digit-recognizer-lenet

March 13, 2024

[22]:

```
import numpy as np
import pandas as pd
import keras
from keras.models import Sequential
from keras.layers import Conv2D, Dense, MaxPool2D, Dropout, Flatten
from keras.optimizers import Adam
from keras.callbacks import ReduceLROnPlateau
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
import seaborn as sns
```

[23]:

```
df_train = pd.read_csv('/kaggle/input/digit-recognizer/train.csv')
X_train = df_train.iloc[:, 1:]
Y_train = df_train.iloc[:, 0]
```

[24]:

```
X_train.head()
```

[24]:

```
   pixel0  pixel1  pixel2  pixel3  pixel4  pixel5  pixel6  pixel7  pixel8  \
0       0       0       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0       0       0
2       0       0       0       0       0       0       0       0       0
3       0       0       0       0       0       0       0       0       0
4       0       0       0       0       0       0       0       0       0

   pixel9  …  pixel774  pixel775  pixel776  pixel777  pixel778  pixel779  \
0       0  …         0         0         0         0         0         0
1       0  …         0         0         0         0         0         0
2       0  …         0         0         0         0         0         0
3       0  …         0         0         0         0         0         0
4       0  …         0         0         0         0         0         0

   pixel780  pixel781  pixel782  pixel783
0         0         0         0         0
1         0         0         0         0
2         0         0         0         0
3         0         0         0         0
4         0         0         0         0
```

```
[5 rows x 784 columns]
```

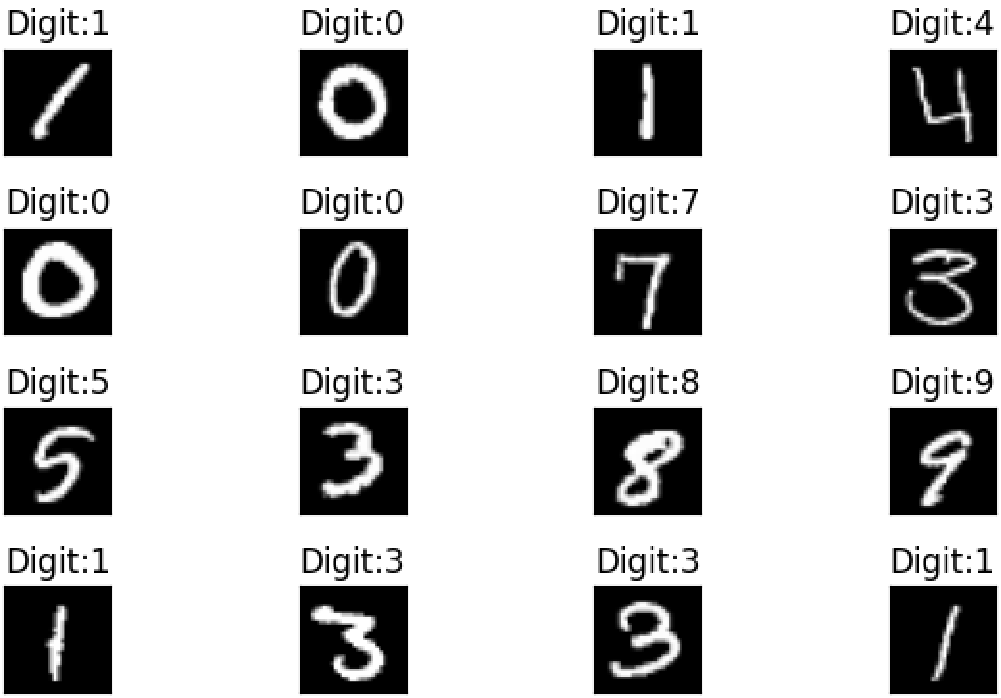
[25]:
```
Y_train.head()
```

[25]:
```
0    1
1    0
2    1
3    4
4    0
Name: label, dtype: int64
```

[26]:
```
X_train = np.array(X_train)
Y_train = np.array(Y_train)
# Normalize inputs
X_train = X_train / 255.0
```

[27]:
```
def plot_digits(X, Y):
    for i in range(16):
        plt.subplot(5, 4, i+1)
        plt.tight_layout()
        plt.imshow(X[i].reshape(28, 28), cmap='gray')
        plt.title('Digit:{}'.format(Y[i]))
        plt.xticks([])
        plt.yticks([])
    plt.show()
```

[28]:
```
plot_digits(X_train, Y_train)
```



[36]:

```
#Train-Test Split
X_dev, X_val, Y_dev, Y_val = train_test_split(X_train, Y_train, test_size=0.03,␣
  ↪shuffle=True, random_state=2019)
```

[37]:

```
T_dev = pd.get_dummies(Y_dev).values
T_val = pd.get_dummies(Y_val).values
```

[38]:

```
#Reshape the input
X_dev = X_dev.reshape(X_dev.shape[0], 28, 28, 1)
X_val = X_val.reshape(X_val.shape[0], 28, 28, 1)
```

[39]:

```
model = Sequential()
model.add(Conv2D(filters=32, kernel_size=(5,5), padding='same',␣
  ↪activation='relu', input_shape=(28, 28, 1)))
model.add(MaxPool2D(strides=2))
model.add(Conv2D(filters=48, kernel_size=(5,5), padding='valid',␣
  ↪activation='relu'))
model.add(MaxPool2D(strides=2))
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dense(84, activation='relu'))
model.add(Dense(10, activation='softmax'))
model.build()
model.summary()
```

```
Model: "sequential_2"


 Layer (type)                      Output Shape                 Param #

 conv2d_4 (Conv2D)                 (None, 28, 28, 32)               832

 max_pooling2d_4 (MaxPooling2D)    (None, 14, 14, 32)                 0

 conv2d_5 (Conv2D)                 (None, 10, 10, 48)            38,448

 max_pooling2d_5 (MaxPooling2D)    (None, 5, 5, 48)                   0

 flatten_2 (Flatten)               (None, 1200)                       0

 dense_6 (Dense)                   (None, 256)                  307,456

 dense_7 (Dense)                   (None, 84)                    21,588

 dense_8 (Dense)                   (None, 10)                       850


 Total params: 369,174 (1.41 MB)

 Trainable params: 369,174 (1.41 MB)

 Non-trainable params: 0 (0.00 B)
```

[40]:

```python
adam = Adam(learning_rate=5e-4)
model.compile(loss='categorical_crossentropy', metrics=['accuracy'],␣
 ↪optimizer=adam)
```

[41]:

```python
# Set a learning rate annealer
reduce_lr = ReduceLROnPlateau(monitor='val_acc',
                                patience=3,
                                verbose=1,
                                factor=0.2,
                                min_lr=1e-6)
```

[44]:

```python
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Data Augmentation
datagen = ImageDataGenerator(
            rotation_range=10,
            width_shift_range=0.1,
            height_shift_range=0.1,
            zoom_range=0.1)
```

[47]:

```
datagen.fit(X_dev)
model.fit(datagen.flow(X_dev, T_dev, batch_size=100),␣
 ↪steps_per_epoch=int(len(X_dev)/100),
          epochs=30, validation_data=(X_val, T_val), callbacks=[reduce_lr])
```

```
Epoch 1/30
```

```
/opt/conda/lib/python3.10/site-
packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:122:
UserWarning: Your `PyDataset` class should call `super().__init__(**kwargs)` in
its constructor. `**kwargs` can include `workers`, `use_multiprocessing`,
`max_queue_size`. Do not pass these arguments to `fit()`, as they will be
ignored.
  self._warn_if_super_not_called()
```

```
407/407              35s 80ms/step -
accuracy: 0.7171 - loss: 0.8715 - val_accuracy: 0.9667 - val_loss: 0.1378 -
learning_rate: 5.0000e-04
Epoch 2/30
  1/407              25s 63ms/step - accuracy:
0.9100 - loss: 0.2468
```

```
/opt/conda/lib/python3.10/site-packages/keras/src/callbacks/callback_list.py:97:
UserWarning: Learning rate reduction is conditioned on metric `val_acc` which is
not available. Available metrics are:
accuracy,loss,val_accuracy,val_loss,learning_rate.
  callback.on_epoch_end(epoch, logs)
/opt/conda/lib/python3.10/contextlib.py:153: UserWarning: Your input ran out of
data; interrupting training. Make sure that your dataset or generator can
generate at least `steps_per_epoch * epochs` batches. You may need to use the
`.repeat()` function when building your dataset.
  self.gen.throw(typ, value, traceback)
```

```
407/407              0s 945us/step -
accuracy: 0.9100 - loss: 0.1237 - val_accuracy: 0.9675 - val_loss: 0.1301 -
learning_rate: 5.0000e-04
Epoch 3/30
407/407              33s 79ms/step -
accuracy: 0.9478 - loss: 0.1653 - val_accuracy: 0.9738 - val_loss: 0.0898 -
learning_rate: 5.0000e-04
Epoch 4/30
407/407              0s 903us/step -
accuracy: 0.9600 - loss: 0.0473 - val_accuracy: 0.9746 - val_loss: 0.0852 -
learning_rate: 5.0000e-04
Epoch 5/30
```

```
407/407             32s 79ms/step -
accuracy: 0.9654 - loss: 0.1078 - val_accuracy: 0.9825 - val_loss: 0.0654 -
learning_rate: 5.0000e-04
Epoch 6/30
407/407             0s 906us/step -
accuracy: 0.9700 - loss: 0.0563 - val_accuracy: 0.9802 - val_loss: 0.0689 -
learning_rate: 5.0000e-04
Epoch 7/30
407/407             32s 79ms/step -
accuracy: 0.9719 - loss: 0.0875 - val_accuracy: 0.9889 - val_loss: 0.0515 -
learning_rate: 5.0000e-04
Epoch 8/30
407/407             0s 884us/step -
accuracy: 0.9700 - loss: 0.0259 - val_accuracy: 0.9881 - val_loss: 0.0505 -
learning_rate: 5.0000e-04
Epoch 9/30
407/407             40s 78ms/step -
accuracy: 0.9790 - loss: 0.0686 - val_accuracy: 0.9802 - val_loss: 0.0681 -
learning_rate: 5.0000e-04
Epoch 10/30
407/407             0s 898us/step -
accuracy: 0.9800 - loss: 0.0521 - val_accuracy: 0.9817 - val_loss: 0.0652 -
learning_rate: 5.0000e-04
Epoch 11/30
407/407             40s 78ms/step -
accuracy: 0.9782 - loss: 0.0641 - val_accuracy: 0.9873 - val_loss: 0.0517 -
learning_rate: 5.0000e-04
Epoch 12/30
407/407             0s 863us/step -
accuracy: 0.9800 - loss: 0.0390 - val_accuracy: 0.9881 - val_loss: 0.0515 -
learning_rate: 5.0000e-04
Epoch 13/30
407/407             41s 78ms/step -
accuracy: 0.9814 - loss: 0.0574 - val_accuracy: 0.9905 - val_loss: 0.0422 -
learning_rate: 5.0000e-04
Epoch 14/30
407/407             0s 856us/step -
accuracy: 1.0000 - loss: 0.0027 - val_accuracy: 0.9897 - val_loss: 0.0430 -
learning_rate: 5.0000e-04
Epoch 15/30
407/407             40s 78ms/step -
accuracy: 0.9845 - loss: 0.0508 - val_accuracy: 0.9889 - val_loss: 0.0478 -
learning_rate: 5.0000e-04
Epoch 16/30
407/407             1s 1ms/step -
accuracy: 0.9700 - loss: 0.0351 - val_accuracy: 0.9889 - val_loss: 0.0483 -
learning_rate: 5.0000e-04
Epoch 17/30
```

```
407/407            40s 77ms/step -
accuracy: 0.9849 - loss: 0.0478 - val_accuracy: 0.9937 - val_loss: 0.0259 -
learning_rate: 5.0000e-04
Epoch 18/30
407/407            0s 894us/step -
accuracy: 0.9900 - loss: 0.0114 - val_accuracy: 0.9937 - val_loss: 0.0267 -
learning_rate: 5.0000e-04
Epoch 19/30
407/407            32s 77ms/step -
accuracy: 0.9868 - loss: 0.0423 - val_accuracy: 0.9889 - val_loss: 0.0524 -
learning_rate: 5.0000e-04
Epoch 20/30
407/407            0s 889us/step -
accuracy: 0.9900 - loss: 0.0081 - val_accuracy: 0.9865 - val_loss: 0.0539 -
learning_rate: 5.0000e-04
Epoch 21/30
407/407            32s 77ms/step -
accuracy: 0.9875 - loss: 0.0394 - val_accuracy: 0.9929 - val_loss: 0.0346 -
learning_rate: 5.0000e-04
Epoch 22/30
407/407            0s 898us/step -
accuracy: 1.0000 - loss: 0.0088 - val_accuracy: 0.9921 - val_loss: 0.0357 -
learning_rate: 5.0000e-04
Epoch 23/30
407/407            41s 78ms/step -
accuracy: 0.9893 - loss: 0.0348 - val_accuracy: 0.9937 - val_loss: 0.0287 -
learning_rate: 5.0000e-04
Epoch 24/30
407/407            0s 944us/step -
accuracy: 1.0000 - loss: 0.0051 - val_accuracy: 0.9944 - val_loss: 0.0287 -
learning_rate: 5.0000e-04
Epoch 25/30
407/407            32s 78ms/step -
accuracy: 0.9881 - loss: 0.0375 - val_accuracy: 0.9921 - val_loss: 0.0417 -
learning_rate: 5.0000e-04
Epoch 26/30
407/407            0s 923us/step -
accuracy: 1.0000 - loss: 0.0070 - val_accuracy: 0.9905 - val_loss: 0.0461 -
learning_rate: 5.0000e-04
Epoch 27/30
407/407            32s 77ms/step -
accuracy: 0.9892 - loss: 0.0352 - val_accuracy: 0.9905 - val_loss: 0.0397 -
learning_rate: 5.0000e-04
Epoch 28/30
407/407            0s 894us/step -
accuracy: 0.9900 - loss: 0.0198 - val_accuracy: 0.9905 - val_loss: 0.0394 -
learning_rate: 5.0000e-04
Epoch 29/30
```

```
407/407              32s 77ms/step -
accuracy: 0.9906 - loss: 0.0315 - val_accuracy: 0.9897 - val_loss: 0.0475 -
learning_rate: 5.0000e-04
Epoch 30/30
407/407              0s 907us/step -
accuracy: 0.9800 - loss: 0.0811 - val_accuracy: 0.9905 - val_loss: 0.0482 -
learning_rate: 5.0000e-04
```

[47]:

```
<keras.src.callbacks.history.History at 0x7ca65eaf31c0>
```

[48]:

```python
score = model.evaluate(X_val, T_val, batch_size=32)
score
```

```
40/40              0s 9ms/step -
accuracy: 0.9916 - loss: 0.0218
```

[48]:

```
[0.048181574791669846, 0.9904761910438538]
```

[50]:

```python
df_test = pd.read_csv('/kaggle/input/digit-recognizer/test.csv')
```

[51]:

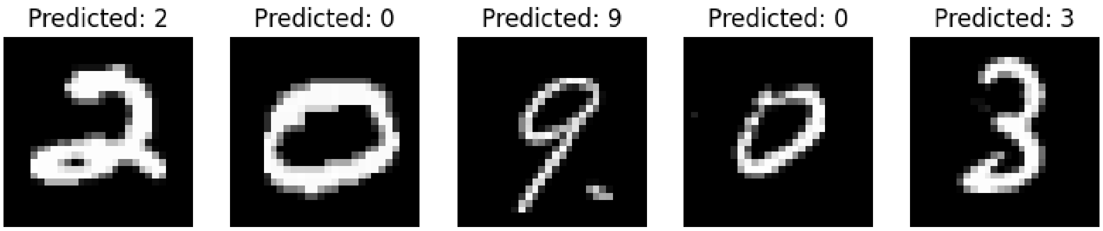
```python
X_test = np.array(df_test)
X_test = X_test/255.0
```

[55]:

```python
import matplotlib.pyplot as plt

# Define a function to display images and their predictions
def display_images(images, predictions, num_images=5):
    plt.figure(figsize=(10, 4))
    for i in range(num_images):
        plt.subplot(1, num_images, i+1)
        plt.imshow(images[i].reshape(28, 28), cmap='gray')
        plt.title(f'Predicted: {predictions[i]}', fontsize=12)
        plt.axis('off')
    plt.show()

# Display the first 5 images along with their predictions
display_images(X_test[:5], Y_test[:5])
```



Predicted: 2

Predicted: 0

Predicted: 9

Predicted: 0

Predicted: 3