

ICP 4 REPORT

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import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Flatten, Dropout, BatchNormalization
from tensorflow.keras.datasets import mnist
from tensorflow.keras.utils import to_categorical

# Load the MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# Preprocess the data: normalize images and one-hot encode labels
x_train = x_train.astype('float32') / 255.0
x_test = x_test.astype('float32') / 255.0
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y_train = to_categorical(y_train, 10)
y_test = to_categorical(y_test, 10)

# Build a Sequential model
model = Sequential()

# Flatten the input (28x28 images) into a vector of size 784
model.add(Flatten(input_shape=(28, 28)))

# Add 5 hidden layers with increased neurons and Batch Normalization
model.add(Dense(1024, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.3))

model.add(Dense(512, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.3))

model.add(Dense(256, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.3))

model.add(Dense(128, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.3))

model.add(Dense(64, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.3))

# Add the output layer with 10 neurons (one for each class) and softmax activation
model.add(Dense(10, activation='softmax'))

# Compile the model using the 'adam' optimizer with a lower learning rate
optimizer = tf.keras.optimizers.Adam(learning_rate=0.0001)
model.compile(optimizer=optimizer,
              loss='categorical_crossentropy',
              metrics=['accuracy'])
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# Train the model with increased epochs
model.fit(x_train, y_train, epochs=100, batch_size=64, validation_split=0.2)

# Evaluate the model on the test data
test_loss, test_acc = model.evaluate(x_test, y_test)
print(f'Test accuracy: {test_acc}')
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Epoch 1/100
750/750 ————— 12s 5ms/step - accuracy: 0.4398 - loss: 1.7732 - val_accuracy: 0.9190 - val_loss: 0.2922
Epoch 2/100
750/750 ————— 3s 4ms/step - accuracy: 0.8445 - loss: 0.5362 - val_accuracy: 0.9473 - val_loss: 0.1823
Epoch 3/100
750/750 ————— 5s 4ms/step - accuracy: 0.8997 - loss: 0.3562 - val_accuracy: 0.9599 - val_loss: 0.1387
Epoch 4/100
750/750 ————— 5s 4ms/step - accuracy: 0.9222 - loss: 0.2719 - val_accuracy: 0.9664 - val_loss: 0.1159
Epoch 5/100
750/750 ————— 3s 4ms/step - accuracy: 0.9402 - loss: 0.2140 - val_accuracy: 0.9697 - val_loss: 0.1028
Epoch 6/100
750/750 ————— 5s 4ms/step - accuracy: 0.9480 - loss: 0.1852 - val_accuracy: 0.9727 - val_loss: 0.0957
Epoch 7/100
750/750 ————— 3s 4ms/step - accuracy: 0.9562 - loss: 0.1555 - val_accuracy: 0.9755 - val_loss: 0.0878
Epoch 8/100
750/750 ————— 3s 4ms/step - accuracy: 0.9622 - loss: 0.1316 - val_accuracy: 0.9769 - val_loss: 0.0846
Epoch 9/100
750/750 ————— 5s 4ms/step - accuracy: 0.9663 - loss: 0.1160 - val_accuracy: 0.9772 - val_loss: 0.0835
Epoch 10/100

Epoch 10/100
750/750 ————— 3s 4ms/step - accuracy: 0.9695 - loss: 0.1060 - val_accuracy: 0.9784 - val_loss: 0.0822
Epoch 11/100
750/750 ————— 3s 4ms/step - accuracy: 0.9736 - loss: 0.0919 - val_accuracy: 0.9785 - val_loss: 0.0810
Epoch 12/100
750/750 ————— 5s 4ms/step - accuracy: 0.9767 - loss: 0.0815 - val_accuracy: 0.9784 - val_loss: 0.0793
Epoch 13/100
750/750 ————— 3s 4ms/step - accuracy: 0.9797 - loss: 0.0707 - val_accuracy: 0.9801 - val_loss: 0.0789
Epoch 14/100
750/750 ————— 5s 4ms/step - accuracy: 0.9801 - loss: 0.0701 - val_accuracy: 0.9798 - val_loss: 0.0786
Epoch 15/100
750/750 ————— 3s 4ms/step - accuracy: 0.9818 - loss: 0.0605 - val_accuracy: 0.9788 - val_loss: 0.0806
Epoch 16/100
750/750 ————— 4s 4ms/step - accuracy: 0.9820 - loss: 0.0591 - val_accuracy: 0.9792 - val_loss: 0.0836
Epoch 17/100
750/750 ————— 3s 4ms/step - accuracy: 0.9855 - loss: 0.0524 - val_accuracy: 0.9821 - val_loss: 0.0775
Epoch 18/100
750/750 ————— 3s 4ms/step - accuracy: 0.9838 - loss: 0.0537 - val_accuracy: 0.9810 - val_loss: 0.0780
Epoch 19/100
750/750 ————— 3s 4ms/step - accuracy: 0.9873 - loss: 0.0455 - val_accuracy: 0.9807 - val_loss: 0.0826
Epoch 20/100
750/750 ————— 4s 3ms/step - accuracy: 0.9871 - loss: 0.0436 - val_accuracy: 0.9803 - val_loss: 0.0832
Epoch 21/100
750/750 ————— 3s 4ms/step - accuracy: 0.9868 - loss: 0.0441 - val_accuracy: 0.9817 - val_loss: 0.0777
Epoch 22/100
750/750 ————— 6s 4ms/step - accuracy: 0.9896 - loss: 0.0341 - val_accuracy: 0.9809 - val_loss: 0.0828
Epoch 23/100
750/750 ————— 5s 4ms/step - accuracy: 0.9885 - loss: 0.0383 - val_accuracy: 0.9814 - val_loss: 0.0824

Epoch 24/100
750/750 ————— 3s 4ms/step - accuracy: 0.9905 - loss: 0.0328 - val_accuracy: 0.9811 - val_loss: 0.0822
Epoch 25/100
750/750 ————— 3s 4ms/step - accuracy: 0.9895 - loss: 0.0345 - val_accuracy: 0.9814 - val_loss: 0.0846
Epoch 26/100
750/750 ————— 3s 4ms/step - accuracy: 0.9908 - loss: 0.0306 - val_accuracy: 0.9812 - val_loss: 0.0837
Epoch 27/100
750/750 ————— 5s 4ms/step - accuracy: 0.9892 - loss: 0.0329 - val_accuracy: 0.9811 - val_loss: 0.0852
Epoch 28/100
750/750 ————— 6s 4ms/step - accuracy: 0.9911 - loss: 0.0289 - val_accuracy: 0.9816 - val_loss: 0.0854
Epoch 29/100
750/750 ————— 3s 4ms/step - accuracy: 0.9906 - loss: 0.0300 - val_accuracy: 0.9826 - val_loss: 0.0823
Epoch 30/100
750/750 ————— 3s 4ms/step - accuracy: 0.9917 - loss: 0.0275 - val_accuracy: 0.9827 - val_loss: 0.0849
Epoch 31/100
750/750 ————— 5s 4ms/step - accuracy: 0.9920 - loss: 0.0269 - val_accuracy: 0.9818 - val_loss: 0.0880
Epoch 32/100
750/750 ————— 3s 5ms/step - accuracy: 0.9921 - loss: 0.0269 - val_accuracy: 0.9807 - val_loss: 0.0914
Epoch 33/100
750/750 ————— 4s 4ms/step - accuracy: 0.9925 - loss: 0.0275 - val_accuracy: 0.9821 - val_loss: 0.0894
Epoch 34/100
750/750 ————— 5s 4ms/step - accuracy: 0.9927 - loss: 0.0243 - val_accuracy: 0.9812 - val_loss: 0.0864
Epoch 35/100
750/750 ————— 4s 5ms/step - accuracy: 0.9933 - loss: 0.0220 - val_accuracy: 0.9828 - val_loss: 0.0855
Epoch 36/100
750/750 ————— 3s 4ms/step - accuracy: 0.9929 - loss: 0.0236 - val_accuracy: 0.9835 - val_loss: 0.0807
Epoch 37/100
750/750 ————— 3s 4ms/step - accuracy: 0.9930 - loss: 0.0218 - val_accuracy: 0.9836 - val_loss: 0.0838

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Epoch 38/100
750/750 6s 5ms/step - accuracy: 0.9935 - loss: 0.0217 - val_accuracy: 0.9826 - val_loss: 0.0861
Epoch 39/100
750/750 3s 4ms/step - accuracy: 0.9935 - loss: 0.0215 - val_accuracy: 0.9826 - val_loss: 0.0861
Epoch 40/100
750/750 5s 4ms/step - accuracy: 0.9939 - loss: 0.0204 - val_accuracy: 0.9840 - val_loss: 0.0872
Epoch 41/100
750/750 6s 5ms/step - accuracy: 0.9941 - loss: 0.0194 - val_accuracy: 0.9829 - val_loss: 0.0905
Epoch 42/100
750/750 3s 4ms/step - accuracy: 0.9947 - loss: 0.0176 - val_accuracy: 0.9822 - val_loss: 0.0958
Epoch 43/100
750/750 3s 3ms/step - accuracy: 0.9938 - loss: 0.0193 - val_accuracy: 0.9823 - val_loss: 0.0901
Epoch 44/100
750/750 6s 5ms/step - accuracy: 0.9942 - loss: 0.0192 - val_accuracy: 0.9828 - val_loss: 0.0912
Epoch 45/100
750/750 4s 4ms/step - accuracy: 0.9936 - loss: 0.0203 - val_accuracy: 0.9827 - val_loss: 0.0888
Epoch 46/100
750/750 3s 4ms/step - accuracy: 0.9941 - loss: 0.0180 - val_accuracy: 0.9825 - val_loss: 0.0892
Epoch 47/100
750/750 6s 4ms/step - accuracy: 0.9943 - loss: 0.0185 - val_accuracy: 0.9825 - val_loss: 0.0880
Epoch 48/100
750/750 3s 4ms/step - accuracy: 0.9941 - loss: 0.0175 - val_accuracy: 0.9827 - val_loss: 0.0876
Epoch 49/100
750/750 3s 4ms/step - accuracy: 0.9944 - loss: 0.0191 - val_accuracy: 0.9833 - val_loss: 0.0859
Epoch 50/100
750/750 3s 4ms/step - accuracy: 0.9952 - loss: 0.0150 - val_accuracy: 0.9833 - val_loss: 0.0899
Epoch 51/100
750/750 3s 4ms/step - accuracy: 0.9945 - loss: 0.0180 - val_accuracy: 0.9843 - val_loss: 0.0879
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Epoch 52/100
750/750 3s 4ms/step - accuracy: 0.9948 - loss: 0.0159 - val_accuracy: 0.9827 - val_loss: 0.0892
Epoch 53/100
750/750 5s 4ms/step - accuracy: 0.9955 - loss: 0.0153 - val_accuracy: 0.9839 - val_loss: 0.0897
Epoch 54/100
750/750 3s 4ms/step - accuracy: 0.9953 - loss: 0.0156 - val_accuracy: 0.9837 - val_loss: 0.0884
Epoch 55/100
750/750 5s 4ms/step - accuracy: 0.9949 - loss: 0.0156 - val_accuracy: 0.9818 - val_loss: 0.0965
Epoch 56/100
750/750 3s 4ms/step - accuracy: 0.9955 - loss: 0.0143 - val_accuracy: 0.9829 - val_loss: 0.0902
Epoch 57/100
750/750 6s 4ms/step - accuracy: 0.9948 - loss: 0.0183 - val_accuracy: 0.9838 - val_loss: 0.0898
Epoch 58/100
750/750 3s 4ms/step - accuracy: 0.9953 - loss: 0.0157 - val_accuracy: 0.9832 - val_loss: 0.0871
Epoch 59/100
750/750 3s 4ms/step - accuracy: 0.9957 - loss: 0.0139 - val_accuracy: 0.9826 - val_loss: 0.0892
Epoch 60/100
750/750 3s 4ms/step - accuracy: 0.9962 - loss: 0.0132 - val_accuracy: 0.9822 - val_loss: 0.0913
Epoch 61/100
750/750 5s 4ms/step - accuracy: 0.9964 - loss: 0.0121 - val_accuracy: 0.9832 - val_loss: 0.0908
Epoch 62/100
750/750 3s 4ms/step - accuracy: 0.9961 - loss: 0.0129 - val_accuracy: 0.9824 - val_loss: 0.0947
Epoch 63/100
750/750 5s 4ms/step - accuracy: 0.9953 - loss: 0.0159 - val_accuracy: 0.9823 - val_loss: 0.0967
Epoch 64/100
750/750 6s 4ms/step - accuracy: 0.9960 - loss: 0.0137 - val_accuracy: 0.9842 - val_loss: 0.0891
Epoch 65/100
750/750 3s 4ms/step - accuracy: 0.9961 - loss: 0.0128 - val_accuracy: 0.9828 - val_loss: 0.0937
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Epoch 66/100
750/750 5s 4ms/step - accuracy: 0.9964 - loss: 0.0121 - val_accuracy: 0.9835 - val_loss: 0.0924
Epoch 67/100
750/750 5s 4ms/step - accuracy: 0.9958 - loss: 0.0132 - val_accuracy: 0.9839 - val_loss: 0.0876
Epoch 68/100
750/750 3s 4ms/step - accuracy: 0.9962 - loss: 0.0125 - val_accuracy: 0.9837 - val_loss: 0.0887
Epoch 69/100
750/750 5s 4ms/step - accuracy: 0.9963 - loss: 0.0126 - val_accuracy: 0.9833 - val_loss: 0.0915
Epoch 70/100
750/750 5s 4ms/step - accuracy: 0.9957 - loss: 0.0126 - val_accuracy: 0.9833 - val_loss: 0.0918
Epoch 71/100
750/750 5s 4ms/step - accuracy: 0.9964 - loss: 0.0119 - val_accuracy: 0.9841 - val_loss: 0.0917
Epoch 72/100
750/750 5s 4ms/step - accuracy: 0.9971 - loss: 0.0111 - val_accuracy: 0.9829 - val_loss: 0.0889
Epoch 73/100
750/750 3s 4ms/step - accuracy: 0.9958 - loss: 0.0119 - val_accuracy: 0.9835 - val_loss: 0.0909
Epoch 74/100
750/750 6s 4ms/step - accuracy: 0.9966 - loss: 0.0115 - val_accuracy: 0.9848 - val_loss: 0.0900
Epoch 75/100
750/750 3s 4ms/step - accuracy: 0.9963 - loss: 0.0124 - val_accuracy: 0.9844 - val_loss: 0.0864
Epoch 76/100
750/750 5s 4ms/step - accuracy: 0.9964 - loss: 0.0117 - val_accuracy: 0.9848 - val_loss: 0.0880
Epoch 77/100
750/750 3s 4ms/step - accuracy: 0.9967 - loss: 0.0106 - val_accuracy: 0.9837 - val_loss: 0.0865
Epoch 78/100
750/750 3s 4ms/step - accuracy: 0.9967 - loss: 0.0111 - val_accuracy: 0.9837 - val_loss: 0.0920
Epoch 79/100
750/750 5s 4ms/step - accuracy: 0.9966 - loss: 0.0113 - val_accuracy: 0.9837 - val_loss: 0.0906
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