ICP-4 REPORT

ICP4.ipynb ☆

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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

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)))
```

```python
# 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'))
```

```python
# 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'])

# 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}')
```

```
Epoch 1/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 11s 5ms/step - accuracy: 0.4525 - loss: 1.7411 - val_accuracy: 0.9141 - val_loss: 0.2917
Epoch 2/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8473 - loss: 0.5206 - val_accuracy: 0.9434 - val_loss: 0.1847
Epoch 3/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 3ms/step - accuracy: 0.9025 - loss: 0.3444 - val_accuracy: 0.9566 - val_loss: 0.1446
Epoch 4/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9261 - loss: 0.2662 - val_accuracy: 0.9647 - val_loss: 0.1185
Epoch 5/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9388 - loss: 0.2158 - val_accuracy: 0.9693 - val_loss: 0.1047
Epoch 6/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9484 - loss: 0.1840 - val_accuracy: 0.9732 - val_loss: 0.0958
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Epoch 7/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9577 - loss: 0.1519 - val_accuracy: 0.9742 - val_loss: 0.0[illegible]
Epoch 8/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9627 - loss: 0.1289 - val_accuracy: 0.9752 - val_loss: 0.0885
Epoch 9/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9670 - loss: 0.1149 - val_accuracy: 0.9767 - val_loss: 0.0852
Epoch 10/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9684 - loss: 0.1092 - val_accuracy: 0.9783 - val_loss: 0.0815
Epoch 11/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9736 - loss: 0.0926 - val_accuracy: 0.9791 - val_loss: 0.0794
Epoch 12/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9736 - loss: 0.0889 - val_accuracy: 0.9787 - val_loss: 0.0785
Epoch 13/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9770 - loss: 0.0762 - val_accuracy: 0.9797 - val_loss: 0.0789
Epoch 14/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9789 - loss: 0.0696 - val_accuracy: 0.9800 - val_loss: 0.0804
Epoch 15/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9808 - loss: 0.0640 - val_accuracy: 0.9798 - val_loss: 0.0790
Epoch 16/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9812 - loss: 0.0607 - val_accuracy: 0.9808 - val_loss: 0.0760
Epoch 17/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9840 - loss: 0.0569 - val_accuracy: 0.9807 - val_loss: 0.0788
Epoch 18/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9849 - loss: 0.0513 - val_accuracy: 0.9807 - val_loss: 0.0759
Epoch 19/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9843 - loss: 0.0527 - val_accuracy: 0.9808 - val_loss: 0.0765
Epoch 20/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9868 - loss: 0.0450 - val_accuracy: 0.9809 - val_loss: 0.0818
Epoch 21/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9874 - loss: 0.0413 - val_accuracy: 0.9815 - val_loss: 0.0775
Epoch 22/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 3ms/step - accuracy: 0.9870 - loss: 0.0419 - val_accuracy: 0.9819 - val_loss: 0.0776
Epoch 23/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9877 - loss: 0.0399 - val_accuracy: 0.9817 - val_loss: 0.0835
Epoch 24/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9882 - loss: 0.0385 - val_accuracy: 0.9819 - val_loss: 0.0795
Epoch 25/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9890 - loss: 0.0354 - val_accuracy: 0.9827 - val_loss: 0.0785
Epoch 26/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9905 - loss: 0.0298 - val_accuracy: 0.9822 - val_loss: 0.0767
Epoch 27/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9911 - loss: 0.0288 - val_accuracy: 0.9822 - val_loss: 0.0783
Epoch 28/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9911 - loss: 0.0290 - val_accuracy: 0.9819 - val_loss: 0.0808
Epoch 29/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9900 - loss: 0.0328 - val_accuracy: 0.9819 - val_loss: 0.0832
Epoch 30/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9918 - loss: 0.0276 - val_accuracy: 0.9832 - val_loss: 0.0802
Epoch 31/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9910 - loss: 0.0287 - val_accuracy: 0.9826 - val_loss: 0.0765
Epoch 32/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 4s 4ms/step - accuracy: 0.9932 - loss: 0.0239 - val_accuracy: 0.9837 - val_loss: 0.0751
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Epoch 33/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9921 - loss: 0.0257 - val_accuracy: 0.9840 - val_loss: 0.0766
Epoch 34/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9920 - loss: 0.0242 - val_accuracy: 0.9831 - val_loss: 0.0766
Epoch 35/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9916 - loss: 0.0264 - val_accuracy: 0.9833 - val_loss: 0.0780
Epoch 36/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9934 - loss: 0.0218 - val_accuracy: 0.9833 - val_loss: 0.0787
Epoch 37/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9936 - loss: 0.0226 - val_accuracy: 0.9835 - val_loss: 0.0794
Epoch 38/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9922 - loss: 0.0245 - val_accuracy: 0.9834 - val_loss: 0.0781
Epoch 39/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9935 - loss: 0.0200 - val_accuracy: 0.9843 - val_loss: 0.0758
Epoch 40/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9932 - loss: 0.0213 - val_accuracy: 0.9841 - val_loss: 0.0787
Epoch 41/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9929 - loss: 0.0231 - val_accuracy: 0.9834 - val_loss: 0.0816
Epoch 42/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9940 - loss: 0.0196 - val_accuracy: 0.9832 - val_loss: 0.0820
Epoch 43/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 4s 4ms/step - accuracy: 0.9949 - loss: 0.0163 - val_accuracy: 0.9821 - val_loss: 0.0842
Epoch 44/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9950 - loss: 0.0175 - val_accuracy: 0.9836 - val_loss: 0.0810
Epoch 45/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9939 - loss: 0.0199 - val_accuracy: 0.9836 - val_loss: 0.0760
Epoch 46/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9949 - loss: 0.0171 - val_accuracy: 0.9837 - val_loss: 0.0782
Epoch 47/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9947 - loss: 0.0181 - val_accuracy: 0.9843 - val_loss: 0.0782
Epoch 48/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9941 - loss: 0.0186 - val_accuracy: 0.9836 - val_loss: 0.0849
Epoch 49/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9953 - loss: 0.0149 - val_accuracy: 0.9850 - val_loss: 0.0786
Epoch 50/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9950 - loss: 0.0160 - val_accuracy: 0.9845 - val_loss: 0.0766
Epoch 51/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 4s 4ms/step - accuracy: 0.9948 - loss: 0.0176 - val_accuracy: 0.9843 - val_loss: 0.0798
Epoch 52/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9949 - loss: 0.0172 - val_accuracy: 0.9847 - val_loss: 0.0750
Epoch 53/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9946 - loss: 0.0165 - val_accuracy: 0.9846 - val_loss: 0.0747
Epoch 54/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9953 - loss: 0.0161 - val_accuracy: 0.9833 - val_loss: 0.0815
Epoch 55/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9958 - loss: 0.0146 - val_accuracy: 0.9837 - val_loss: 0.0817
Epoch 56/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9957 - loss: 0.0155 - val_accuracy: 0.9838 - val_loss: 0.0825
Epoch 57/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9943 - loss: 0.0192 - val_accuracy: 0.9833 - val_loss: 0.0799
Epoch 58/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9957 - loss: 0.0149 - val_accuracy: 0.9831 - val_loss: 0.0829
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Epoch 59/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9957 - loss: 0.0157 - val_accuracy: 0.9849 - val_loss: 0.0761
Epoch 60/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9962 - loss: 0.0136 - val_accuracy: 0.9858 - val_loss: 0.0773
Epoch 61/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9963 - loss: 0.0116 - val_accuracy: 0.9847 - val_loss: 0.0761
Epoch 62/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.9958 - loss: 0.0146 - val_accuracy: 0.9837 - val_loss: 0.0796
Epoch 63/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 4s 4ms/step - accuracy: 0.9962 - loss: 0.0122 - val_accuracy: 0.9852 - val_loss: 0.0787
Epoch 64/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9955 - loss: 0.0147 - val_accuracy: 0.9833 - val_loss: 0.0838
Epoch 65/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 4s 4ms/step - accuracy: 0.9949 - loss: 0.0167 - val_accuracy: 0.9849 - val_loss: 0.0778
Epoch 66/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9959 - loss: 0.0125 - val_accuracy: 0.9851 - val_loss: 0.0755
Epoch 67/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 5ms/step - accuracy: 0.9960 - loss: 0.0125 - val_accuracy: 0.9844 - val_loss: 0.0836
Epoch 68/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 4s 4ms/step - accuracy: 0.9964 - loss: 0.0114 - val_accuracy: 0.9841 - val_loss: 0.0796
Epoch 69/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9971 - loss: 0.0100 - val_accuracy: 0.9836 - val_loss: 0.0822
Epoch 70/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 5ms/step - accuracy: 0.9960 - loss: 0.0128 - val_accuracy: 0.9844 - val_loss: 0.0842
Epoch 71/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9965 - loss: 0.0126 - val_accuracy: 0.9847 - val_loss: 0.0867
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Epoch 72/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9963 - loss: 0.0110 - val_accuracy: 0.9854 - val_loss: 0.0788
Epoch 73/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9964 - loss: 0.0115 - val_accuracy: 0.9843 - val_loss: 0.0802
Epoch 74/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9962 - loss: 0.0109 - val_accuracy: 0.9847 - val_loss: 0.0798
Epoch 75/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9966 - loss: 0.0116 - val_accuracy: 0.9838 - val_loss: 0.0819
Epoch 76/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9965 - loss: 0.0121 - val_accuracy: 0.9845 - val_loss: 0.0826
Epoch 77/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9959 - loss: 0.0132 - val_accuracy: 0.9849 - val_loss: 0.0808
Epoch 78/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9968 - loss: 0.0105 - val_accuracy: 0.9850 - val_loss: 0.0791
Epoch 79/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9971 - loss: 0.0097 - val_accuracy: 0.9841 - val_loss: 0.0813
Epoch 80/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9970 - loss: 0.0097 - val_accuracy: 0.9846 - val_loss: 0.0821
Epoch 81/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 5ms/step - accuracy: 0.9967 - loss: 0.0123 - val_accuracy: 0.9844 - val_loss: 0.0814
Epoch 82/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9973 - loss: 0.0089 - val_accuracy: 0.9841 - val_loss: 0.0825
Epoch 83/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9974 - loss: 0.0088 - val_accuracy: 0.9844 - val_loss: 0.0855
Epoch 84/100
750/750 ━━━━━━━━━━━━━━━━━━━━ 3s 4ms/step - accuracy: 0.9971 - loss: 0.0101 - val_accuracy: 0.9847 - val_loss: 0.0820
```

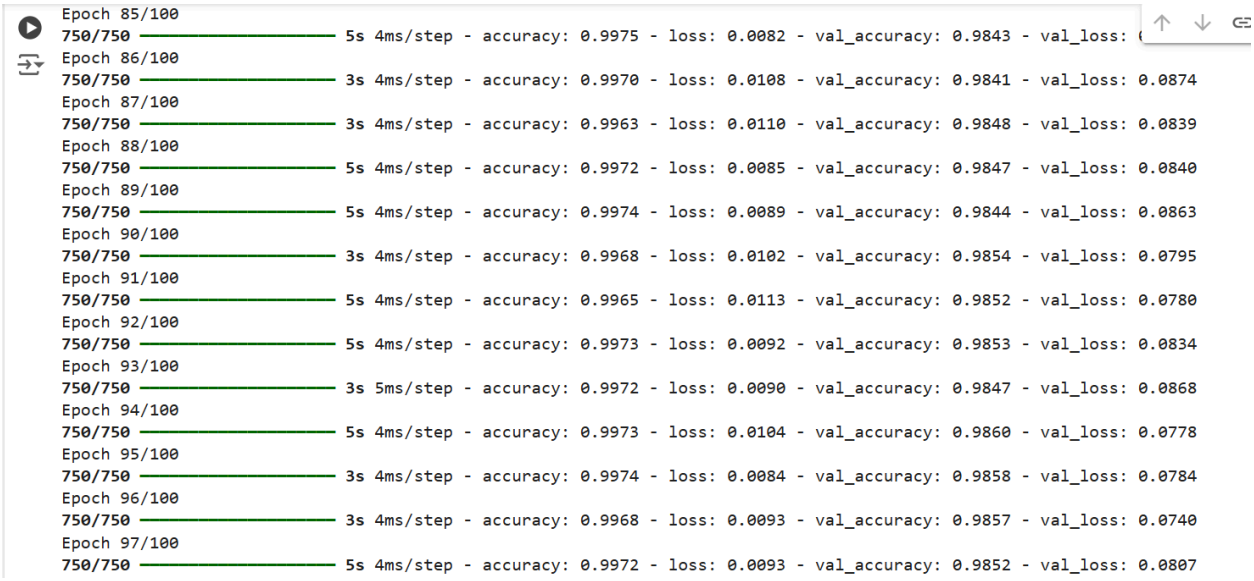

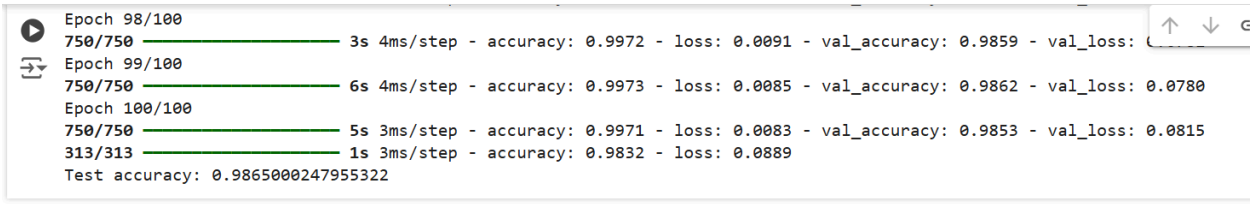

GITHUB REPO:- https://github.com/niharika0912/BDA.git

YOUTUBE URL:- https://youtu.be/9LHf5oh8J7w