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Nandakumar Vuppalapati-101179916

SRINIVASA ADITYA PREETHAM NIDADAVOLU-101177832

VENUGOPAL KILAARI MUNASWAMY-101164641

Shiva Shanth Reddy Nalla-101181446

Anantha Reddy Pingili-101178565

Agasya Sandilya Devarasetty-101176016

Ashok Sravan Gajjala-101181052

Mahesh Babu Akula-101176611

Maharshi Devarasetty -101139650

Nishyanth varun reddy Somagattu -101177053

pip install --upgrade pip

Requirement already satisfied: pip in c:\users\nalla\new folder\lib\
site-packages (23.3.1)Note: you may need to restart the kernel to use
updated packages.

Collecting pip
  Downloading pip-24.0-py3-none-any.whl.metadata (3.6 kB)
Downloading pip-24.0-py3-none-any.whl (2.1 MB)
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Installing collected packages: pip
  Attempting uninstall: pip
    Found existing installation: pip 23.3.1
    Uninstalling pip-23.3.1:
      Successfully uninstalled pip-23.3.1
Successfully installed pip-24.0
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pip install tensorflow

Collecting tensorflow
  Downloading tensorflow-2.16.1-cp311-cp311-win_amd64.whl.metadata
(3.5 kB)
Collecting tensorflow-intel==2.16.1 (from tensorflow)
  Downloading tensorflow_intel-2.16.1-cp311-cp311-
win_amd64.whl.metadata (5.0 kB)
Collecting absl-py>=1.0.0 (from tensorflow-intel==2.16.1->tensorflow)
  Downloading absl_py-2.1.0-py3-none-any.whl.metadata (2.3 kB)
Collecting astunparse>=1.6.0 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading astunparse-1.6.3-py2.py3-none-any.whl.metadata (4.4 kB)
Collecting flatbuffers>=23.5.26 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading flatbuffers-24.3.25-py2.py3-none-any.whl.metadata (850
bytes)
Collecting gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 (from tensorflow-
intel==2.16.1->tensorflow)
  Downloading gast-0.5.4-py3-none-any.whl.metadata (1.3 kB)
Collecting google-pasta>=0.1.1 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading google_pasta-0.2.0-py3-none-any.whl.metadata (814 bytes)
Collecting h5py>=3.10.0 (from tensorflow-intel==2.16.1->tensorflow)
  Downloading h5py-3.11.0-cp311-cp311-win_amd64.whl.metadata (2.5 kB)
Collecting libclang>=13.0.0 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading libclang-18.1.1-py2.py3-none-win_amd64.whl.metadata (5.3
kB)
Collecting ml-dtypes~=0.3.1 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading ml_dtypes-0.3.2-cp311-cp311-win_amd64.whl.metadata (20
kB)
Collecting opt-einsum>=2.3.2 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading opt_einsum-3.3.0-py3-none-any.whl.metadata (6.5 kB)
Requirement already satisfied: packaging in c:\users\nalla\new folder\
lib\site-packages (from tensorflow-intel==2.16.1->tensorflow) (23.1)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!
=4.21.3,!=4.21.4,!=4.21.5,<5.0.0dev,>=3.20.3 in c:\users\nalla\new
folder\lib\site-packages (from tensorflow-intel==2.16.1->tensorflow)
(3.20.3)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\nalla\
new folder\lib\site-packages (from tensorflow-intel==2.16.1-
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Requirement already satisfied: setuptools in c:\users\nalla\new
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(68.2.2)
Requirement already satisfied: six>=1.12.0 in c:\users\nalla\new
folder\lib\site-packages (from tensorflow-intel==2.16.1->tensorflow)
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Collecting termcolor>=1.1.0 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading termcolor-2.4.0-py3-none-any.whl.metadata (6.1 kB)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\
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Requirement already satisfied: wrapt>=1.11.0 in c:\users\nalla\new
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(1.14.1)
Collecting grpcio<2.0,>=1.24.3 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading grpcio-1.63.0-cp311-cp311-win_amd64.whl.metadata (3.3
kB)
Collecting tensorboard<2.17,>=2.16 (from tensorflow-intel==2.16.1-
>tensorflow)
  Downloading tensorboard-2.16.2-py3-none-any.whl.metadata (1.6 kB)
Collecting keras>=3.0.0 (from tensorflow-intel==2.16.1->tensorflow)
  Downloading keras-3.3.3-py3-none-any.whl.metadata (5.7 kB)
Collecting tensorflow-io-gcs-filesystem>=0.23.1 (from tensorflow-
intel==2.16.1->tensorflow)
  Downloading tensorflow_io_gcs_filesystem-0.31.0-cp311-cp311-
win_amd64.whl.metadata (14 kB)
Requirement already satisfied: numpy<2.0.0,>=1.23.5 in c:\users\nalla\
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Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\nalla\
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intel==2.16.1->tensorflow) (0.41.2)
Requirement already satisfied: rich in c:\users\nalla\new folder\lib\
site-packages (from keras>=3.0.0->tensorflow-intel==2.16.1-
>tensorflow) (13.3.5)
Collecting namex (from keras>=3.0.0->tensorflow-intel==2.16.1-
>tensorflow)
  Downloading namex-0.0.8-py3-none-any.whl.metadata (246 bytes)
Collecting optree (from keras>=3.0.0->tensorflow-intel==2.16.1-
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  Downloading optree-0.11.0-cp311-cp311-win_amd64.whl.metadata (46 kB)
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Requirement already satisfied: idna<4,>=2.5 in c:\users\nalla\new
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Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\nalla\
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Requirement already satisfied: markdown>=2.6.8 in c:\users\nalla\new
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Collecting tensorboard-data-server<0.8.0,>=0.7.0 (from
tensorboard<2.17,>=2.16->tensorflow-intel==2.16.1->tensorflow)
  Downloading tensorboard_data_server-0.7.2-py3-none-any.whl.metadata
(1.1 kB)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\nalla\new
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Requirement already satisfied: MarkupSafe>=2.1.1 in c:\users\nalla\new
folder\lib\site-packages (from werkzeug>=1.0.1-
>tensorboard<2.17,>=2.16->tensorflow-intel==2.16.1->tensorflow)
(2.1.3)
Requirement already satisfied: markdown-it-py<3.0.0,>=2.2.0 in c:\
users\nalla\new folder\lib\site-packages (from rich->keras>=3.0.0-
>tensorflow-intel==2.16.1->tensorflow) (2.2.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in c:\users\
nalla\new folder\lib\site-packages (from rich->keras>=3.0.0-
>tensorflow-intel==2.16.1->tensorflow) (2.15.1)
Requirement already satisfied: mdurl~=0.1 in c:\users\nalla\new
folder\lib\site-packages (from markdown-it-py<3.0.0,>=2.2.0->rich-
>keras>=3.0.0->tensorflow-intel==2.16.1->tensorflow) (0.1.0)
Downloading tensorflow-2.16.1-cp311-cp311-win_amd64.whl (2.1 kB)
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Downloading grpcio-1.63.0-cp311-cp311-win_amd64.whl (3.9 MB)
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   ---------------------------------------- 3.0/3.0 MB 27.0 MB/s eta
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Downloading keras-3.3.3-py3-none-any.whl (1.1 MB)
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   ---------------------------------------- 1.1/1.1 MB 23.5 MB/s eta
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Downloading libclang-18.1.1-py2.py3-none-win_amd64.whl (26.4 MB)
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   ---- ----------------------------------- 2.9/26.4 MB 31.4 MB/s eta
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   ---------- ----------------------------- 7.4/26.4 MB 31.5 MB/s eta
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   ---------------------------------------- 26.4/26.4 MB 25.1 MB/s eta
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Downloading ml_dtypes-0.3.2-cp311-cp311-win_amd64.whl (127 kB)
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Downloading opt_einsum-3.3.0-py3-none-any.whl (65 kB)
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Downloading tensorboard-2.16.2-py3-none-any.whl (5.5 MB)
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   ------------------------------ --------- 4.2/5.5 MB 29.8 MB/s eta
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   ---------------------------------------  5.5/5.5 MB 31.9 MB/s eta
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   ---------------------------------------- 5.5/5.5 MB 29.1 MB/s eta
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Downloading tensorflow_io_gcs_filesystem-0.31.0-cp311-cp311-
win_amd64.whl (1.5 MB)
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   ---------------------------------------- 1.5/1.5 MB 31.4 MB/s eta
0:00:00
Downloading termcolor-2.4.0-py3-none-any.whl (7.7 kB)
Downloading tensorboard_data_server-0.7.2-py3-none-any.whl (2.4 kB)
Downloading namex-0.0.8-py3-none-any.whl (5.8 kB)
Downloading optree-0.11.0-cp311-cp311-win_amd64.whl (245 kB)
   ---------------------------------------- 0.0/245.0 kB ? eta -:--:--
   ---------------------------------------- 245.0/245.0 kB 7.3 MB/s
eta 0:00:00
Installing collected packages: namex, libclang, flatbuffers,
termcolor, tensorflow-io-gcs-filesystem, tensorboard-data-server,
optree, opt-einsum, ml-dtypes, h5py, grpcio, google-pasta, gast,
astunparse, absl-py, tensorboard, keras, tensorflow-intel, tensorflow
  Attempting uninstall: h5py
    Found existing installation: h5py 3.9.0
    Uninstalling h5py-3.9.0:
      Successfully uninstalled h5py-3.9.0
Successfully installed absl-py-2.1.0 astunparse-1.6.3 flatbuffers-
24.3.25 gast-0.5.4 google-pasta-0.2.0 grpcio-1.63.0 h5py-3.11.0 keras-
3.3.3 libclang-18.1.1 ml-dtypes-0.3.2 namex-0.0.8 opt-einsum-3.3.0
optree-0.11.0 tensorboard-2.16.2 tensorboard-data-server-0.7.2
tensorflow-2.16.1 tensorflow-intel-2.16.1 tensorflow-io-gcs-
```

```
filesystem-0.31.0 termcolor-2.4.0
Note: you may need to restart the kernel to use updated packages.
```

```
import numpy as np
import tensorflow as tf
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten,
Dense
from sklearn.model_selection import KFold
from sklearn.metrics import confusion_matrix, accuracy_score
import matplotlib.pyplot as plt
import seaborn as sns

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

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-
keras-datasets/mnist.npz
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 1s 0us/step
```

```
# Preprocess the data
x_train = x_train.reshape(-1, 28, 28, 1).astype('float32') / 255.0
x_test = x_test.reshape(-1, 28, 28, 1).astype('float32') / 255.0

# Define the CNN architecture
def create_model():
 model = Sequential([
 Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)),
 MaxPooling2D((2, 2)),
 Conv2D(64, (3, 3), activation='relu'),
 MaxPooling2D((2, 2)),
 Conv2D(64, (3, 3), activation='relu'),
 Flatten(),
 Dense(64, activation='relu'),
 Dense(10, activation='softmax')
 ])
 return model

# Define K-Fold cross-validation
kfold = KFold(n_splits=5, shuffle=True)
fold = 0
accuracies = []
conf_matrices = []

for train_idx, val_idx in kfold.split(x_train):
    fold += 1
    print(f"Fold {fold}:")

    # Split data into training and validation sets
    x_fold_train, x_fold_val = x_train[train_idx], x_train[val_idx]
```

```
    y_fold_train, y_fold_val = y_train[train_idx], y_train[val_idx]

    class_labels = [str(i) for i in range(10)]

    # Create and compile the model
    model = create_model()
    model.compile(optimizer='adam',
loss='sparse_categorical_crossentropy', metrics=['accuracy'])

    # Train the model
    history = model.fit(x_fold_train, y_fold_train, epochs=5,
batch_size=64, validation_data=(x_fold_val, y_fold_val), verbose=1)

    # Evaluate the model
    _, accuracy = model.evaluate(x_test, y_test, verbose=0)
    accuracies.append(accuracy)
    print(f"Test Accuracy for Fold {fold}: {accuracy}")

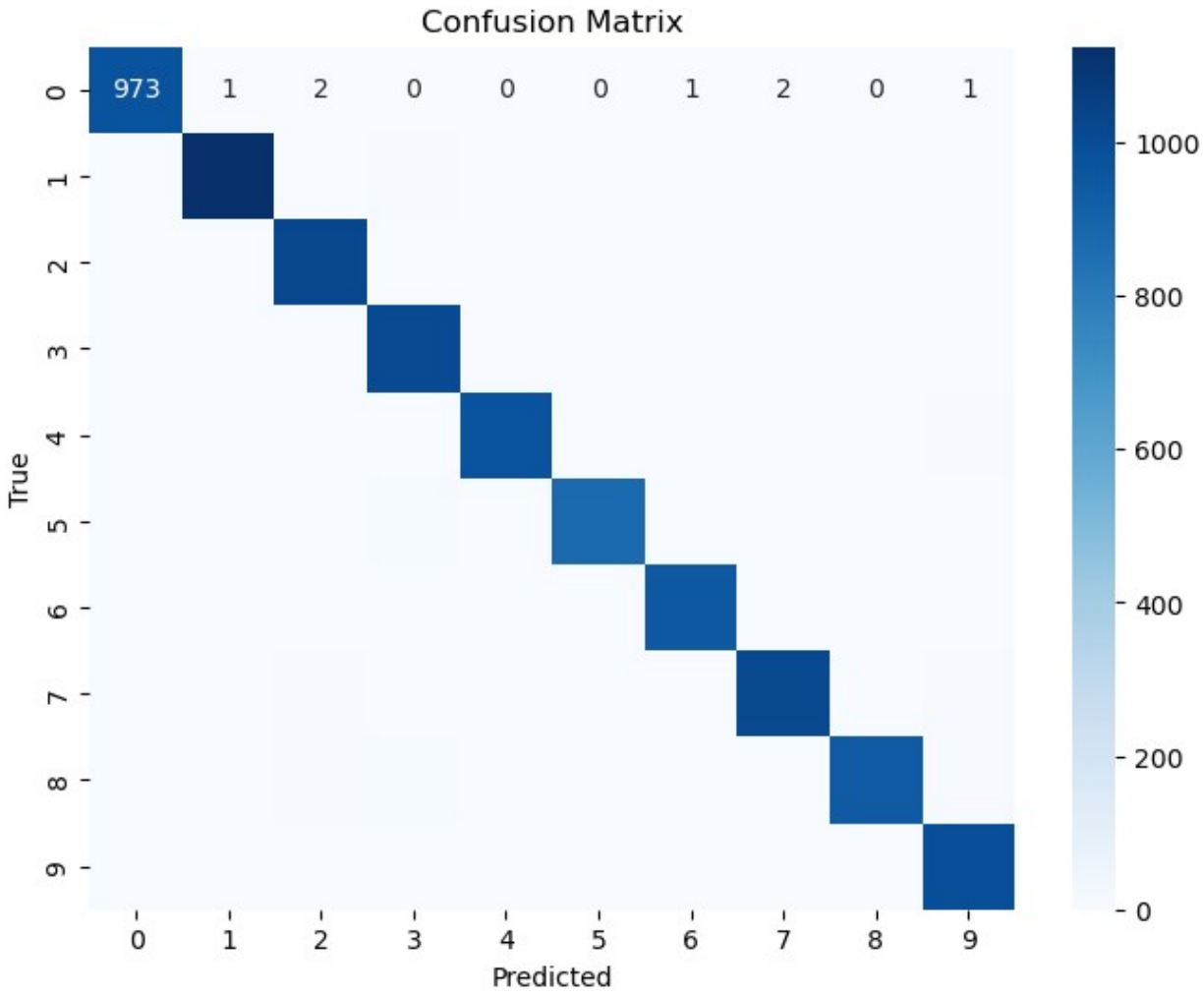
    # Confusion Matrix
    y_pred = np.argmax(model.predict(x_test), axis=-1)
    conf_matrix = confusion_matrix(y_test, y_pred)
    conf_matrices.append(conf_matrix)
    print("Confusion Matrix:")
    print(conf_matrix)
    plt.figure(figsize=(8, 6))
    sns.heatmap(conf_matrix, annot=True, fmt="d", cmap="Blues",
xticklabels=class_labels, yticklabels=class_labels)
    plt.xlabel("Predicted")
    plt.ylabel("True")
    plt.title("Confusion Matrix")
    plt.show()

Fold 1:
Epoch 1/5

C:\Users\nalla\New folder\Lib\site-packages\keras\src\layers\
convolutional\base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

750/750 ━━━━━━━━━━━━━━━━━━━━ 9s 10ms/step - accuracy: 0.8451 - loss:
0.4901 - val_accuracy: 0.9803 - val_loss: 0.0616
Epoch 2/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.9820 - loss:
0.0587 - val_accuracy: 0.9768 - val_loss: 0.0713
Epoch 3/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9874 - loss:
```

```
0.0410 - val_accuracy: 0.9857 - val_loss: 0.0450
Epoch 4/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 7ms/step - accuracy: 0.9908 - loss:
0.0296 - val_accuracy: 0.9855 - val_loss: 0.0471
Epoch 5/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 7ms/step - accuracy: 0.9923 - loss:
0.0257 - val_accuracy: 0.9868 - val_loss: 0.0440
Test Accuracy for Fold 1: 0.9882000088691711
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
Confusion Matrix:
[[ 973    1    2    0    0    0    1    2    0    1]
 [   0 1125    1    6    1    0    0    2    0    0]
 [   1    0 1027    1    0    0    0    3    0    0]
 [   0    0    2 1007    0    1    0    0    0    0]
 [   0    0    1    0  972    0    1    1    0    7]
 [   0    0    1   10    0  878    2    0    0    1]
 [   2    3    1    0    2    3  947    0    0    0]
 [   0    1    6    0    0    0    0 1016    0    5]
 [   2    0    7   12    1    2    2    3  940    5]
 [   0    0    0    2    3    4    0    3    0  997]]
```

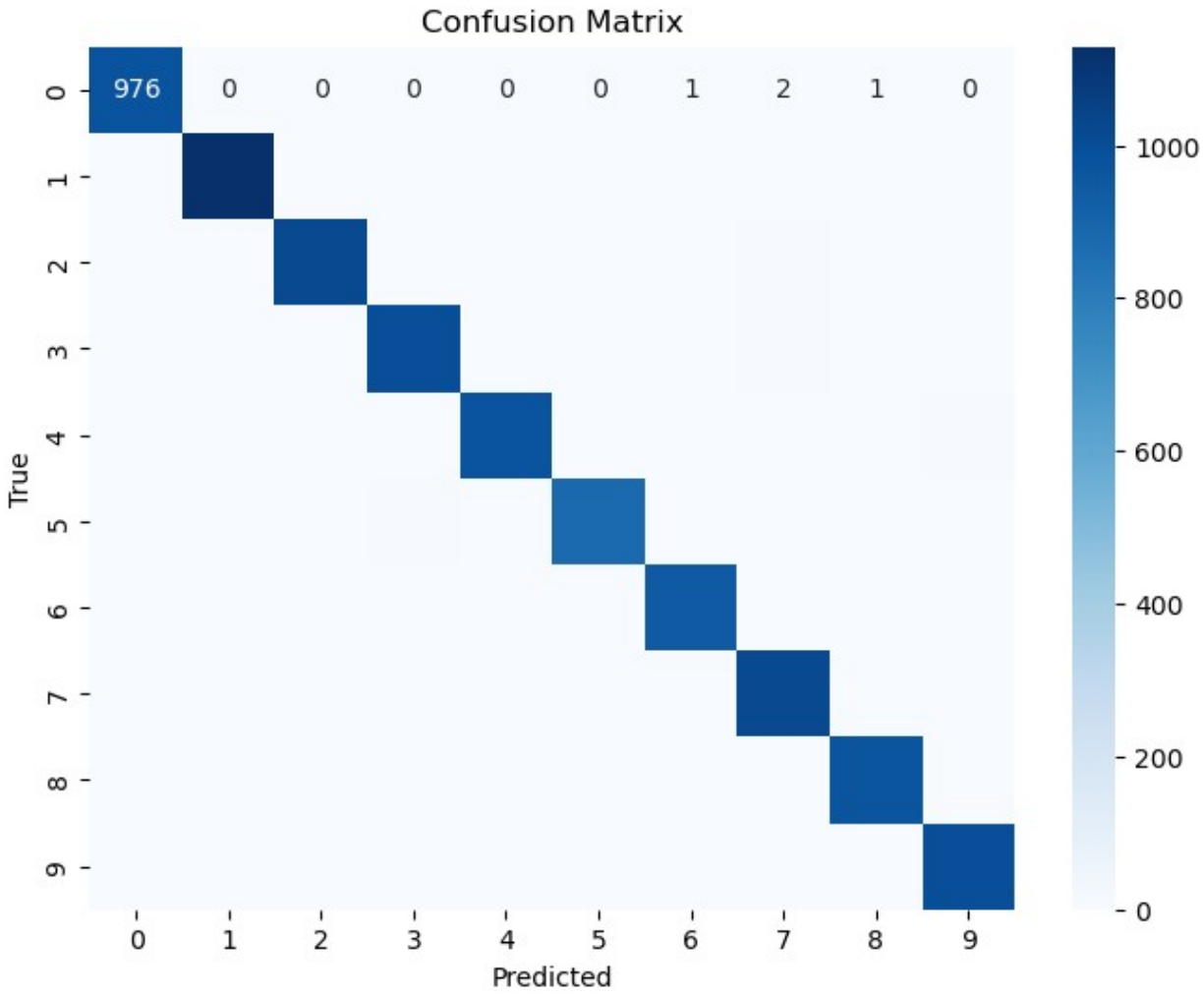



```
Fold 2:
Epoch 1/5

C:\Users\nalla\New folder\Lib\site-packages\keras\src\layers\
convolutional\base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

750/750 ━━━━━━━━━━━━━━━━━━━━ 10s 11ms/step - accuracy: 0.8454 - loss:
0.5145 - val_accuracy: 0.9772 - val_loss: 0.0715
Epoch 2/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9794 - loss:
0.0691 - val_accuracy: 0.9842 - val_loss: 0.0552
Epoch 3/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.9860 - loss:
0.0425 - val_accuracy: 0.9863 - val_loss: 0.0460
```

```
Epoch 4/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9906 - loss:
0.0314 - val_accuracy: 0.9882 - val_loss: 0.0382
Epoch 5/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9922 - loss:
0.0235 - val_accuracy: 0.9883 - val_loss: 0.0393
Test Accuracy for Fold 2: 0.9915000200271606
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
Confusion Matrix:
[[ 976    0    0    0    0    0    1    2    1    0]
 [   0 1129    0    1    0    0    0    2    3    0]
 [   0    2 1023    0    1    0    0    6    0    0]
 [   0    0    2 1000    0    2    0    5    1    0]
 [   0    0    0    0  976    0    1    0    0    5]
 [   0    0    1    6    0  880    2    1    1    1]
 [   4    2    1    0    1    2  944    0    4    0]
 [   0    2    1    1    0    0    0 1022    0    2]
 [   0    0    1    2    0    1    0    2  967    1]
 [   0    1    0    1    1    2    0    4    2  998]]
```

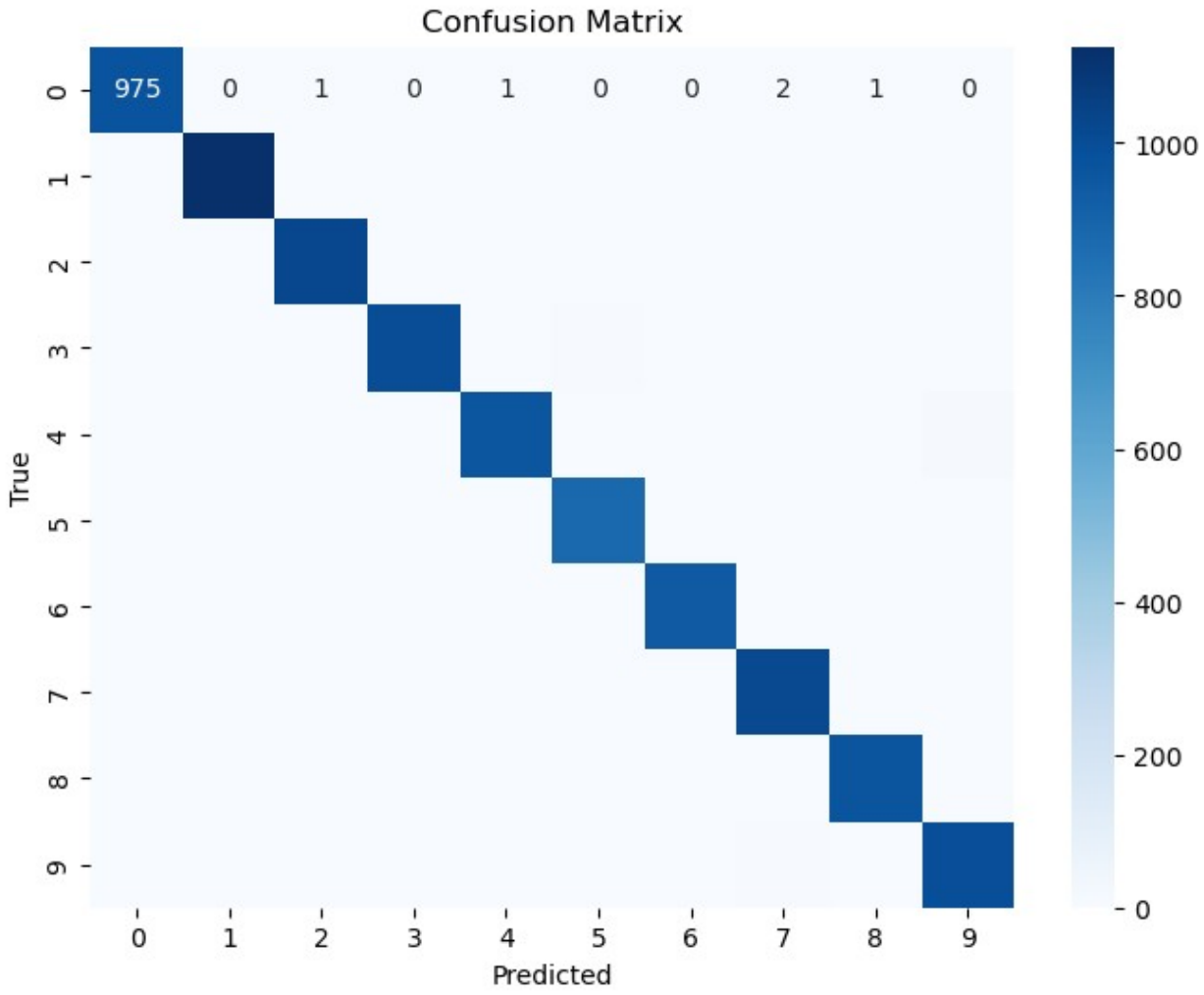



```
Fold 3:
Epoch 1/5

C:\Users\nalla\New folder\Lib\site-packages\keras\src\layers\
convolutional\base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

750/750 ━━━━━━━━━━━━━━━━━━━━ 8s 8ms/step - accuracy: 0.8650 - loss:
0.4639 - val_accuracy: 0.9810 - val_loss: 0.0634
Epoch 2/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9810 - loss:
0.0619 - val_accuracy: 0.9858 - val_loss: 0.0482
Epoch 3/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 7ms/step - accuracy: 0.9872 - loss:
0.0399 - val_accuracy: 0.9885 - val_loss: 0.0430
```

```
Epoch 4/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 7ms/step - accuracy: 0.9896 - loss:
0.0318 - val_accuracy: 0.9894 - val_loss: 0.0405
Epoch 5/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 7ms/step - accuracy: 0.9920 - loss:
0.0246 - val_accuracy: 0.9883 - val_loss: 0.0420
Test Accuracy for Fold 3: 0.9891999959945679
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
Confusion Matrix:
[[ 975    0    1    0    1    0    0    2    1    0]
 [   0 1126    4    1    0    0    0    3    1    0]
 [   0    0 1027    0    1    0    0    4    0    0]
 [   0    0    1  999    0    8    0    2    0    0]
 [   0    0    1    0  961    0    1    1    1   17]
 [   1    0    1    4    0  880    1    0    3    2]
 [   3    2    3    0    2    1  945    0    2    0]
 [   0    2    2    1    0    0    0 1020    0    3]
 [   2    0    2    2    1    1    0    1  964    1]
 [   0    0    0    1    2    4    0    6    1  995]]
```

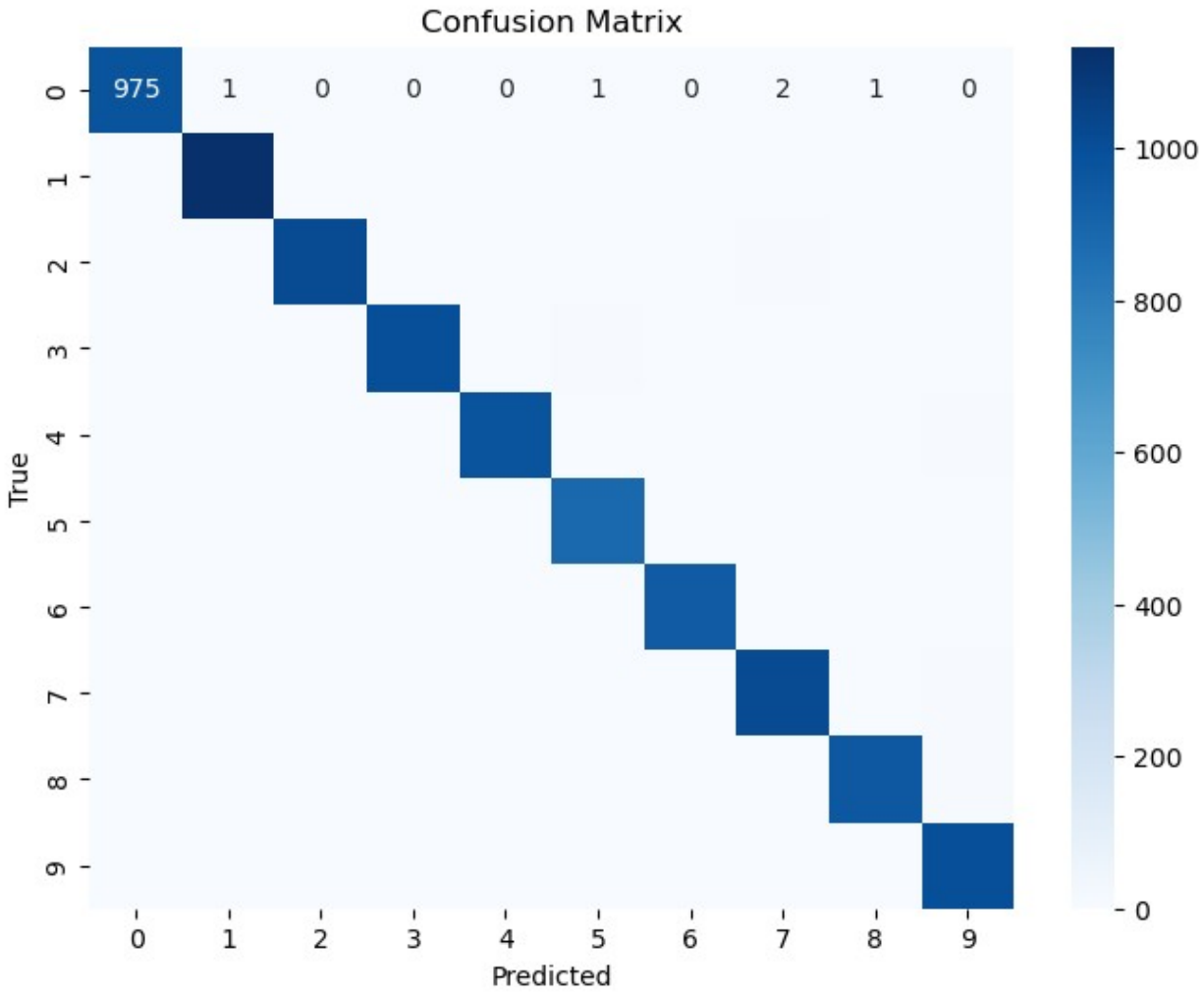



```
Fold 4:
Epoch 1/5

C:\Users\nalla\New folder\Lib\site-packages\keras\src\layers\
convolutional\base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

750/750 ━━━━━━━━━━━━━━━━━━━━ 8s 8ms/step - accuracy: 0.8476 - loss:
0.4875 - val_accuracy: 0.9738 - val_loss: 0.0847
Epoch 2/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.9792 - loss:
0.0653 - val_accuracy: 0.9852 - val_loss: 0.0514
Epoch 3/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9863 - loss:
0.0443 - val_accuracy: 0.9877 - val_loss: 0.0391
```

```
Epoch 4/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 7ms/step - accuracy: 0.9900 - loss:
0.0309 - val_accuracy: 0.9856 - val_loss: 0.0475
Epoch 5/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9911 - loss:
0.0268 - val_accuracy: 0.9888 - val_loss: 0.0353
Test Accuracy for Fold 4: 0.9904000163078308
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 4ms/step
Confusion Matrix:
[[ 975    1    0    0    0    1    0    2    1    0]
 [   0 1134    0    0    0    0    1    0    0    0]
 [   1    4 1015    4    1    0    0    6    1    0]
 [   0    0    1 1000    0    6    0    1    2    0]
 [   0    0    0    0  975    0    0    0    0    7]
 [   1    0    0    2    0  886    1    0    0    2]
 [   3    3    0    1    3    1  945    0    2    0]
 [   0    4    1    1    0    0    0 1015    0    7]
 [   2    0    2    2    1    0    0    2  958    7]
 [   0    0    0    0    3    2    1    1    1 1001]]
```

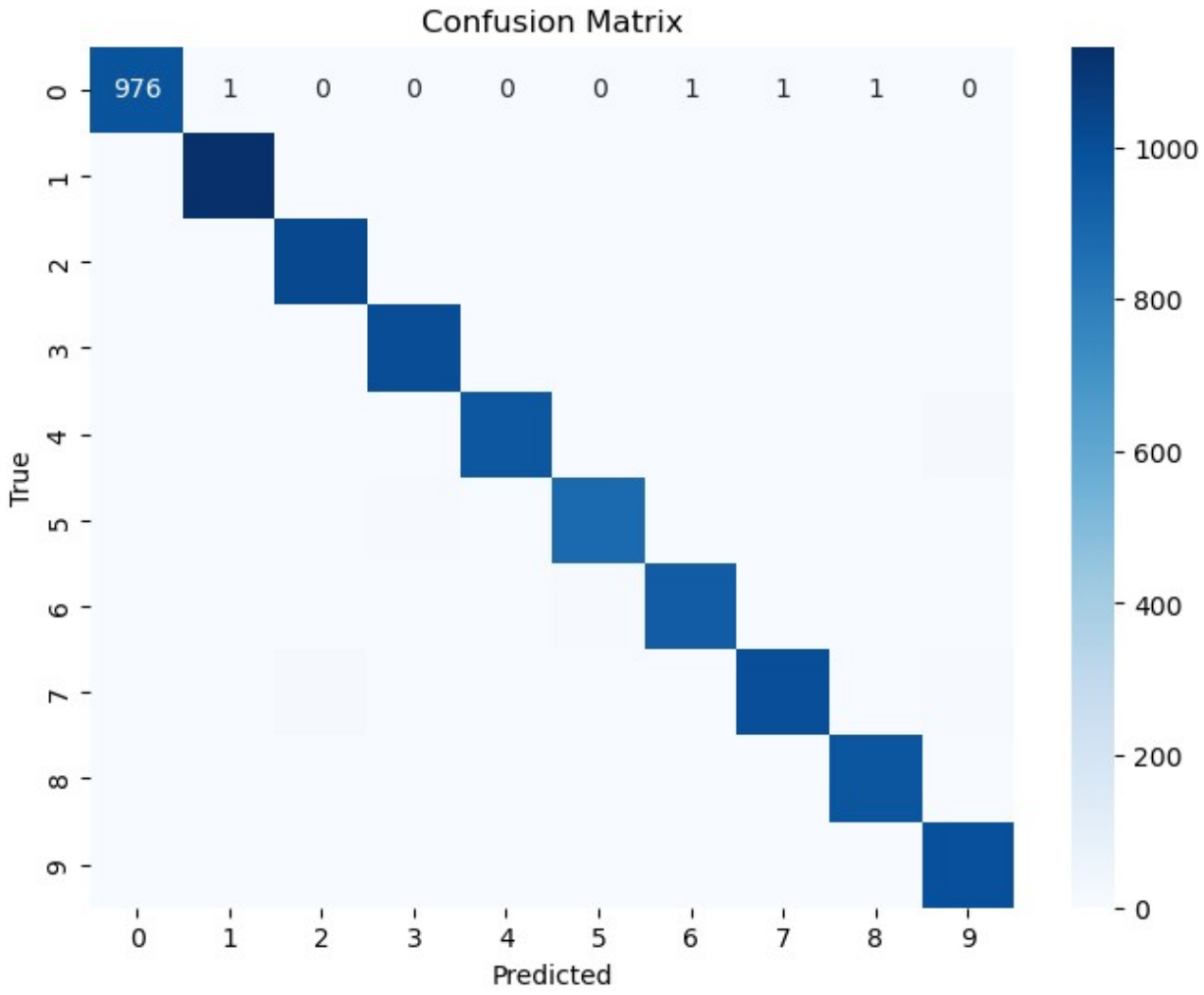



```
Fold 5:
Epoch 1/5

C:\Users\nalla\New folder\Lib\site-packages\keras\src\layers\
convolutional\base_conv.py:107: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(activity_regularizer=activity_regularizer,
**kwargs)

750/750 ━━━━━━━━━━━━━━━━━━━━ 8s 8ms/step - accuracy: 0.8371 - loss:
0.5236 - val_accuracy: 0.9693 - val_loss: 0.0982
Epoch 2/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9790 - loss:
0.0679 - val_accuracy: 0.9816 - val_loss: 0.0596
Epoch 3/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 5s 7ms/step - accuracy: 0.9877 - loss:
0.0423 - val_accuracy: 0.9866 - val_loss: 0.0418
```

```
Epoch 4/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 8ms/step - accuracy: 0.9898 - loss:
0.0312 - val_accuracy: 0.9874 - val_loss: 0.0431
Epoch 5/5
750/750 ━━━━━━━━━━━━━━━━━━━━ 6s 7ms/step - accuracy: 0.9927 - loss:
0.0244 - val_accuracy: 0.9877 - val_loss: 0.0407
Test Accuracy for Fold 5: 0.9883000254631042
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
Confusion Matrix:
[[ 976    1    0    0    0    0    1    1    1    0]
 [   0 1132    1    1    0    0    1    0    0    0]
 [   1    1 1027    0    1    0    0    2    0    0]
 [   0    0    1 1006    0    3    0    0    0    0]
 [   0    1    1    0  961    0    1    0    2   16]
 [   2    0    0    6    0  881    1    0    2    0]
 [   4    2    0    1    1    5  941    0    4    0]
 [   0    4   14    4    0    0    0 1000    1    5]
 [   2    0    1    1    0    1    1    1  965    2]
 [   1    3    0    1    2    4    0    0    4  994]]
```




```
# Average accuracy
print(f"\nAverage Test Accuracy: {np.mean(accuracies)}")

# Average Confusion Matrix
avg_conf_matrix = np.mean(conf_matrices, axis=0)
print("\nAverage Confusion Matrix:")
print(avg_conf_matrix)
# Define class labels for visualization
class_labels = [str(i) for i in range(10)]

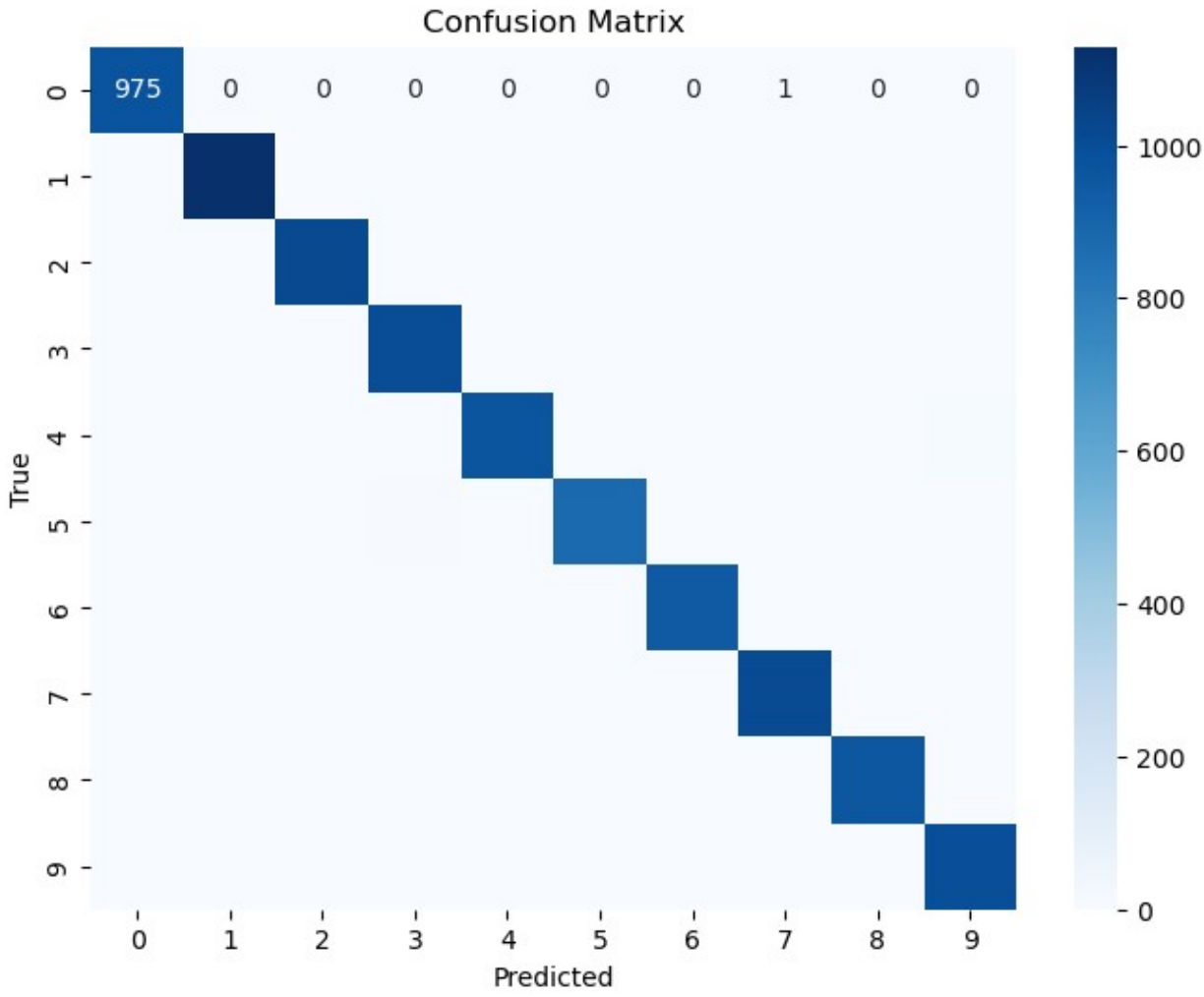
# Function to plot confusion matrix
def plot_confusion_matrix(conf_matrix):
    plt.figure(figsize=(8, 6))
    sns.heatmap(conf_matrix.astype(int), annot=True, cmap="Blues",
xticklabels=class_labels, yticklabels=class_labels, fmt='d')
    plt.xlabel("Predicted")
    plt.ylabel("True")
    plt.title("Confusion Matrix")
```

```
    plt.show()

# Plot average confusion matrix
plot_confusion_matrix(avg_conf_matrix)


Average Test Accuracy: 0.9895200133323669

Average Confusion Matrix:
[[9.7500e+02 6.0000e-01 6.0000e-01 0.0000e+00 2.0000e-01 2.0000e-01
  6.0000e-01 1.8000e+00 8.0000e-01 2.0000e-01]
 [0.0000e+00 1.1292e+03 1.2000e+00 1.8000e+00 2.0000e-01 0.0000e+00
  4.0000e-01 1.4000e+00 8.0000e-01 0.0000e+00]
 [6.0000e-01 1.4000e+00 1.0238e+03 1.0000e+00 8.0000e-01 0.0000e+00
  0.0000e+00 4.2000e+00 2.0000e-01 0.0000e+00]
 [0.0000e+00 0.0000e+00 1.4000e+00 1.0024e+03 0.0000e+00 4.0000e+00
  0.0000e+00 1.6000e+00 6.0000e-01 0.0000e+00]
 [0.0000e+00 2.0000e-01 6.0000e-01 0.0000e+00 9.6900e+02 0.0000e+00
  8.0000e-01 4.0000e-01 6.0000e-01 1.0400e+01]
 [8.0000e-01 0.0000e+00 6.0000e-01 5.6000e+00 0.0000e+00 8.8100e+02
  1.4000e+00 2.0000e-01 1.2000e+00 1.2000e+00]
 [3.2000e+00 2.4000e+00 1.0000e+00 4.0000e-01 1.8000e+00 2.4000e+00
  9.4440e+02 0.0000e+00 2.4000e+00 0.0000e+00]
 [0.0000e+00 2.6000e+00 4.8000e+00 1.4000e+00 0.0000e+00 0.0000e+00
  0.0000e+00 1.0146e+03 2.0000e-01 4.4000e+00]
 [1.6000e+00 0.0000e+00 2.6000e+00 3.8000e+00 6.0000e-01 1.0000e+00
  6.0000e-01 1.8000e+00 9.5880e+02 3.2000e+00]
 [2.0000e-01 8.0000e-01 0.0000e+00 1.0000e+00 2.2000e+00 3.2000e+00
  2.0000e-01 2.8000e+00 1.6000e+00 9.9700e+02]]
```


Confusion Matrix
975 0 0 0 0 0 0 1 0 0
0 1 2 3 4 5 6 7 8 9
True
Predicted
1000
800
600
400
200
0