MNIST database

It is a dataset of 60,000 small square 28×28 pixel grayscale images of handwritten single digits between 0 and 9.

The task is to classify a given image of a handwritten digit into one of 10 classes representing integer values from 0 to 9, inclusively.

MNIST challenge is to develop a machine learning algorithm that can classify these images into 10 classes (0 to 9).

For classification of these images into class of 10 we are using XGBoost Classification algorithm .

Methodology

1)Import libraries required and import dataset from keras.

2)Visualize data.

3)Train the model on dataset and predict for the testing data.

4)Evaluate the model.

Importing necessary Libraries

In [42]:

```
import matplotlib.pyplot as plt
from keras.datasets import mnist
import xgboost as xgb
import numpy as np
from sklearn.metrics import mean_squared_error, r2_score, classification_report
```

Importing and splitting MNIST dataset

In [43]:

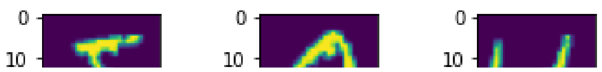
```
# load dataset
(trainX, trainy), (testX, testy) = mnist.load_data()
# summarize loaded dataset
print('Train: X=%s, y=%s' % (trainX.shape, trainy.shape))
print('Test: X=%s, y=%s' % (testX.shape, testy.shape))
```

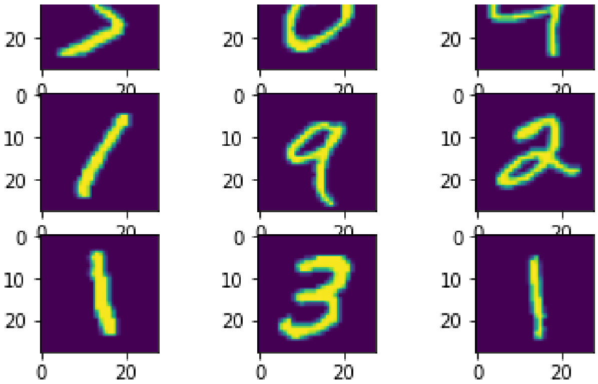
```
Train: X=(60000, 28, 28), y=(60000,)
Test: X=(10000, 28, 28), y=(10000,)
```

Plotting few images

In [44]:

```
# plot first few images
for i in range(9):
 # define subplot
 pyplot.subplot(330 + 1 + i)
 # plot raw pixel data
 pyplot.imshow(trainX[i])
# show the figure
pyplot.show()
```





In [45]:

```
print(trainX.shape)  #shows that it is a collection of 60,000 images and each image is 28
X28 pixel image implies there are 28x28=784 input values in each image.
print(trainX[0])     #matrix of how the image looks like .It is basically a bunch of numb
er where each number show pixel intensity range from 0 to a maximum value of 253 .
print(trainy.shape)
print(testX.shape)
print(testy.shape)
```

```
(60000, 28, 28)
[[  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   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   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   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   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   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   0   0   3  18  18  18 126 136
  175  26 166 255 247 127   0   0   0   0]
 [  0   0   0   0   0   0   0   0  30  36  94 154 170 253 253 253 253 253
  225 172 253 242 195  64   0   0   0   0]
 [  0   0   0   0   0   0   0  49 238 253 253 253 253 253 253 253 253 251
   93  82  82  56  39   0   0   0   0   0]
 [  0   0   0   0   0   0   0  18 219 253 253 253 253 253 198 182 247 241
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0  80 156 107 253 253 205  11   0  43 154
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0  14   1 154 253  90   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0 139 253 190   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  11 190 253  70   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  35 241 225 160 108   1
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0  81 240 253 253 119
   25   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  45 186 253 253
  150  27   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16  93 252
  253 187   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 249
  253 249  64   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  46 130 183 253
  253 207   2   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  39 148 229 253 253 253
  250 182   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0  24 114 221 253 253 253 253 201
   78   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0  23  66 213 253 253 253 253 198  81   2
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0  18 171 219 253 253 253 253 195  80   9   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0  55 172 226 253 253 253 253 244 133  11   0   0   0   0
```

```
     0    0    0    0    0    0    0    0    0    0]
 [   0    0    0    0  136  253  253  253  212  135  132   16    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    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    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    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]]
(60000,)
(10000, 28, 28)
(10000,)
```

Reshaping trainX and testX

In [46]:

```
trainX= trainX.reshape(60000,784)
testX = testX.reshape(10000,784)
```

XGBoost classification

In [51]:

```
XG = xgb.XGBClassifier(objective ='reg:squarederror', colsample_bytree = 0.5, learning_ra
te = 0.1,
max_depth = 7, alpha = 10, n_estimators = 200)
```

In [54]:

```
XG.fit(trainX, trainy)
```

Out[54]:

```
XGBClassifier(alpha=10, base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=0.5, gamma=0,
              learning_rate=0.1, max_delta_step=0, max_depth=7,
              min_child_weight=1, missing=None, n_estimators=200, n_jobs=1,
              nthread=None, objective='multi:softprob', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
```

Evaluation

In [55]:

```
XG.score(testX,testy)
```

Out[55]:

```
0.9793
```

Prediction

In [64]:

```
y_pred = XG.predict(testX)
```

There are four ways to check if the predictions are right or wrong:

TN / True Negative: the case was negative and predicted negative

TP / True Positive: the case was positive and predicted positive

FN / False Negative: the case was positive but predicted negative

FP / False Positive: the case was negative but predicted positive

1) Precision = TP/(TP + FP)

2) Recall = TP/(TP+FN)

3) F1 Score = 2 *(Recall* Precision) / (Recall + Precision)

In [65]:

```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.98      0.99      0.98       980
           1       0.99      0.99      0.99      1135
           2       0.97      0.97      0.97      1032
           3       0.98      0.98      0.98      1010
           4       0.99      0.98      0.98       982
           5       0.99      0.98      0.98       892
           6       0.98      0.98      0.98       958
           7       0.98      0.97      0.97      1028
           8       0.97      0.98      0.97       974
           9       0.97      0.97      0.97      1009

    accuracy                           0.98     10000
   macro avg       0.98      0.98      0.98     10000
weighted avg       0.98      0.98      0.98     10000
```