MNIST Handwritten Digits Dataset

The data set contains images of hand-written digits: 10 classes where each class refers to a digit.

Preprocessing programs made available by NIST were used to extract normalized bitmaps of handwritten digits from a preprinted form. 30 contributed to this training set. 32x32 bitmaps are divided into nonoverlapping blocks of 4x4 and the number of on pixels are counted in each block. This generates an input matrix of 8x8 where each element is an integer in the range 0..16. This reduces dimensionality and gives invariance to small distortions.

For info on NIST preprocessing routines, see M. D. Garris, J. L. Blue, G. T. Candela, D. L. Dimmick, J. Geist, P. J. Grother, S. A. Janet, and C. L. Wilson, NIST Form-Based Handprint Recognition System, NISTIR 5469, 1994.

Loading the Data

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```
df = pd.read_csv('data/mnist.csv')

df.head()
```

Image already in csv, [redacted]ical format

Out[2]:

	pixel_0	pixel_1	pixel_2	pixel_3	pixel_4	pixel_5	pixel_6	pixel_7	pixel_8	pixel_9	...	pixel_55	pixel_56	pixel_57	pixel_58	pixel_59	pixel_60	pixel_61	pixel_62	pixel_63	label
0	0.0	0.0	5.0	13.0	9.0	1.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	6.0	13.0	10.0	0.0	0.0	0.0	0
1	0.0	0.0	0.0	12.0	13.0	5.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	11.0	16.0	10.0	0.0	0.0	1
2	0.0	0.0	0.0	4.0	15.0	12.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	3.0	11.0	16.0	9.0	0.0	2
3	0.0	0.0	7.0	15.0	13.0	1.0	0.0	0.0	0.0	8.0	...	0.0	0.0	0.0	7.0	13.0	13.0	9.0	0.0	0.0	3
4	0.0	0.0	0.0	1.0	11.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	2.0	16.0	4.0	0.0	0.0	4

5 rows × 65 columns

64 + 1 (label)

8 X 8 img → flatten → 64

In [3]:
```
df.shape
```

Out[3]:
```
(1797, 65)
```

no. of images

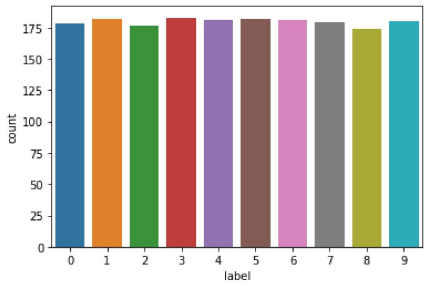
In [4]:
```
df.label.value_counts()
```

Out[4]:
```
3    183
5    182
1    182
6    181
4    181
9    180
7    179
0    178
2    177
8    174
Name: label, dtype: int64
```

multi-class classification

In [5]:
```
sns.countplot(data=df, x='label')
```

Out[5]:
```
<AxesSubplot:xlabel='label', ylabel='count'>
```



Quite a balanced data

In [6]:
```
X = df.drop('label', axis=1)

y = df['label']
```

In [7]:
```
idx = np.random.randint(0, 1796, 9)

print(idx)
```

Random indexes

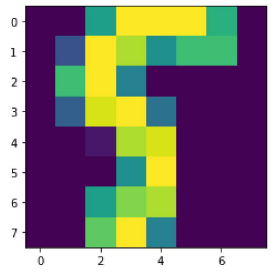
```
[ 316 1616  440 1032  822 1107 1487  939  806]
```

In [8]:
```
print(y[idx[4]])

print(np.reshape(X.values[idx[4]], (8,8)))

img = np.reshape(X.values[idx[4]], (8,8))

plt.imshow(img)
```

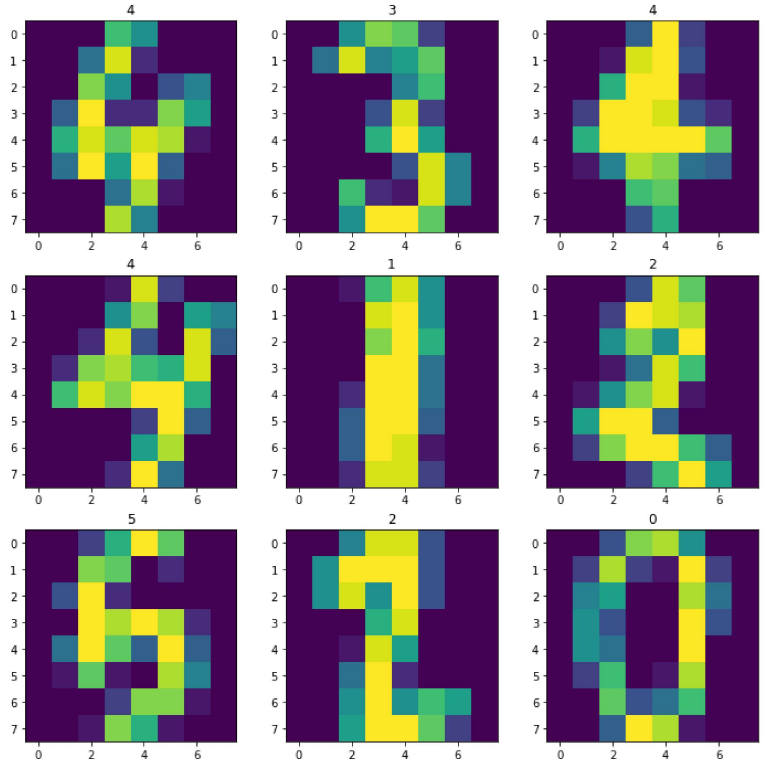
for 1D to 2D reshape

```
5
[[ 0.  0.  9. 16. 16. 16. 10.  0.]
 [ 0.  4. 16. 14.  8. 11. 11.  0.]
 [ 0. 11. 16.  7.  0.  0.  0.  0.]
 [ 0.  5. 15. 16.  6.  0.  0.  0.]
 [ 0.  0.  1. 14. 15.  0.  0.  0.]
 [ 0.  0.  0.  8. 16.  0.  0.  0.]
 [ 0.  0.  9. 13. 14.  0.  0.  0.]
 [ 0.  0. 12. 16.  7.  0.  0.  0.]]
```

Out[8]:
```
<matplotlib.image.AxesImage at 0x20404362430>
```



In [9]:
```
plt.figure(figsize=(12, 12))
idx = np.random.randint(0, 1796, 9)

for i in range(len(idx)):
    plt.subplot(3, 3, i+1)
    plt.title(y[idx[i]])
    img_grid = np.reshape(X.values[idx[i]], (8,8))
    plt.imshow(img_grid)
```



Test Train Split

In [10]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random_state=0)
```

Training

In [11]:
```
from sklearn.linear_model import LogisticRegression
classifier = LogisticRegression()
classifier.fit(X_train, y_train)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:444: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

{ give max_iter = 500 }

Out[11]:
```
LogisticRegression()
```

Prediction

In [12]:
```
y_test_pred = classifier.predict(X_test)
```

Measuring Performance

Accuracy

In [13]:
```
# calculate accuracy of class predictions

from sklearn import metrics

metrics.accuracy_score(y_test, y_test_pred)
```

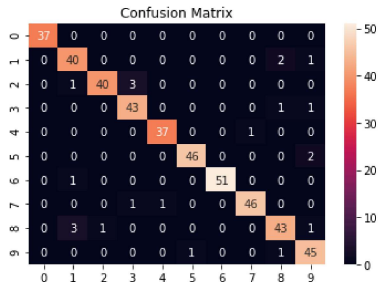
Out[13]: 0.9511111111111111

Confusion Metrics

In [14]:
```
# print the confusion matrix
con_metrics = metrics.confusion_matrix(y_test, y_test_pred)
con_metrics
```

Out[14]:
```
array([[37,  0,  0,  0,  0,  0,  0,  0,  0,  0],
       [ 0, 40,  0,  0,  0,  0,  0,  0,  2,  1],
       [ 0,  1, 40,  3,  0,  0,  0,  0,  0,  0],
       [ 0,  0,  0, 43,  0,  0,  0,  0,  1,  1],
       [ 0,  0,  0,  0, 37,  0,  0,  1,  0,  0],
       [ 0,  0,  0,  0,  0, 46,  0,  0,  0,  2],
       [ 0,  1,  0,  0,  0,  0, 51,  0,  0,  0],
       [ 0,  0,  0,  1,  1,  0,  0, 46,  0,  0],
       [ 0,  3,  1,  0,  0,  0,  0,  0, 43,  1],
       [ 0,  0,  0,  0,  0,  1,  0,  0,  1, 45]], dtype=int64)
```

In [15]:
```
#ploting heatmap for confusion matrix

sns.heatmap(con_metrics, annot=True, fmt='d')
plt.title("Confusion Matrix")
plt.show()
```



Classification Report

In [16]:
```
#Checking Precision, Recall and F1 Score
print(metrics.classification_report(y_test, y_test_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        37
           1       0.89      0.93      0.91        43
           2       0.98      0.91      0.94        44
           3       0.91      0.96      0.93        45
           4       0.97      0.97      0.97        38
           5       0.98      0.96      0.97        48
           6       1.00      0.98      0.99        52
           7       0.98      0.96      0.97        48
           8       0.91      0.90      0.91        48
           9       0.90      0.96      0.93        47

    accuracy                           0.95       450
   macro avg       0.95      0.95      0.95       450
weighted avg       0.95      0.95      0.95       450
```

Decision Tree Model

In [17]:
```
from sklearn.tree import DecisionTreeClassifier

dt_classifier = DecisionTreeClassifier()
dt_classifier.fit(X_train, y_train)

y_test_pred = dt_classifier.predict(X_test)

metrics.accuracy_score(y_test, y_test_pred)
```

Out[17]: 0.8422222222222222