# Andrew Vu - CS156_HW7

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# 1 CS156 (Introduction to AI), Spring 2022

# 2 Homework 7 submission

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Any special notes or anything you would like to communicate to me about this homework submission goes in here.

## 2.1 References and sources

List all your references and sources here. This includes all sites/discussion boards/blogs/posts/etc. where you grabbed some code examples.

- https://www.geeksforgeeks.org/violinplot-using-seaborn-in-python/
- https://stackoverflow.com/questions/68629457/seaborn-grouped-violin-plot-without-pandas
- https://seaborn.pydata.org/generated/seaborn.swarmplot.html#seaborn.swarmplot

## 2.2 Solution

**Load libraries and set random number generator seed**

[137]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

from sklearn import datasets
from sklearn.model_selection import train_test_split
from sklearn.neural_network import MLPClassifier

from sklearn.model_selection import StratifiedKFold
from sklearn.model_selection import cross_val_score
```

[138]:

```
np.random.seed(42)
```

**Code the solution**

### 2.2.1 Load the Dataset

[139]:
```
digits = datasets.load_digits()
X = digits.data
X = X.astype("float32") / 255
Y = digits.target
class_names = digits.target_names
X.shape, Y.shape, class_names
```

[139]:
```
((1797, 64), (1797,), array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9]))
```

[140]:
```
digits_df = pd.DataFrame(X, columns=digits.feature_names)
digits_df['output_digit'] = Y
digits_df.head()
```

[140]:
```
   pixel_0_0  pixel_0_1  pixel_0_2  pixel_0_3  pixel_0_4  pixel_0_5  \
0        0.0        0.0   0.019608   0.050980   0.035294   0.003922
1        0.0        0.0   0.000000   0.047059   0.050980   0.019608
2        0.0        0.0   0.000000   0.015686   0.058824   0.047059
3        0.0        0.0   0.027451   0.058824   0.050980   0.003922
4        0.0        0.0   0.000000   0.003922   0.043137   0.000000

   pixel_0_6  pixel_0_7  pixel_1_0  pixel_1_1  …  pixel_6_7  pixel_7_0  \
0        0.0        0.0        0.0   0.000000  …        0.0        0.0
1        0.0        0.0        0.0   0.000000  …        0.0        0.0
2        0.0        0.0        0.0   0.000000  …        0.0        0.0
3        0.0        0.0        0.0   0.031373  …        0.0        0.0
4        0.0        0.0        0.0   0.000000  …        0.0        0.0

   pixel_7_1  pixel_7_2  pixel_7_3  pixel_7_4  pixel_7_5  pixel_7_6  \
0        0.0   0.023529   0.050980   0.039216   0.000000   0.000000
1        0.0   0.000000   0.043137   0.062745   0.039216   0.000000
2        0.0   0.000000   0.011765   0.043137   0.062745   0.035294
3        0.0   0.027451   0.050980   0.050980   0.035294   0.000000
4        0.0   0.000000   0.007843   0.062745   0.015686   0.000000

   pixel_7_7  output_digit
0        0.0             0
1        0.0             1
2        0.0             2
3        0.0             3
4        0.0             4

[5 rows x 65 columns]
```

### 2.2.2 Split data into training and test & stratify

[141]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2,␣
 ↪random_state=0, stratify=Y)
X_train.shape, X_test.shape, Y_train.shape, Y_test.shape
```

[141]:
```
((1437, 64), (360, 64), (1437,), (360,))
```

### 2.2.3 6 different MLP models

[142]:
```
# change to 10000 max iter
model1 = MLPClassifier(random_state=1, max_iter=10000).fit(X_train, Y_train)
model2 = MLPClassifier(hidden_layer_sizes=(400,150,50), activation = 'relu',␣
 ↪random_state=1, max_iter=10000).fit(X_train, Y_train)
model3 = MLPClassifier(hidden_layer_sizes=(64,32,8), activation = 'relu',␣
 ↪random_state=1, max_iter=10000).fit(X_train, Y_train)
model4 = MLPClassifier(hidden_layer_sizes=(32,16), activation = 'relu',␣
 ↪random_state=1, max_iter=10000).fit(X_train, Y_train)
model5 = MLPClassifier(hidden_layer_sizes=(120,64,16), activation = 'relu',␣
 ↪random_state=1, max_iter=10000).fit(X_train, Y_train)
model6 = MLPClassifier(hidden_layer_sizes=(320,120,32), activation = 'relu',␣
 ↪random_state=1, max_iter=10000).fit(X_train, Y_train)
```

### 2.2.4 Stratified 5-fold cross-val prediction accuracy per fold

[143]:
```
cross_vals1 = cross_val_score(model1, X_train, Y_train, cv=5)
cross_vals2 = cross_val_score(model2, X_train, Y_train, cv=5)
cross_vals3 = cross_val_score(model3, X_train, Y_train, cv=5)
cross_vals4 = cross_val_score(model4, X_train, Y_train, cv=5)
cross_vals5 = cross_val_score(model5, X_train, Y_train, cv=5)
cross_vals6 = cross_val_score(model6, X_train, Y_train, cv=5)

print('Individual cross-validation accuracies for Model 1: ' + str(cross_vals1))
print('Individual cross-validation accuracies for Model 2: ' + str(cross_vals2))
print('Individual cross-validation accuracies for Model 3: ' + str(cross_vals3))
print('Individual cross-validation accuracies for Model 4: ' + str(cross_vals4))
print('Individual cross-validation accuracies for Model 5: ' + str(cross_vals5))
print('Individual cross-validation accuracies for Model 6: ' + str(cross_vals6))
```

```
Individual cross-validation accuracies for Model 1: [0.96180556 0.98263889
0.95818815 0.96864111 0.96515679]
Individual cross-validation accuracies for Model 2: [0.95486111 0.97569444
0.95121951 0.95818815 0.95121951]
Individual cross-validation accuracies for Model 3: [0.93402778 0.95833333
0.92682927 0.93031359 0.93728223]
Individual cross-validation accuracies for Model 4: [0.9375     0.95486111
0.91289199 0.95121951 0.94425087]
Individual cross-validation accuracies for Model 5: [0.94444444 0.96527778
0.95121951 0.93728223 0.94425087]
Individual cross-validation accuracies for Model 6: [0.94791667 0.97222222
0.94425087 0.95121951 0.95121951]
```

### 2.2.5 Prediction Accuracy for each model on test set

[144]:
```
model1accuracy = model1.score(X_test, Y_test)
model2accuracy = model2.score(X_test, Y_test)
model3accuracy = model3.score(X_test, Y_test)
model4accuracy = model4.score(X_test, Y_test)
model5accuracy = model5.score(X_test, Y_test)
model6accuracy = model6.score(X_test, Y_test)

print('Accuracy of MLPClassifier Model1 on test set: {:.2f}'.
 ↪format(model1accuracy))
print('Accuracy of MLPClassifier Model2 on test set: {:.2f}'.
 ↪format(model2accuracy))
print('Accuracy of MLPClassifier Model3 on test set: {:.2f}'.
 ↪format(model3accuracy))
print('Accuracy of MLPClassifier Model4 on test set: {:.2f}'.
 ↪format(model4accuracy))
print('Accuracy of MLPClassifier Model5 on test set: {:.2f}'.
 ↪format(model5accuracy))
print('Accuracy of MLPClassifier Model6 on test set: {:.2f}'.
 ↪format(model6accuracy))
```

```
Accuracy of MLPClassifier Model1 on test set: 0.97
Accuracy of MLPClassifier Model2 on test set: 0.95
Accuracy of MLPClassifier Model3 on test set: 0.94
Accuracy of MLPClassifier Model4 on test set: 0.93
Accuracy of MLPClassifier Model5 on test set: 0.95
Accuracy of MLPClassifier Model6 on test set: 0.95
```

### 2.2.6 Setting up the variables for plotting

[145]:
```
models = ['Model1', 'Model1', 'Model1', 'Model1', 'Model1',
          'Model2', 'Model2', 'Model2', 'Model2', 'Model2',
          'Model3', 'Model3', 'Model3', 'Model3', 'Model3',
          'Model4', 'Model4', 'Model4', 'Model4', 'Model4',
          'Model5', 'Model5', 'Model5', 'Model5', 'Model5',
          'Model6', 'Model6', 'Model6', 'Model6', 'Model6']
models_for_score = ['Model1', 'Model2', 'Model3', 'Model4', 'Model5', 'Model6']
modelnumber = [1, 2, 3, 4, 5, 6]
model_accs = [model1accuracy, model2accuracy, model3accuracy, model4accuracy,␣
 ↪model5accuracy, model6accuracy]
vals = np.array([cross_vals1, cross_vals2, cross_vals3, cross_vals4,␣
 ↪cross_vals5, cross_vals6])
```

```
vals = vals.flatten()
```

### 2.2.7 Plotting the cross vals & test set accuracy

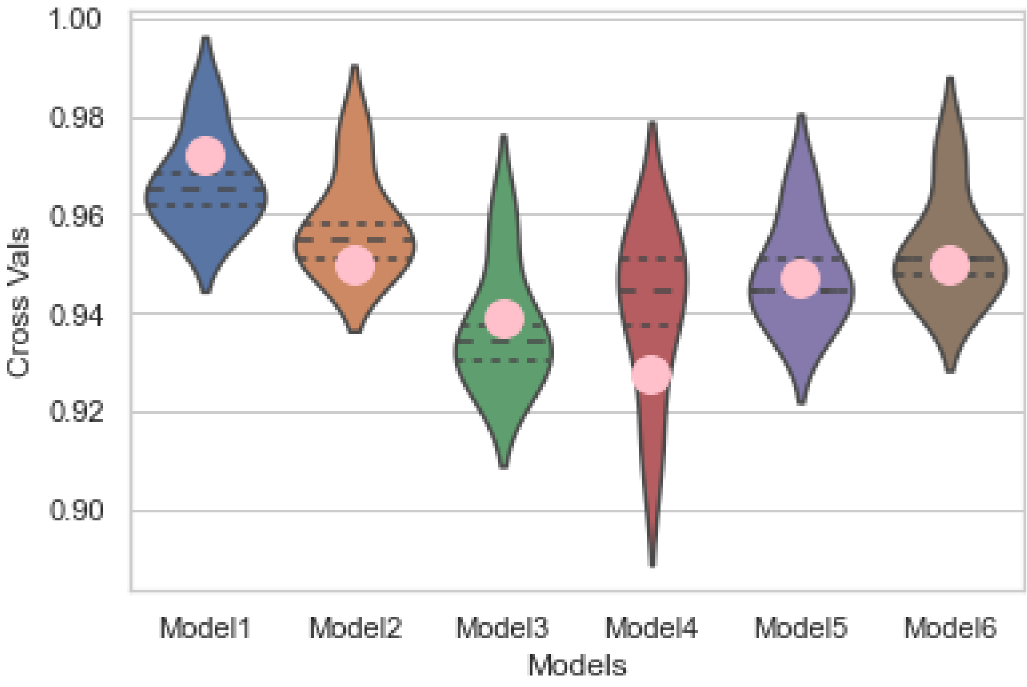
[146]:
```
fig, ax = plt.subplots()

# cross vals plot
sns.set(style = 'whitegrid')
vplot = sns.violinplot(x = models, y = vals, inner = "quartile", ax = ax)
vplot.set_xlabel("Models")
vplot.set_ylabel("Cross Vals")

# could not figure out a way for pink X's, so i just used regular dots
# test data accuracy plot
vplot = sns.swarmplot(x = models_for_score, y = model_accs, color = 'pink',␣
 ↪edgecolor = 'white', size = 15, ax = ax)

print(vplot)
```

```
AxesSubplot(0.125,0.125;0.775x0.755)
```



[ ]:
```
```