```
import matplotlib.pyplot as plt
import cv2
import numpy as np
from keras.models import Sequential
from keras.layers import Dense, Flatten, Conv2D, MaxPool2D, Dropout
from tensorflow.keras.optimizers import SGD, Adam
from keras.callbacks import ReduceLROnPlateau, EarlyStopping
from tensorflow.keras.utils import to_categorical
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.utils import shuffle
from tensorflow.python.keras import optimizers as opt
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True)
```

```
data = pd.read_csv(r"/content/drive/MyDrive/SGP SEM 7/A_Z Handwritten Data.csv.zip").astype('float32')

print(data.head(10))
```

```
     0  0.1  0.2  0.3  0.4  0.5  ...  0.643  0.644  0.645  0.646  0.647  0.648
0  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
1  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
2  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
3  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
4  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
5  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
6  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
7  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
8  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
9  0.0  0.0  0.0  0.0  0.0  0.0  ...    0.0    0.0    0.0    0.0    0.0    0.0
```

```
     [10 rows x 785 columns]
```

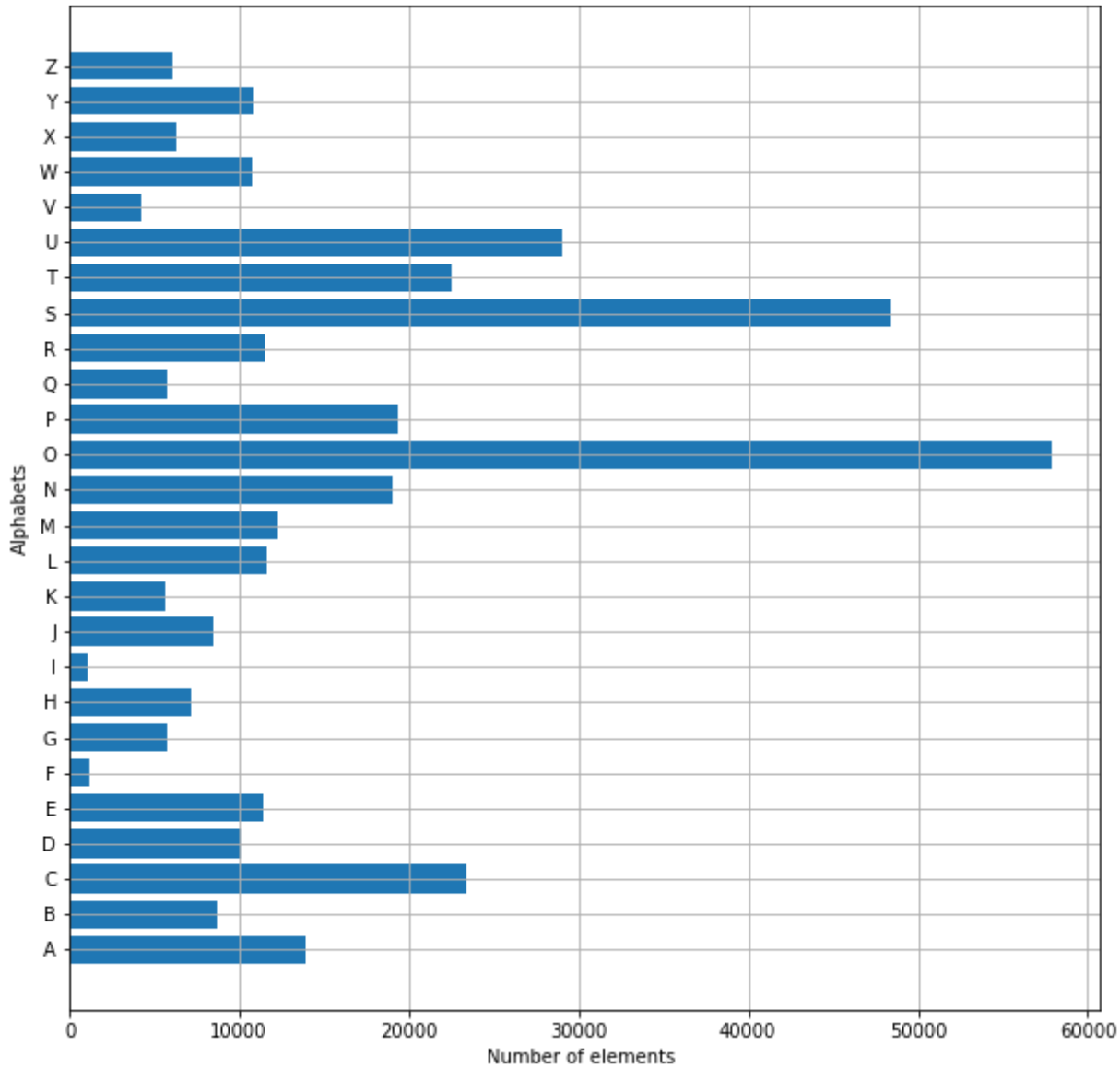
```
X = data.drop('0',axis = 1)
y = data['0']
```

```
train_x, test_x, train_y, test_y = train_test_split(X, y, test_size = 0.2)

train_x = np.reshape(train_x.values, (train_x.shape[0], 28,28))
test_x = np.reshape(test_x.values, (test_x.shape[0], 28,28))

print("Train data shape: ", train_x.shape)
print("Test data shape: ", test_x.shape)
```

```
     Train data shape:  (297960, 28, 28)
     Test data shape:  (74490, 28, 28)
```

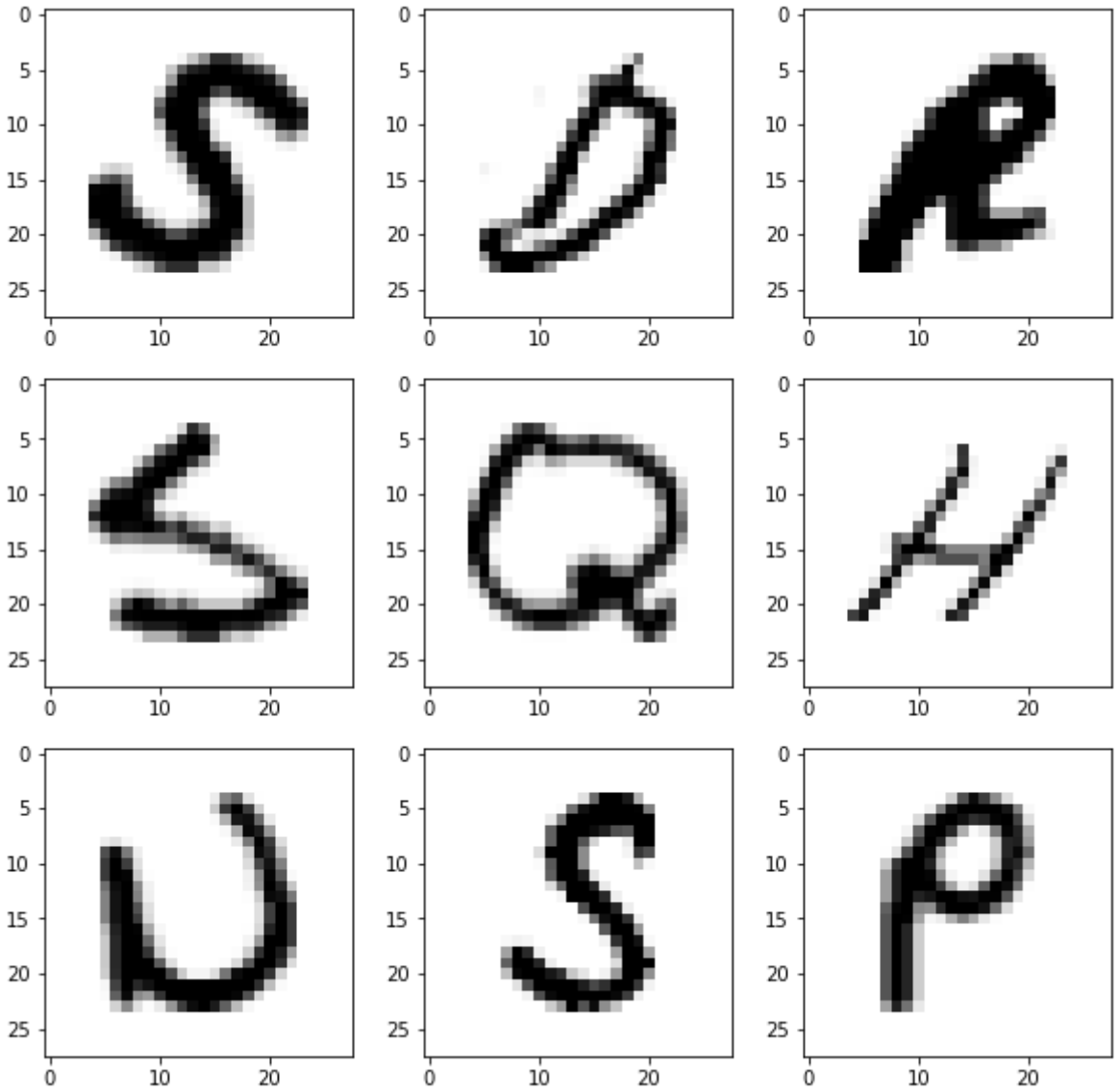
```
word_dict = {0:'A',1:'B',2:'C',3:'D',4:'E',5:'F',6:'G',7:'H',8:'I',9:'J',10:'K',11:'L',12:'M',13:'N',14:'O',15:'P',16:'Q',17:'R',18:'
```

```
y_int = np.int0(y)
count = np.zeros(26, dtype='int')
for i in y_int:
    count[i] +=1

alphabets = []
for i in word_dict.values():
    alphabets.append(i)

fig, ax = plt.subplots(1,1, figsize=(10,10))
ax.barh(alphabets, count)

plt.xlabel("Number of elements ")
plt.ylabel("Alphabets")
plt.grid()
plt.show()
```




```
shuff = shuffle(train_x[:100])

fig, ax = plt.subplots(3,3, figsize = (10,10))
axes = ax.flatten()
```

```
for i in range(9):
    _, shu = cv2.threshold(shuff[i], 30, 200, cv2.THRESH_BINARY)
    axes[i].imshow(np.reshape(shuff[i], (28,28)), cmap="Greys")
plt.show()
```



```
train_X = train_x.reshape(train_x.shape[0],train_x.shape[1],train_x.shape[2],1)
```

```
print("train data shape: ", train_X.shape)

test_X = test_x.reshape(test_x.shape[0], test_x.shape[1], test_x.shape[2],1)
print("test data shape: ", test_X.shape)

train_x.shape:  (297960, 28, 28, 1)
test_x.shape:  (74490, 28, 28, 1)
```

```
train data shape:  (297960, 28, 28, 1)
test data shape:  (74490, 28, 28, 1)
```

```
train_yOHE = to_categorical(train_y, num_classes = 26, dtype='int')
print("New shape of train labels: ", train_yOHE.shape)

test_yOHE = to_categorical(test_y, num_classes = 26, dtype='int')
print("New shape of test labels: ", test_yOHE.shape)
```

```
New shape of train labels:  (297960, 26)
New shape of test labels:  (74490, 26)
```

```
model = Sequential()

model.add(Conv2D(filters=32, kernel_size=(3, 3), activation='relu', input_shape=(28,28,1)))
model.add(MaxPool2D(pool_size=(2, 2), strides=2))

model.add(Conv2D(filters=64, kernel_size=(3, 3), activation='relu', padding = 'same'))
model.add(MaxPool2D(pool_size=(2, 2), strides=2))

model.add(Conv2D(filters=128, kernel_size=(3, 3), activation='relu', padding = 'valid'))
model.add(MaxPool2D(pool_size=(2, 2), strides=2))

model.add(Flatten())

model.add(Dense(64,activation ="relu"))
model.add(Dense(128,activation ="relu"))
```

```
model.add(Dense(26.activation ="softmax"))
model.compile(optimizer = Adam(learning_rate=0.001), loss='categorical_crossentropy', metrics=['accuracy'])

history = model.fit(train_X, train_yOHE, epochs=1,  validation_data = (test_X,test_yOHE))
```

```
9312/9312 [==============================] - 414s 44ms/step - loss: 0.1587 - accuracy: 0.9569 - val_loss: 0.0825 - val_accuracy
```

```
model.summary()
model.save(r'model_hand.h5')
```

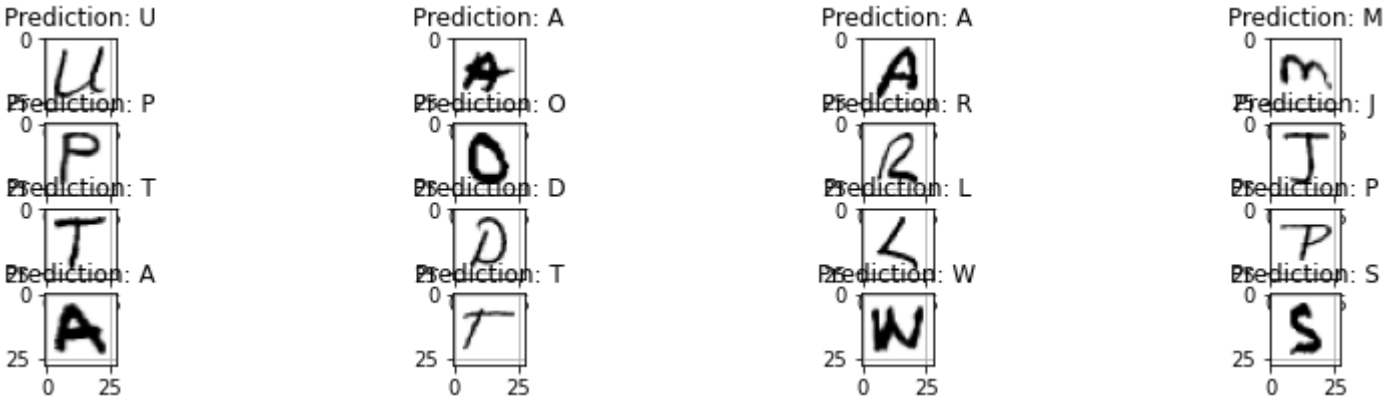
```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320

 max_pooling2d (MaxPooling2D  (None, 13, 13, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_2 (Conv2D)           (None, 4, 4, 128)         73856

 max_pooling2d_2 (MaxPooling  (None, 2, 2, 128)        0
 2D)

 flatten (Flatten)           (None, 512)               0

 dense (Dense)               (None, 64)                32832

 dense_1 (Dense)             (None, 128)               8320

 dense_2 (Dense)             (None, 26)                3354
```

```
=================================================================
Total params: 137,178
Trainable params: 137,178
Non-trainable params: 0
_________________________________________________________________
```

```
print("The validation accuracy is :", history.history['val_accuracy'])
print("The training accuracy is :", history.history['accuracy'])
print("The validation loss is :", history.history['val_loss'])
print("The training loss is :", history.history['loss'])
```

```
The validation accuracy is : [0.9770841598510742]
The training accuracy is : [0.9569170475006104]
The validation loss is : [0.08246023952960968]
The training loss is : [0.15866714715957642]
```

```
fig, axes = plt.subplots(4,4, figsize=(14,3))
axes = axes.flatten()

for i,ax in enumerate(axes):
    img = np.reshape(test_X[i], (28,28))
    ax.imshow(img, cmap="Greys")

    pred = word_dict[np.argmax(test_yOHE[i])]
    ax.set_title("Prediction: "+pred)
    ax.grid()
```



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