 2.2169 - accuracy: 0.3535 - val_loss: 2.1778 - val_accuracy: 0.4462
Epoch 3/200
469/469 [=====] - 1s 2ms/step - loss: 2.1365 - accuracy: 0.5069 - val_loss: 2.0803 - val_accuracy: 0.5661
Epoch 4/200
469/469 [=====] - 1s 2ms/step - loss: 2.0201 - accuracy: 0.5953 - val_loss: 1.9373 - val_accuracy: 0.6528
Epoch 5/200
469/469 [=====] - 1s 2ms/step - loss: 1.8522 - accuracy: 0.6434 - val_loss: 1.7389 - val_accuracy: 0.6537
Epoch 6/200
469/469 [=====] - 1s 2ms/step - loss: 1.6399 - accuracy: 0.6834 - val_loss: 1.5116 - val_accuracy: 0.7111
Epoch 7/200
469/469 [=====] - 1s 2ms/step - loss: 1.4204 - accuracy: 0.7172 - val_loss: 1.3004 - val_accuracy: 0.7534
Epoch 8/200
469/469 [=====] - 1s 2ms/step - loss: 1.2299 - accuracy: 0.7453 - val_loss: 1.1291 - val_accuracy: 0.7662
Epoch 9/200
469/469 [=====] - 1s 2ms/step - loss: 1.0787 - accuracy: 0.7661 - val_loss: 0.9965 - val_accuracy: 0.7827
Epoch 10/200
469/469 [=====] - 1s 2ms/step - loss: 0.9619 - accuracy: 0.7826 - val_loss: 0.8937 - val_accuracy: 0.7992
Epoch 11/200
469/469 [=====] - 1s 2ms/step - loss: 0.8707 - accuracy: 0.7965 - val_loss: 0.8134 - val_accuracy: 0.8156
Epoch 12/200
469/469 [=====] - 1s 2ms/step - loss: 0.7980 - accuracy: 0.8099 - val_loss: 0.7489 - val_accuracy: 0.8218
Epoch 13/200
469/469 [=====] - 1s 2ms/step - loss: 0.7393 - accuracy: 0.8198 - val_loss: 0.6952 - val_accuracy: 0.8310
Epoch 14/200
469/469 [=====] - 1s 2ms/step - loss: 0.6909 - accuracy: 0.8289 - val_loss: 0.6515 - val_accuracy: 0.8400
Epoch 15/200
469/469 [=====] - 1s 2ms/step - loss: 0.6504 - accuracy: 0.8376 - val_loss: 0.6145 - val_accuracy: 0.8454
Epoch 16/200
469/469 [=====] - 1s 2ms/step - loss: 0.6163 - accuracy: 0.8427 - val_loss: 0.5837 - val_accuracy: 0.8508
Epoch 17/200
469/469 [=====] - 1s 2ms/step - loss: 0.5871 - accuracy: 0.8494 - val_loss: 0.5560 - val_accuracy: 0.8581
Epoch 18/200
469/469 [=====] - 1s 2ms/step - loss: 0.5617 - accuracy: 0.8549 - val_loss: 0.5324 - val_accuracy: 0.8630
Epoch 19/200
469/469 [=====] - 1s 2ms/step - loss: 0.5398 - accuracy: 0.8596 - val_loss: 0.5126 - val_accuracy: 0.8686
Epoch 20/200
469/469 [=====] - 1s 2ms/step - loss: 0.5203 - a
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accuracy: 0.8636 - val_loss: 0.4939 - val_accuracy: 0.8729
Epoch 21/200
469/469 [=====] - 1s 2ms/step - loss: 0.5031 - a
curacy: 0.8671 - val_loss: 0.4779 - val_accuracy: 0.8737
Epoch 22/200
469/469 [=====] - 1s 2ms/step - loss: 0.4878 - a
curacy: 0.8709 - val_loss: 0.4638 - val_accuracy: 0.8791
Epoch 23/200
469/469 [=====] - 1s 2ms/step - loss: 0.4741 - a
curacy: 0.8742 - val_loss: 0.4511 - val_accuracy: 0.8819
Epoch 24/200
469/469 [=====] - 1s 2ms/step - loss: 0.4617 - a
curacy: 0.8771 - val_loss: 0.4392 - val_accuracy: 0.8854
Epoch 25/200
469/469 [=====] - 1s 2ms/step - loss: 0.4505 - a
curacy: 0.8798 - val_loss: 0.4288 - val_accuracy: 0.8854
Epoch 26/200
469/469 [=====] - 1s 2ms/step - loss: 0.4405 - a
curacy: 0.8818 - val_loss: 0.4192 - val_accuracy: 0.8870
Epoch 27/200
469/469 [=====] - 1s 2ms/step - loss: 0.4312 - a
curacy: 0.8837 - val_loss: 0.4108 - val_accuracy: 0.8896
Epoch 28/200
469/469 [=====] - 1s 2ms/step - loss: 0.4228 - a
curacy: 0.8860 - val_loss: 0.4033 - val_accuracy: 0.8923
Epoch 29/200
469/469 [=====] - 1s 2ms/step - loss: 0.4151 - a
curacy: 0.8876 - val_loss: 0.3955 - val_accuracy: 0.8929
Epoch 30/200
469/469 [=====] - 1s 2ms/step - loss: 0.4081 - a
curacy: 0.8890 - val_loss: 0.3892 - val_accuracy: 0.8940
Epoch 31/200
469/469 [=====] - 1s 2ms/step - loss: 0.4015 - a
curacy: 0.8902 - val_loss: 0.3828 - val_accuracy: 0.8949
Epoch 32/200
469/469 [=====] - 1s 2ms/step - loss: 0.3956 - a
curacy: 0.8918 - val_loss: 0.3775 - val_accuracy: 0.8946
Epoch 33/200
469/469 [=====] - 1s 2ms/step - loss: 0.3900 - a
curacy: 0.8927 - val_loss: 0.3727 - val_accuracy: 0.8958
Epoch 34/200
469/469 [=====] - 1s 2ms/step - loss: 0.3848 - a
curacy: 0.8942 - val_loss: 0.3677 - val_accuracy: 0.8991
Epoch 35/200
469/469 [=====] - 1s 2ms/step - loss: 0.3801 - a
curacy: 0.8950 - val_loss: 0.3634 - val_accuracy: 0.8987
Epoch 36/200
469/469 [=====] - 1s 2ms/step - loss: 0.3756 - a
curacy: 0.8962 - val_loss: 0.3595 - val_accuracy: 0.9007
Epoch 37/200
469/469 [=====] - 1s 2ms/step - loss: 0.3715 - a
curacy: 0.8970 - val_loss: 0.3550 - val_accuracy: 0.9012
Epoch 38/200
469/469 [=====] - 1s 2ms/step - loss: 0.3675 - a
curacy: 0.8971 - val_loss: 0.3518 - val_accuracy: 0.9017
Epoch 39/200
469/469 [=====] - 1s 2ms/step - loss: 0.3638 - a
curacy: 0.8979 - val_loss: 0.3483 - val_accuracy: 0.9024
Epoch 40/200
469/469 [=====] - 1s 2ms/step - loss: 0.3603 - a
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accuracy: 0.8989 - val_loss: 0.3449 - val_accuracy: 0.9034
Epoch 41/200
469/469 [=====] - 1s 2ms/step - loss: 0.3570 - a
ccuracy: 0.8999 - val_loss: 0.3419 - val_accuracy: 0.9046
Epoch 42/200
469/469 [=====] - 1s 2ms/step - loss: 0.3539 - a
ccuracy: 0.9005 - val_loss: 0.3392 - val_accuracy: 0.9046
Epoch 43/200
469/469 [=====] - 1s 2ms/step - loss: 0.3509 - a
ccuracy: 0.9013 - val_loss: 0.3366 - val_accuracy: 0.9057
Epoch 44/200
469/469 [=====] - 1s 2ms/step - loss: 0.3479 - a
ccuracy: 0.9020 - val_loss: 0.3341 - val_accuracy: 0.9056
Epoch 45/200
469/469 [=====] - 1s 2ms/step - loss: 0.3452 - a
ccuracy: 0.9026 - val_loss: 0.3312 - val_accuracy: 0.9066
Epoch 46/200
469/469 [=====] - 1s 2ms/step - loss: 0.3426 - a
ccuracy: 0.9032 - val_loss: 0.3291 - val_accuracy: 0.9069
Epoch 47/200
469/469 [=====] - 1s 2ms/step - loss: 0.3402 - a
ccuracy: 0.9036 - val_loss: 0.3262 - val_accuracy: 0.9074
Epoch 48/200
469/469 [=====] - 1s 2ms/step - loss: 0.3377 - a
ccuracy: 0.9043 - val_loss: 0.3244 - val_accuracy: 0.9077
Epoch 49/200
469/469 [=====] - 1s 2ms/step - loss: 0.3354 - a
ccuracy: 0.9046 - val_loss: 0.3224 - val_accuracy: 0.9071
Epoch 50/200
469/469 [=====] - 1s 2ms/step - loss: 0.3332 - a
ccuracy: 0.9054 - val_loss: 0.3202 - val_accuracy: 0.9086
Epoch 51/200
469/469 [=====] - 1s 2ms/step - loss: 0.3309 - a
ccuracy: 0.9058 - val_loss: 0.3185 - val_accuracy: 0.9095
Epoch 52/200
469/469 [=====] - 1s 2ms/step - loss: 0.3290 - a
ccuracy: 0.9063 - val_loss: 0.3164 - val_accuracy: 0.9094
Epoch 53/200
469/469 [=====] - 1s 2ms/step - loss: 0.3268 - a
ccuracy: 0.9066 - val_loss: 0.3147 - val_accuracy: 0.9102
Epoch 54/200
469/469 [=====] - 1s 2ms/step - loss: 0.3249 - a
ccuracy: 0.9072 - val_loss: 0.3132 - val_accuracy: 0.9103
Epoch 55/200
469/469 [=====] - 1s 2ms/step - loss: 0.3230 - a
ccuracy: 0.9078 - val_loss: 0.3110 - val_accuracy: 0.9115
Epoch 56/200
469/469 [=====] - 1s 2ms/step - loss: 0.3212 - a
ccuracy: 0.9081 - val_loss: 0.3098 - val_accuracy: 0.9114
Epoch 57/200
469/469 [=====] - 1s 2ms/step - loss: 0.3194 - a
ccuracy: 0.9087 - val_loss: 0.3083 - val_accuracy: 0.9119
Epoch 58/200
469/469 [=====] - 1s 2ms/step - loss: 0.3177 - a
ccuracy: 0.9090 - val_loss: 0.3064 - val_accuracy: 0.9129
Epoch 59/200
469/469 [=====] - 1s 2ms/step - loss: 0.3160 - a
ccuracy: 0.9094 - val_loss: 0.3048 - val_accuracy: 0.9127
Epoch 60/200
469/469 [=====] - 1s 2ms/step - loss: 0.3143 - a
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accuracy: 0.9099 - val_loss: 0.3035 - val_accuracy: 0.9140
Epoch 61/200
469/469 [=====] - 1s 2ms/step - loss: 0.3128 - a
ccuracy: 0.9105 - val_loss: 0.3018 - val_accuracy: 0.9140
Epoch 62/200
469/469 [=====] - 1s 2ms/step - loss: 0.3112 - a
ccuracy: 0.9105 - val_loss: 0.3006 - val_accuracy: 0.9143
Epoch 63/200
469/469 [=====] - 1s 2ms/step - loss: 0.3096 - a
ccuracy: 0.9111 - val_loss: 0.2993 - val_accuracy: 0.9140
Epoch 64/200
469/469 [=====] - 1s 2ms/step - loss: 0.3081 - a
ccuracy: 0.9115 - val_loss: 0.2980 - val_accuracy: 0.9143
Epoch 65/200
469/469 [=====] - 1s 2ms/step - loss: 0.3066 - a
ccuracy: 0.9123 - val_loss: 0.2968 - val_accuracy: 0.9150
Epoch 66/200
469/469 [=====] - 1s 2ms/step - loss: 0.3052 - a
ccuracy: 0.9123 - val_loss: 0.2954 - val_accuracy: 0.9157
Epoch 67/200
469/469 [=====] - 1s 2ms/step - loss: 0.3038 - a
ccuracy: 0.9126 - val_loss: 0.2942 - val_accuracy: 0.9155
Epoch 68/200
469/469 [=====] - 1s 2ms/step - loss: 0.3024 - a
ccuracy: 0.9128 - val_loss: 0.2929 - val_accuracy: 0.9165
Epoch 69/200
469/469 [=====] - 1s 2ms/step - loss: 0.3012 - a
ccuracy: 0.9137 - val_loss: 0.2916 - val_accuracy: 0.9171
Epoch 70/200
469/469 [=====] - 1s 2ms/step - loss: 0.2998 - a
ccuracy: 0.9136 - val_loss: 0.2905 - val_accuracy: 0.9168
Epoch 71/200
469/469 [=====] - 1s 2ms/step - loss: 0.2985 - a
ccuracy: 0.9140 - val_loss: 0.2893 - val_accuracy: 0.9168
Epoch 72/200
469/469 [=====] - 1s 2ms/step - loss: 0.2972 - a
ccuracy: 0.9147 - val_loss: 0.2885 - val_accuracy: 0.9176
Epoch 73/200
469/469 [=====] - 1s 2ms/step - loss: 0.2960 - a
ccuracy: 0.9152 - val_loss: 0.2871 - val_accuracy: 0.9189
Epoch 74/200
469/469 [=====] - 1s 2ms/step - loss: 0.2947 - a
ccuracy: 0.9153 - val_loss: 0.2863 - val_accuracy: 0.9186
Epoch 75/200
469/469 [=====] - 1s 2ms/step - loss: 0.2935 - a
ccuracy: 0.9160 - val_loss: 0.2857 - val_accuracy: 0.9188
Epoch 76/200
469/469 [=====] - 1s 2ms/step - loss: 0.2923 - a
ccuracy: 0.9161 - val_loss: 0.2840 - val_accuracy: 0.9187
Epoch 77/200
469/469 [=====] - 1s 2ms/step - loss: 0.2911 - a
ccuracy: 0.9161 - val_loss: 0.2836 - val_accuracy: 0.9205
Epoch 78/200
469/469 [=====] - 1s 2ms/step - loss: 0.2900 - a
ccuracy: 0.9166 - val_loss: 0.2823 - val_accuracy: 0.9197
Epoch 79/200
469/469 [=====] - 1s 2ms/step - loss: 0.2889 - a
ccuracy: 0.9172 - val_loss: 0.2808 - val_accuracy: 0.9197
Epoch 80/200
469/469 [=====] - 1s 2ms/step - loss: 0.2878 - a
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accuracy: 0.9176 - val_loss: 0.2799 - val_accuracy: 0.9196
Epoch 81/200
469/469 [=====] - 1s 2ms/step - loss: 0.2866 - a
ccuracy: 0.9176 - val_loss: 0.2792 - val_accuracy: 0.9209
Epoch 82/200
469/469 [=====] - 1s 2ms/step - loss: 0.2856 - a
ccuracy: 0.9181 - val_loss: 0.2784 - val_accuracy: 0.9208
Epoch 83/200
469/469 [=====] - 1s 2ms/step - loss: 0.2844 - a
ccuracy: 0.9187 - val_loss: 0.2770 - val_accuracy: 0.9210
Epoch 84/200
469/469 [=====] - 1s 2ms/step - loss: 0.2834 - a
ccuracy: 0.9186 - val_loss: 0.2764 - val_accuracy: 0.9210
Epoch 85/200
469/469 [=====] - 1s 2ms/step - loss: 0.2824 - a
ccuracy: 0.9189 - val_loss: 0.2757 - val_accuracy: 0.9216
Epoch 86/200
469/469 [=====] - 1s 2ms/step - loss: 0.2812 - a
ccuracy: 0.9192 - val_loss: 0.2743 - val_accuracy: 0.9216
Epoch 87/200
469/469 [=====] - 1s 2ms/step - loss: 0.2803 - a
ccuracy: 0.9193 - val_loss: 0.2736 - val_accuracy: 0.9229
Epoch 88/200
469/469 [=====] - 1s 2ms/step - loss: 0.2793 - a
ccuracy: 0.9199 - val_loss: 0.2728 - val_accuracy: 0.9223
Epoch 89/200
469/469 [=====] - 1s 2ms/step - loss: 0.2783 - a
ccuracy: 0.9199 - val_loss: 0.2719 - val_accuracy: 0.9220
Epoch 90/200
469/469 [=====] - 1s 2ms/step - loss: 0.2773 - a
ccuracy: 0.9202 - val_loss: 0.2709 - val_accuracy: 0.9234
Epoch 91/200
469/469 [=====] - 1s 2ms/step - loss: 0.2763 - a
ccuracy: 0.9203 - val_loss: 0.2702 - val_accuracy: 0.9237
Epoch 92/200
469/469 [=====] - 1s 2ms/step - loss: 0.2753 - a
ccuracy: 0.9206 - val_loss: 0.2694 - val_accuracy: 0.9227
Epoch 93/200
469/469 [=====] - 1s 2ms/step - loss: 0.2744 - a
ccuracy: 0.9208 - val_loss: 0.2685 - val_accuracy: 0.9240
Epoch 94/200
469/469 [=====] - 1s 2ms/step - loss: 0.2735 - a
ccuracy: 0.9214 - val_loss: 0.2678 - val_accuracy: 0.9230
Epoch 95/200
469/469 [=====] - 1s 2ms/step - loss: 0.2725 - a
ccuracy: 0.9211 - val_loss: 0.2666 - val_accuracy: 0.9244
Epoch 96/200
469/469 [=====] - 1s 2ms/step - loss: 0.2716 - a
ccuracy: 0.9214 - val_loss: 0.2663 - val_accuracy: 0.9252
Epoch 97/200
469/469 [=====] - 1s 2ms/step - loss: 0.2707 - a
ccuracy: 0.9217 - val_loss: 0.2651 - val_accuracy: 0.9245
Epoch 98/200
469/469 [=====] - 1s 2ms/step - loss: 0.2697 - a
ccuracy: 0.9219 - val_loss: 0.2642 - val_accuracy: 0.9250
Epoch 99/200
469/469 [=====] - 1s 2ms/step - loss: 0.2688 - a
ccuracy: 0.9221 - val_loss: 0.2638 - val_accuracy: 0.9249
Epoch 100/200
469/469 [=====] - 1s 2ms/step - loss: 0.2679 - a
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accuracy: 0.9223 - val\_loss: 0.2628 - val\_accuracy: 0.9254  
Epoch 101/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2670 - a  
ccuracy: 0.9224 - val\_loss: 0.2620 - val\_accuracy: 0.9261  
Epoch 102/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2661 - a  
ccuracy: 0.9228 - val\_loss: 0.2614 - val\_accuracy: 0.9247  
Epoch 103/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2653 - a  
ccuracy: 0.9230 - val\_loss: 0.2607 - val\_accuracy: 0.9256  
Epoch 104/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2644 - a  
ccuracy: 0.9232 - val\_loss: 0.2599 - val\_accuracy: 0.9253  
Epoch 105/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2636 - a  
ccuracy: 0.9233 - val\_loss: 0.2591 - val\_accuracy: 0.9256  
Epoch 106/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2627 - a  
ccuracy: 0.9237 - val\_loss: 0.2578 - val\_accuracy: 0.9261  
Epoch 107/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2618 - a  
ccuracy: 0.9238 - val\_loss: 0.2577 - val\_accuracy: 0.9256  
Epoch 108/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2610 - a  
ccuracy: 0.9239 - val\_loss: 0.2570 - val\_accuracy: 0.9270  
Epoch 109/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2601 - a  
ccuracy: 0.9247 - val\_loss: 0.2558 - val\_accuracy: 0.9256  
Epoch 110/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2593 - a  
ccuracy: 0.9247 - val\_loss: 0.2554 - val\_accuracy: 0.9275  
Epoch 111/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2585 - a  
ccuracy: 0.9250 - val\_loss: 0.2546 - val\_accuracy: 0.9268  
Epoch 112/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2576 - a  
ccuracy: 0.9250 - val\_loss: 0.2541 - val\_accuracy: 0.9266  
Epoch 113/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2569 - a  
ccuracy: 0.9254 - val\_loss: 0.2530 - val\_accuracy: 0.9270  
Epoch 114/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2560 - a  
ccuracy: 0.9258 - val\_loss: 0.2522 - val\_accuracy: 0.9270  
Epoch 115/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2552 - a  
ccuracy: 0.9260 - val\_loss: 0.2515 - val\_accuracy: 0.9272  
Epoch 116/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2544 - a  
ccuracy: 0.9260 - val\_loss: 0.2511 - val\_accuracy: 0.9281  
Epoch 117/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2536 - a  
ccuracy: 0.9265 - val\_loss: 0.2508 - val\_accuracy: 0.9278  
Epoch 118/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2528 - a  
ccuracy: 0.9267 - val\_loss: 0.2499 - val\_accuracy: 0.9280  
Epoch 119/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2520 - a  
ccuracy: 0.9266 - val\_loss: 0.2492 - val\_accuracy: 0.9283  
Epoch 120/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2512 - a

```
accuracy: 0.9269 - val_loss: 0.2479 - val_accuracy: 0.9287
Epoch 121/200
469/469 [=====] - 1s 2ms/step - loss: 0.2504 - a
ccuracy: 0.9274 - val_loss: 0.2473 - val_accuracy: 0.9294
Epoch 122/200
469/469 [=====] - 1s 2ms/step - loss: 0.2496 - a
ccuracy: 0.9275 - val_loss: 0.2466 - val_accuracy: 0.9287
Epoch 123/200
469/469 [=====] - 1s 2ms/step - loss: 0.2489 - a
ccuracy: 0.9281 - val_loss: 0.2461 - val_accuracy: 0.9291
Epoch 124/200
469/469 [=====] - 1s 2ms/step - loss: 0.2480 - a
ccuracy: 0.9280 - val_loss: 0.2455 - val_accuracy: 0.9293
Epoch 125/200
469/469 [=====] - 1s 2ms/step - loss: 0.2474 - a
ccuracy: 0.9280 - val_loss: 0.2448 - val_accuracy: 0.9290
Epoch 126/200
469/469 [=====] - 1s 2ms/step - loss: 0.2465 - a
ccuracy: 0.9281 - val_loss: 0.2443 - val_accuracy: 0.9299
Epoch 127/200
469/469 [=====] - 1s 2ms/step - loss: 0.2458 - a
ccuracy: 0.9287 - val_loss: 0.2433 - val_accuracy: 0.9299
Epoch 128/200
469/469 [=====] - 1s 2ms/step - loss: 0.2451 - a
ccuracy: 0.9292 - val_loss: 0.2428 - val_accuracy: 0.9302
Epoch 129/200
469/469 [=====] - 1s 2ms/step - loss: 0.2443 - a
ccuracy: 0.9295 - val_loss: 0.2418 - val_accuracy: 0.9310
Epoch 130/200
469/469 [=====] - 1s 2ms/step - loss: 0.2436 - a
ccuracy: 0.9296 - val_loss: 0.2414 - val_accuracy: 0.9306
Epoch 131/200
469/469 [=====] - 1s 2ms/step - loss: 0.2428 - a
ccuracy: 0.9297 - val_loss: 0.2406 - val_accuracy: 0.9312
Epoch 132/200
469/469 [=====] - 1s 2ms/step - loss: 0.2420 - a
ccuracy: 0.9297 - val_loss: 0.2400 - val_accuracy: 0.9309
Epoch 133/200
469/469 [=====] - 1s 2ms/step - loss: 0.2412 - a
ccuracy: 0.9305 - val_loss: 0.2396 - val_accuracy: 0.9311
Epoch 134/200
469/469 [=====] - 1s 2ms/step - loss: 0.2406 - a
ccuracy: 0.9301 - val_loss: 0.2388 - val_accuracy: 0.9312
Epoch 135/200
469/469 [=====] - 1s 2ms/step - loss: 0.2398 - a
ccuracy: 0.9302 - val_loss: 0.2385 - val_accuracy: 0.9315
Epoch 136/200
469/469 [=====] - 1s 2ms/step - loss: 0.2391 - a
ccuracy: 0.9309 - val_loss: 0.2374 - val_accuracy: 0.9319
Epoch 137/200
469/469 [=====] - 1s 2ms/step - loss: 0.2384 - a
ccuracy: 0.9313 - val_loss: 0.2369 - val_accuracy: 0.9319
Epoch 138/200
469/469 [=====] - 1s 2ms/step - loss: 0.2376 - a
ccuracy: 0.9312 - val_loss: 0.2366 - val_accuracy: 0.9322
Epoch 139/200
469/469 [=====] - 1s 2ms/step - loss: 0.2369 - a
ccuracy: 0.9316 - val_loss: 0.2354 - val_accuracy: 0.9323
Epoch 140/200
469/469 [=====] - 1s 2ms/step - loss: 0.2362 - a
```

```
accuracy: 0.9313 - val_loss: 0.2348 - val_accuracy: 0.9321
Epoch 141/200
469/469 [=====] - 1s 2ms/step - loss: 0.2355 - a
ccuracy: 0.9317 - val_loss: 0.2341 - val_accuracy: 0.9330
Epoch 142/200
469/469 [=====] - 1s 2ms/step - loss: 0.2348 - a
ccuracy: 0.9317 - val_loss: 0.2337 - val_accuracy: 0.9329
Epoch 143/200
469/469 [=====] - 1s 2ms/step - loss: 0.2340 - a
ccuracy: 0.9323 - val_loss: 0.2328 - val_accuracy: 0.9335
Epoch 144/200
469/469 [=====] - 1s 2ms/step - loss: 0.2334 - a
ccuracy: 0.9323 - val_loss: 0.2322 - val_accuracy: 0.9321
Epoch 145/200
469/469 [=====] - 1s 2ms/step - loss: 0.2327 - a
ccuracy: 0.9328 - val_loss: 0.2317 - val_accuracy: 0.9327
Epoch 146/200
469/469 [=====] - 1s 2ms/step - loss: 0.2320 - a
ccuracy: 0.9330 - val_loss: 0.2311 - val_accuracy: 0.9338
Epoch 147/200
469/469 [=====] - 1s 2ms/step - loss: 0.2313 - a
ccuracy: 0.9330 - val_loss: 0.2302 - val_accuracy: 0.9338
Epoch 148/200
469/469 [=====] - 1s 2ms/step - loss: 0.2305 - a
ccuracy: 0.9334 - val_loss: 0.2297 - val_accuracy: 0.9336
Epoch 149/200
469/469 [=====] - 1s 2ms/step - loss: 0.2299 - a
ccuracy: 0.9335 - val_loss: 0.2290 - val_accuracy: 0.9340
Epoch 150/200
469/469 [=====] - 1s 2ms/step - loss: 0.2292 - a
ccuracy: 0.9337 - val_loss: 0.2289 - val_accuracy: 0.9343
Epoch 151/200
469/469 [=====] - 1s 2ms/step - loss: 0.2286 - a
ccuracy: 0.9339 - val_loss: 0.2280 - val_accuracy: 0.9336
Epoch 152/200
469/469 [=====] - 1s 2ms/step - loss: 0.2278 - a
ccuracy: 0.9342 - val_loss: 0.2273 - val_accuracy: 0.9347
Epoch 153/200
469/469 [=====] - 1s 2ms/step - loss: 0.2271 - a
ccuracy: 0.9347 - val_loss: 0.2264 - val_accuracy: 0.9344
Epoch 154/200
469/469 [=====] - 1s 2ms/step - loss: 0.2265 - a
ccuracy: 0.9345 - val_loss: 0.2262 - val_accuracy: 0.9348
Epoch 155/200
469/469 [=====] - 1s 2ms/step - loss: 0.2258 - a
ccuracy: 0.9347 - val_loss: 0.2255 - val_accuracy: 0.9349
Epoch 156/200
469/469 [=====] - 1s 2ms/step - loss: 0.2251 - a
ccuracy: 0.9349 - val_loss: 0.2250 - val_accuracy: 0.9344
Epoch 157/200
469/469 [=====] - 1s 2ms/step - loss: 0.2244 - a
ccuracy: 0.9354 - val_loss: 0.2248 - val_accuracy: 0.9343
Epoch 158/200
469/469 [=====] - 1s 2ms/step - loss: 0.2237 - a
ccuracy: 0.9353 - val_loss: 0.2236 - val_accuracy: 0.9348
Epoch 159/200
469/469 [=====] - 1s 2ms/step - loss: 0.2231 - a
ccuracy: 0.9355 - val_loss: 0.2230 - val_accuracy: 0.9356
Epoch 160/200
469/469 [=====] - 1s 2ms/step - loss: 0.2224 - a
```

```
accuracy: 0.9357 - val_loss: 0.2226 - val_accuracy: 0.9353
Epoch 161/200
469/469 [=====] - 1s 2ms/step - loss: 0.2218 - a
ccuracy: 0.9361 - val_loss: 0.2223 - val_accuracy: 0.9355
Epoch 162/200
469/469 [=====] - 1s 2ms/step - loss: 0.2211 - a
ccuracy: 0.9363 - val_loss: 0.2211 - val_accuracy: 0.9356
Epoch 163/200
469/469 [=====] - 1s 2ms/step - loss: 0.2205 - a
ccuracy: 0.9365 - val_loss: 0.2206 - val_accuracy: 0.9356
Epoch 164/200
469/469 [=====] - 1s 2ms/step - loss: 0.2198 - a
ccuracy: 0.9363 - val_loss: 0.2199 - val_accuracy: 0.9359
Epoch 165/200
469/469 [=====] - 1s 2ms/step - loss: 0.2192 - a
ccuracy: 0.9369 - val_loss: 0.2196 - val_accuracy: 0.9363
Epoch 166/200
469/469 [=====] - 1s 2ms/step - loss: 0.2186 - a
ccuracy: 0.9371 - val_loss: 0.2188 - val_accuracy: 0.9369
Epoch 167/200
469/469 [=====] - 1s 2ms/step - loss: 0.2178 - a
ccuracy: 0.9374 - val_loss: 0.2185 - val_accuracy: 0.9371
Epoch 168/200
469/469 [=====] - 1s 2ms/step - loss: 0.2172 - a
ccuracy: 0.9373 - val_loss: 0.2176 - val_accuracy: 0.9365
Epoch 169/200
469/469 [=====] - 1s 2ms/step - loss: 0.2166 - a
ccuracy: 0.9379 - val_loss: 0.2171 - val_accuracy: 0.9369
Epoch 170/200
469/469 [=====] - 1s 2ms/step - loss: 0.2160 - a
ccuracy: 0.9378 - val_loss: 0.2168 - val_accuracy: 0.9364
Epoch 171/200
469/469 [=====] - 1s 2ms/step - loss: 0.2153 - a
ccuracy: 0.9383 - val_loss: 0.2158 - val_accuracy: 0.9370
Epoch 172/200
469/469 [=====] - 1s 2ms/step - loss: 0.2147 - a
ccuracy: 0.9385 - val_loss: 0.2156 - val_accuracy: 0.9373
Epoch 173/200
469/469 [=====] - 1s 2ms/step - loss: 0.2141 - a
ccuracy: 0.9388 - val_loss: 0.2148 - val_accuracy: 0.9380
Epoch 174/200
469/469 [=====] - 1s 2ms/step - loss: 0.2134 - a
ccuracy: 0.9388 - val_loss: 0.2145 - val_accuracy: 0.9374
Epoch 175/200
469/469 [=====] - 1s 2ms/step - loss: 0.2128 - a
ccuracy: 0.9391 - val_loss: 0.2136 - val_accuracy: 0.9377
Epoch 176/200
469/469 [=====] - 1s 2ms/step - loss: 0.2122 - a
ccuracy: 0.9391 - val_loss: 0.2131 - val_accuracy: 0.9373
Epoch 177/200
469/469 [=====] - 1s 2ms/step - loss: 0.2115 - a
ccuracy: 0.9397 - val_loss: 0.2127 - val_accuracy: 0.9374
Epoch 178/200
469/469 [=====] - 1s 2ms/step - loss: 0.2110 - a
ccuracy: 0.9396 - val_loss: 0.2117 - val_accuracy: 0.9386
Epoch 179/200
469/469 [=====] - 1s 2ms/step - loss: 0.2104 - a
ccuracy: 0.9400 - val_loss: 0.2114 - val_accuracy: 0.9380
Epoch 180/200
469/469 [=====] - 1s 2ms/step - loss: 0.2098 - a
```

accuracy: 0.9400 - val\_loss: 0.2111 - val\_accuracy: 0.9376  
Epoch 181/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2091 - a  
ccuracy: 0.9402 - val\_loss: 0.2104 - val\_accuracy: 0.9379  
Epoch 182/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2085 - a  
ccuracy: 0.9402 - val\_loss: 0.2098 - val\_accuracy: 0.9390  
Epoch 183/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2079 - a  
ccuracy: 0.9405 - val\_loss: 0.2092 - val\_accuracy: 0.9402  
Epoch 184/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2073 - a  
ccuracy: 0.9410 - val\_loss: 0.2088 - val\_accuracy: 0.9384  
Epoch 185/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2067 - a  
ccuracy: 0.9410 - val\_loss: 0.2082 - val\_accuracy: 0.9394  
Epoch 186/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2061 - a  
ccuracy: 0.9410 - val\_loss: 0.2073 - val\_accuracy: 0.9401  
Epoch 187/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2056 - a  
ccuracy: 0.9412 - val\_loss: 0.2068 - val\_accuracy: 0.9396  
Epoch 188/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2050 - a  
ccuracy: 0.9417 - val\_loss: 0.2064 - val\_accuracy: 0.9396  
Epoch 189/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2043 - a  
ccuracy: 0.9417 - val\_loss: 0.2062 - val\_accuracy: 0.9399  
Epoch 190/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2038 - a  
ccuracy: 0.9416 - val\_loss: 0.2053 - val\_accuracy: 0.9392  
Epoch 191/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2032 - a  
ccuracy: 0.9423 - val\_loss: 0.2052 - val\_accuracy: 0.9399  
Epoch 192/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2026 - a  
ccuracy: 0.9422 - val\_loss: 0.2046 - val\_accuracy: 0.9403  
Epoch 193/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2020 - a  
ccuracy: 0.9426 - val\_loss: 0.2039 - val\_accuracy: 0.9399  
Epoch 194/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2014 - a  
ccuracy: 0.9424 - val\_loss: 0.2031 - val\_accuracy: 0.9395  
Epoch 195/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2009 - a  
ccuracy: 0.9428 - val\_loss: 0.2027 - val\_accuracy: 0.9402  
Epoch 196/200  
469/469 [=====] - 1s 2ms/step - loss: 0.2003 - a  
ccuracy: 0.9427 - val\_loss: 0.2026 - val\_accuracy: 0.9408  
Epoch 197/200  
469/469 [=====] - 1s 2ms/step - loss: 0.1998 - a  
ccuracy: 0.9430 - val\_loss: 0.2020 - val\_accuracy: 0.9406  
Epoch 198/200  
469/469 [=====] - 1s 2ms/step - loss: 0.1992 - a  
ccuracy: 0.9436 - val\_loss: 0.2011 - val\_accuracy: 0.9416  
Epoch 199/200  
469/469 [=====] - 1s 2ms/step - loss: 0.1986 - a  
ccuracy: 0.9435 - val\_loss: 0.2005 - val\_accuracy: 0.9411  
Epoch 200/200  
469/469 [=====] - 1s 2ms/step - loss: 0.1979 - a

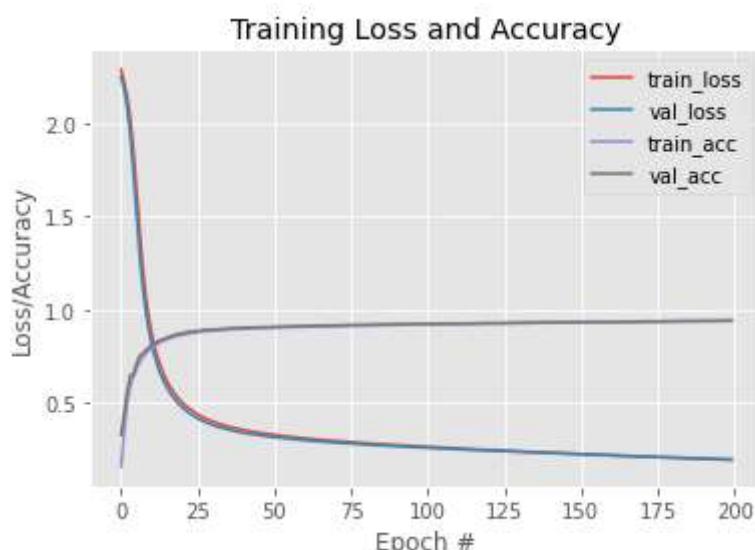
```
accuracy: 0.9434 - val_loss: 0.2001 - val_accuracy: 0.9411
```

```
In [ ]: # evaluate the network
print("[INFO] evaluating network...")
predictions = model.predict(testX, batch_size=128)
print(classification_report(testY.argmax(axis=1),
predictions.argmax(axis=1),
target_names=[str(x) for x in lb.classes_]))
```

```
[INFO] evaluating network...
```

```
79/79 [=====] - 0s 1ms/step
          precision    recall   f1-score   support
          0         0.95     0.98     0.97     980
          1         0.97     0.98     0.98    1135
          2         0.94     0.93     0.93    1032
          3         0.93     0.94     0.93    1010
          4         0.93     0.94     0.94    982
          5         0.94     0.90     0.92    892
          6         0.94     0.95     0.95    958
          7         0.94     0.94     0.94    1028
          8         0.92     0.92     0.92    974
          9         0.94     0.92     0.93    1009
accuracy                           0.94    10000
macro avg      0.94     0.94     0.94    10000
weighted avg   0.94     0.94     0.94    10000
```

```
In [ ]: # plot the training loss and accuracy
plt.style.use("ggplot")
plt.figure()
plt.plot(np.arange(0, 200), H.history["loss"], label="train_loss")
plt.plot(np.arange(0, 200), H.history["val_loss"], label="val_loss")
plt.plot(np.arange(0, 200), H.history["accuracy"], label="train_acc")
plt.plot(np.arange(0, 200), H.history["val_accuracy"], label="val_acc")
plt.title("Training Loss and Accuracy")
plt.xlabel("Epoch #")
plt.ylabel("Loss/Accuracy")
plt.legend()
plt.savefig('output.png')
```



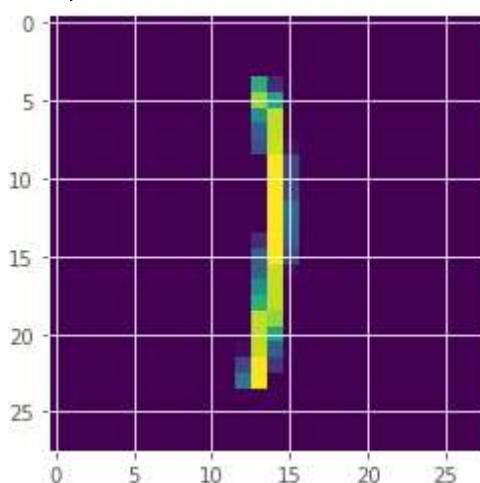
```
In [ ]: import random

r = random.randint(0,100)
#r = 0
plt.imshow(xtest_nonreshape[r])

prediction = model.predict(testX)
print(f"The predicted value is {np.argmax(prediction[r])}")
```

313/313 [=====] - 0s 617us/step

The predicted value is 1



```
In [ ]:
```