Expermient 8

November 18, 2023

Expermient 8 Implement and test Convolutional Neural Network (CNN) for digits recognition.

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[ ]:
```
from __future__ import absolute_import,division,print_function,unicode_literals
import tensorflow as tf
from tensorflow import keras
from keras import layers,datasets,models
from keras.models import Sequential
from keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout
import matplotlib as plt
import numpy as np
%matplotlib inline
```

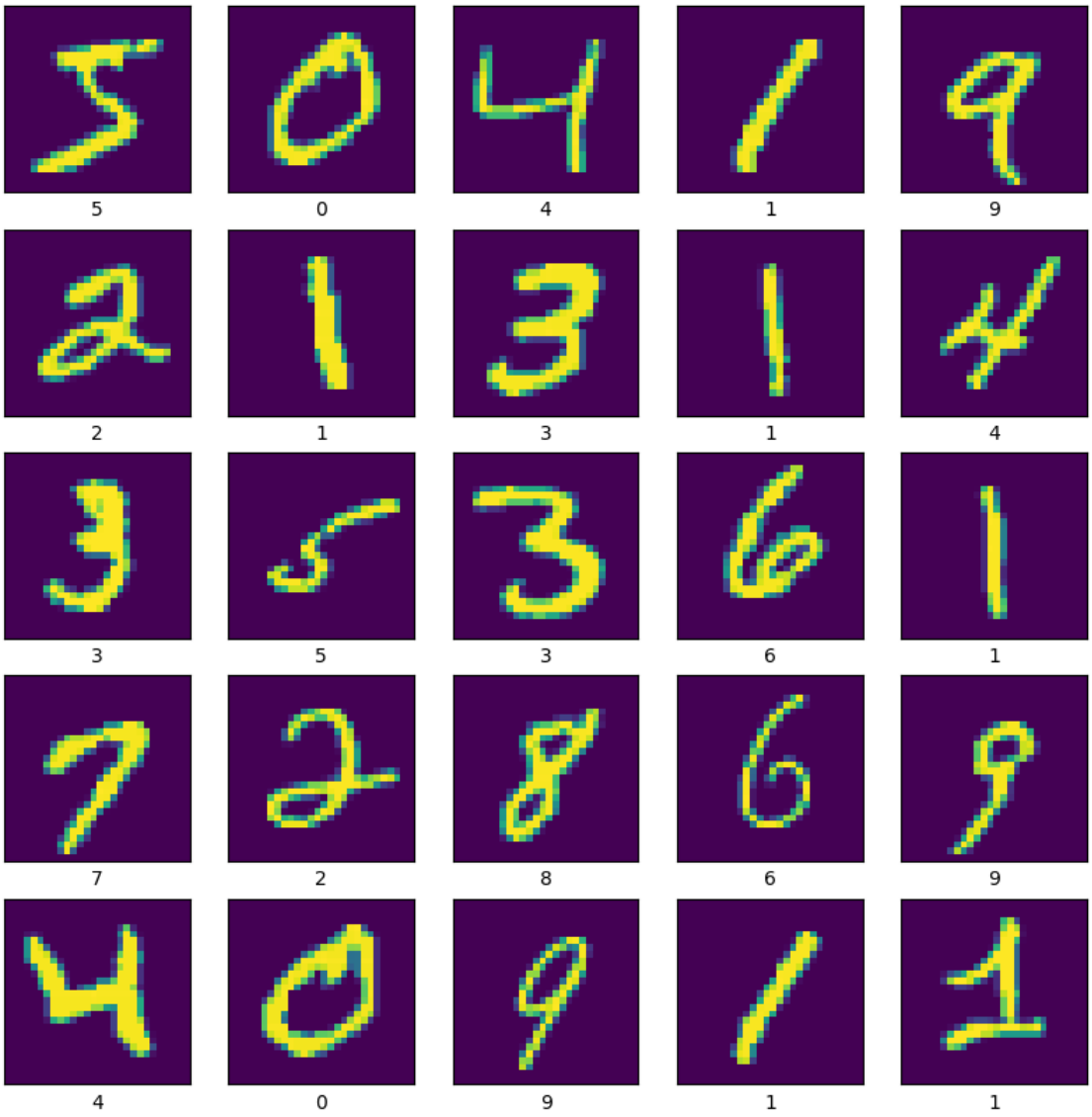
```
WARNING:tensorflow:From
c:\Users\athar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\keras\src\losses.py:2976: The name
tf.losses.sparse_softmax_cross_entropy is deprecated. Please use
tf.compat.v1.losses.sparse_softmax_cross_entropy instead.
```

[ ]:
```
mnist =tf.keras.datasets.mnist
(x_train,y_train),(x_test,y_test) =mnist.load_data()
x_train,x_test=x_train/255.0,x_test/255.0
```

[ ]:
```
import matplotlib.pyplot as plt

class_names = ['0', '1', '2', '3', '4', '5', '6', '7', '8', '9']

plt.figure(figsize=(10, 10))
for i in range(25):
    plt.subplot(5, 5, i + 1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(x_train[i])
    plt.xlabel(class_names[y_train[i]])
plt.show()
```



[ ]:
```
# Reshape the data to fit the model
x_train = x_train.reshape((x_train.shape[0], 28, 28, 1))
x_train.shape
x_test = x_test.reshape((x_test.shape[0], 28, 28, 1))
x_test.shape
```

[ ]:
```
(10000, 28, 28, 1)
```

[ ]:
```
x_train.shape
```

[ ]:
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(60000, 28, 28, 1)
```

[ ]:
```
# Define the CNN 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)),
    Flatten(),
    Dense(128, activation='relu'),
    Dropout(0.5),
    Dense(10, activation='softmax')
])
```

```
WARNING:tensorflow:From
c:\Users\athar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\keras\src\backend.py:873: The name tf.get_default_graph is deprecated.
Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From
c:\Users\athar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\keras\src\layers\pooling\max_pooling2d.py:161: The name tf.nn.max_pool
is deprecated. Please use tf.nn.max_pool2d instead.
```

[ ]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320

 max_pooling2d (MaxPooling2  (None, 13, 13, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 11, 11, 64)        18496

 max_pooling2d_1 (MaxPoolin  (None, 5, 5, 64)          0
 g2D)
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320

 max_pooling2d (MaxPooling2  (None, 13, 13, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 11, 11, 64)        18496
```

```
 max_pooling2d_1 (MaxPoolin  (None, 5, 5, 64)          0
 g2D)

 flatten (Flatten)           (None, 1600)              0

 dense (Dense)               (None, 128)               204928

 dropout (Dropout)           (None, 128)               0

 dense_1 (Dense)             (None, 10)                1290

=================================================================
Total params: 225034 (879.04 KB)
Trainable params: 225034 (879.04 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

[ ]:
```python
# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

```
WARNING:tensorflow:From
c:\Users\athar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\keras\src\optimizers\__init__.py:309: The name tf.train.Optimizer is
deprecated. Please use tf.compat.v1.train.Optimizer instead.
```

[ ]:
```python
# Train the model
history = model.fit(x_train, y_train, epochs=5, batch_size=100,␣
 ↪validation_data=(x_test, y_test))

# Evaluate the model
test_loss, test_accuracy = model.evaluate(x_test, y_test)

print(f"Test accuracy: {test_accuracy}")

# Plot training history (accuracy and loss)
plt.figure(figsize=(10, 4))

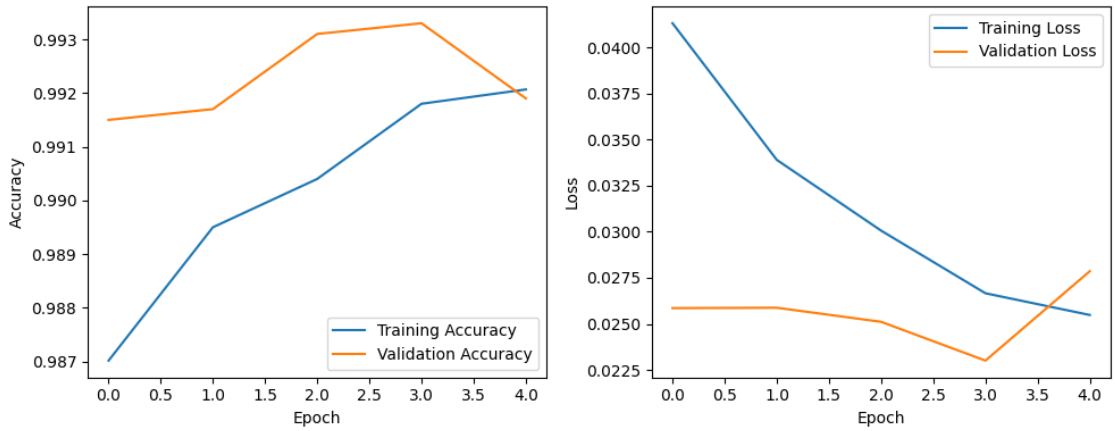
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'], label='Training Accuracy')
plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()

plt.subplot(1, 2, 2)
```

```
plt.plot(history.history['loss'], label='Training Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()

plt.tight_layout()
plt.show()
```

```
Epoch 1/5
600/600 [==============================] - 14s 24ms/step - loss: 0.0413 -
accuracy: 0.9870 - val_loss: 0.0259 - val_accuracy: 0.9915
Epoch 2/5
600/600 [==============================] - 13s 22ms/step - loss: 0.0339 -
accuracy: 0.9895 - val_loss: 0.0259 - val_accuracy: 0.9917
Epoch 3/5
600/600 [==============================] - 15s 25ms/step - loss: 0.0301 -
accuracy: 0.9904 - val_loss: 0.0251 - val_accuracy: 0.9931
Epoch 4/5
600/600 [==============================] - 15s 24ms/step - loss: 0.0267 -
accuracy: 0.9918 - val_loss: 0.0230 - val_accuracy: 0.9933
Epoch 5/5
600/600 [==============================] - 14s 23ms/step - loss: 0.0255 -
accuracy: 0.9921 - val_loss: 0.0279 - val_accuracy: 0.9919
313/313 [==============================] - 1s 4ms/step - loss: 0.0279 -
accuracy: 0.9919
Test accuracy: 0.9919000267982483
```

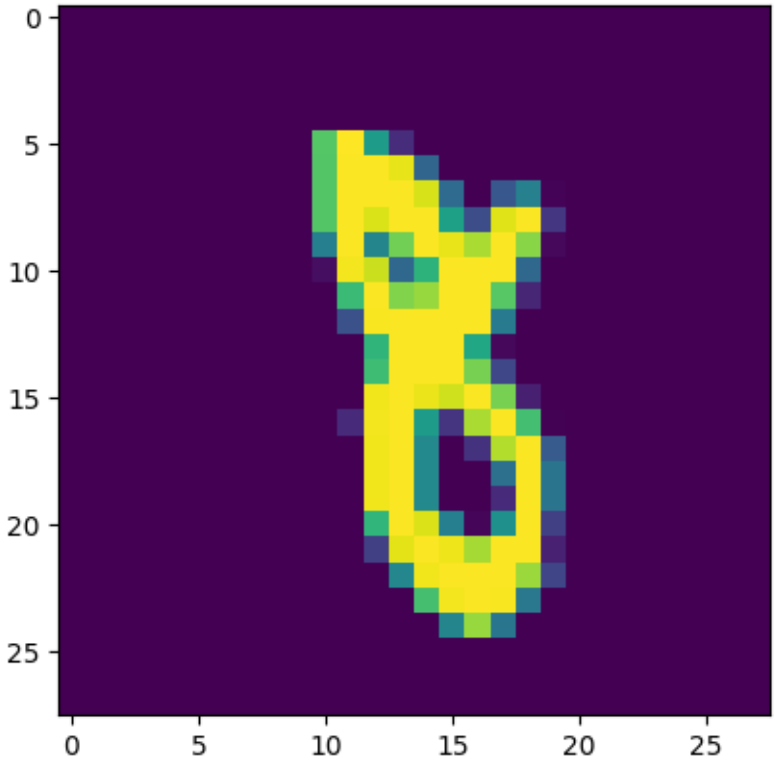


[ ]:
```
model.save("TEMP.h5")
```

```
c:\Users\athar\AppData\Local\Programs\Python\Python311\Lib\site-
packages\keras\src\engine\training.py:3103: UserWarning: You are saving your
model as an HDF5 file via `model.save()`. This file format is considered legacy.
```

```
We recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')`.
  saving_api.save_model(
```

[ ]:
```
x_test =x_test.reshape(x_test.shape[0],28,28,1)
plt.imshow(x_test[1433])
plt.show()
```



[ ]:
```
predictions=model.predict(x_test)
print(predictions[1433])
np.argmax(predictions[1433])
```

```
313/313 [==============================] - 1s 4ms/step
[8.4843032e-06 8.3646242e-04 2.6124348e-05 2.3315877e-05 1.9068830e-07
 5.1133382e-05 4.0274241e-05 4.0306336e-06 9.9900872e-01 1.2135860e-06]
```

[ ]:
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[ ]:
```
y_test
```

[ ]:
```
array([7, 2, 1, …, 4, 5, 6], dtype=uint8)
```

[ ]:
```
pred=[]
for j in range(len(predictions)):
    pred.append(np.argmax(predictions[j]))
```

[ ]:
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pred
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```

[ ]:
```
import sklearn
from sklearn.metrics import confusion_matrix
confusion_matrix(y_test,pred)
```

[ ]:
```
array([[ 977,    0,    0,    0,    0,    0,    1,    1,    1,    0],
       [   0, 1133,    0,    1,    0,    0,    1,    0,    0,    0],
       [   4,    0, 1023,    0,    1,    0,    0,    4,    0,    0],
       [   0,    0,    3, 1002,    0,    3,    0,    1,    1,    0],
       [   0,    0,    0,    0,  978,    0,    1,    0,    0,    3],
       [   2,    0,    0,    4,    0,  884,    1,    0,    0,    1],
       [   7,    3,    0,    0,    1,    2,  945,    0,    0,    0],
       [   0,    4,    1,    0,    0,    0,    0, 1018,    1,    4],
       [   5,    0,    1,    1,    0,    2,    0,    2,  961,    2],
       [   2,    1,    0,    0,    3,    3,    0,    0,    2,  998]],
      dtype=int64)
```

[ ]:
```
from sklearn.metrics import classification_report
print(classification_report(y_test,pred,target_names=class_names))
```

```
              precision    recall  f1-score   support

           0       0.98      1.00      0.99       980
           1       0.99      1.00      1.00      1135
           2       1.00      0.99      0.99      1032
           3       0.99      0.99      0.99      1010
           4       0.99      1.00      1.00       982
           5       0.99      0.99      0.99       892
```

```
              6       1.00      0.99      0.99       958
              7       0.99      0.99      0.99      1028
              8       0.99      0.99      0.99       974
              9       0.99      0.99      0.99      1009

       accuracy                           0.99     10000
      macro avg       0.99      0.99      0.99     10000
   weighted avg       0.99      0.99      0.99     10000
```

[ ]:
```
print('accuracy',sklearn.metrics.accuracy_score(y_test,pred))
print('F1 score',sklearn.metrics.f1_score(y_test,pred,average='weighted'))
print('Recall',sklearn.metrics.recall_score(y_test,pred,average='weighted'))
print('Precision',sklearn.metrics.
 ↪precision_score(y_test,pred,average='weighted'))
```

```
accuracy 0.9919
F1 score 0.9919012708984872
Recall 0.9919
Precision 0.9919274331537717
```

[ ]:
```

```