Required Frameworks

In [ ]:

```
import matplotlib.pyplot as plt

from google.colab.patches import cv2_imshow
import cv2

import numpy as np
import pandas as pd

from keras.models import Sequential
from keras.utils import to_categorical
from keras.optimizers import SGD, Adam
from keras.callbacks import ReduceLROnPlateau, EarlyStopping
from keras.layers import Dense, Flatten, Conv2D, MaxPool2D, Dropout

from sklearn.utils import shuffle
from sklearn.model_selection import train_test_split
```

Read The Data

In [ ]:

```
data = pd.read_csv(r"/content/drive/MyDrive/TEMP/PROJECT/Handwritten Digit & Character Recognition

# Printing The First 10 Images Using Data.Head(10)
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]
```

Split Data Into Images And Their Labels

In [ ]:

```
# Splitting the data read into the images & their corresponding labels.
# The ‘0’ contains the labels, & so we drop the ‘0’ column from the data dataframe read & use it i
X = data.drop('0',axis = 1)
y = data['0']
```

Reshaping The Data In The CSV File So That It Can Be Displayed As An Image

In [ ]:

```
# Also, we are reshaping the train & test image data so that they can be displayed as an image, as
# So we convert it to 28×28 pixels.
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)
```

In [ ]:

```
# All the labels are present in the form of floating point values, that we convert to integer valu
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:'
```

Plotting The Number Of Alphabets In The Dataset

In [ ]:

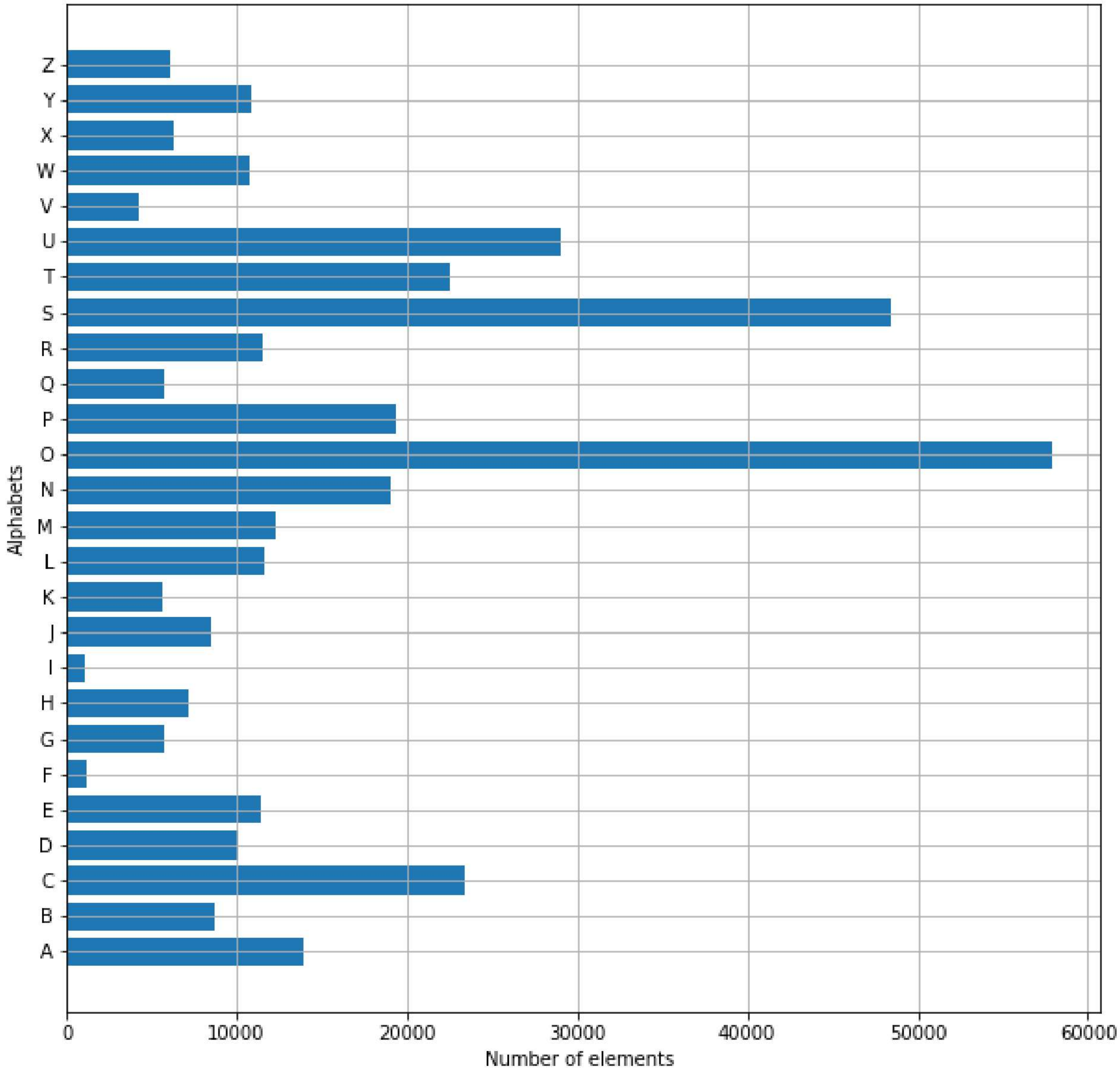
```
# Firstly we convert the labels into integer values and append into the count list according to th
# This count list has the number of images present in the dataset belonging to each alphabet.
# Now we create a list - alphabets containing all the characters using the values() function of th
# Now using the count & alphabets lists we draw the horizontal bar plot.

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()
```



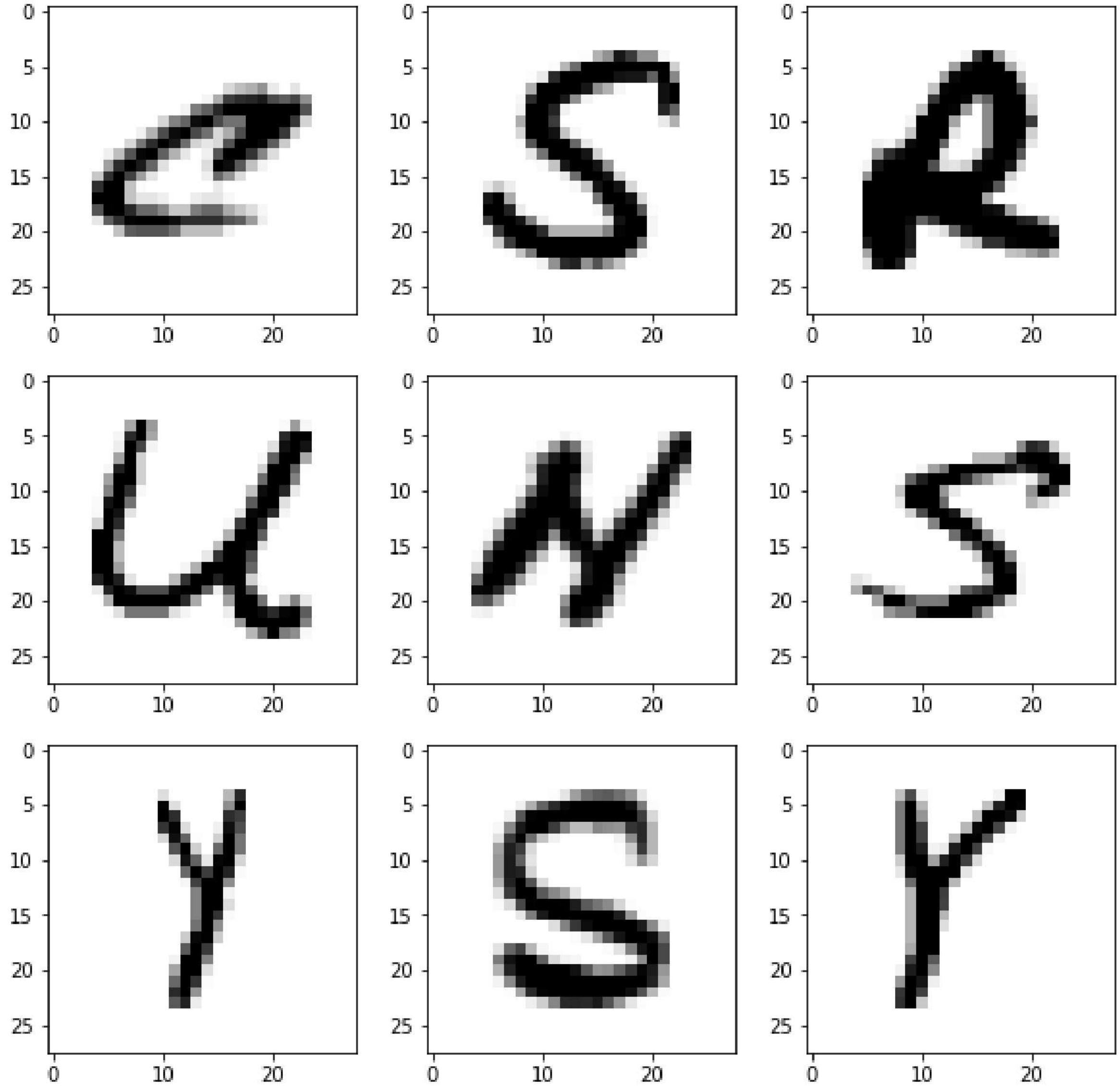
Shuffling The Data

In [ ]:

```
# Now we shuffle some of the images of the train set.
# The shuffling is done using the shuffle() function so that we can display some random images.
# We then create 9 plots in 3x3 shape & display the thresholded images of 9 alphabets.
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()
```



The Above Image Depicts The Grayscale Images That We Got From The Dataset

Data Reshaping

In [ ]:

```
train_X = train_x.reshape(train_x.shape[0],train_x.shape[1],train_x.shape[2],1)
print("New shape of train data: ", train_X.shape)

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

# Now we reshape the train & test image dataset so that they can be put in the model.
```

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

In [ ]:

```
# Here we convert the single float values to categorical values.
# This is done as the CNN model takes input of labels & generates the output as a vector of probab
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)
```

```
In [ ]: # The convolution layers are generally followed by maxpool layers that are used to reduce the numb
        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"))
```

```
In [ ]: # Here we are compiling the model, where we define the optimizing function & the loss function to
        # The optimizing function used is Adam, that is a combination of RMSprop & Adagram optimizing algo
        model.compile(optimizer = Adam(learning_rate=0.001), loss='categorical_crossentropy', metrics=['ac

        # The dataset is very large so we are training for only a single epoch, however, as required we ca
        history = model.fit(train_X, train_yOHE, epochs=1,  validation_data = (test_X,test_yOHE))
```

```
9312/9312 [==============================] - 397s 43ms/step - loss: 0.3805 - accuracy: 0.9059 - va
l_loss: 0.0766 - val_accuracy: 0.9790
```

```
In [ ]: # Now we are getting the model summary that tells us what were the different layers defined in the
        model.summary()
        model.save(r'Character_Model.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 (MaxPooling2 (None, 6, 6, 64)          0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 4, 4, 128)         73856
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 2, 2, 128)         0
_________________________________________________________________
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
_________________________________________________________________
```

Getting the Train & Validation Accuracies & Losses

In [ ]:

```
# Accuracy
print("The Validation Accuracy Is :", history.history['val_accuracy'])
print("The Training Accuracy Is :", history.history['accuracy'])

# Loss
print("The Validation Loss Is :", history.history['val_loss'])
print("The Training Loss Is :", history.history['loss'])
```

```
The Validation Accuracy Is : [0.9789904952049255]
The Training Accuracy Is : [0.9542052745819092]
The Validation Loss Is : [0.07663743942975998]
The Training Loss Is : [0.1649303436279297]
```

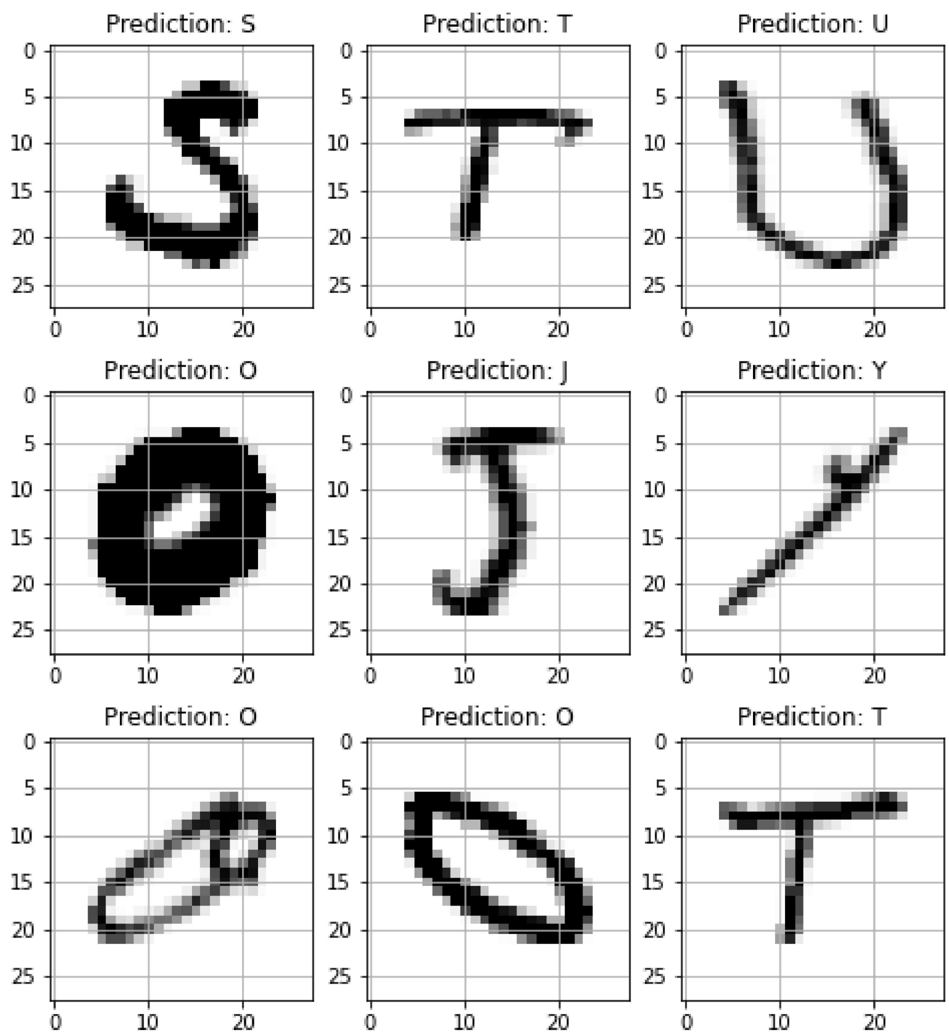
Doing Some Predictions on Test Data

In [ ]:

```
fig, axes = plt.subplots(3,3, figsize=(8,9))
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()
```



Doing Prediction on User Input Image

In [26]:

```
img = cv2.imread(r'/content/drive/MyDrive/TEMP/PROJECT/Handwritten Digit & Character Recognition S
img_copy = img.copy()

img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
img = cv2.resize(img, (400,440))
```

In [27]:

```
img_copy = cv2.GaussianBlur(img_copy, (7,7), 0)
img_gray = cv2.cvtColor(img_copy, cv2.COLOR_BGR2GRAY)
_, img_thresh = cv2.threshold(img_gray, 100, 255, cv2.THRESH_BINARY_INV)

img_final = cv2.resize(img_thresh, (28,28))
img_final =np.reshape(img_final, (1,28,28,1))
```

In [28]:

```
img_pred = word_dict[np.argmax(model.predict(img_final))]

cv2.putText(img, "Prediction: " + img_pred, (20,410), cv2.FONT_HERSHEY_DUPLEX, 1.3, color = (255,0
cv2_imshow(img)
```

In [ ]: