NBAPredictionCode

December 19, 2018

```
In [3]: # Import necessary packages

        %matplotlib inline

        import pandas as pd
        import numpy as np
        import matplotlib.pyplot as plt
        from sklearn.neural_network import MLPClassifier
        import sklearn.metrics as metrics
        from sklearn.model_selection import KFold
        from operator import itemgetter
        from sklearn.model_selection import cross_val_score
        from sklearn.model_selection import RandomizedSearchCV
        from sklearn.model_selection import train_test_split
        from sklearn.svm import SVC
        from sklearn.ensemble import RandomForestClassifier
        from sklearn import neighbors
        import seaborn as sns
        from sklearn import linear_model, preprocessing
```

```
In [4]: # Import the datasets

        rookieDf = pd.read_csv('2017-rookies.csv')
        pastDf = pd.read_csv('historical-rookies.csv')

        # Preview the historical dataset

        pastDf.head()
```

```
Out[4]:    SeasonID                Player   Season  Age   Tm   Lg Pos   G  GS   MPG  \
        0         0        Alaa Abdelnaby  1990-91   22  POR  NBA  PF  43   0   6.7
        1        43      Mahmoud Abdul-Rauf  1990-91   21  DEN  NBA  PG  67  19  22.5
        2        52       Tariq Abdul-Wahad  1997-98   23  SAC  NBA  SG  59  16  16.3
        3        62   Shareef Abdur-Rahim  1996-97   20  VAN  NBA  PF  80  71  35.0
        4        88          Alex Abrines  2016-17   23  OKC  NBA  SG  66   6  15.5

             ...     DWS   WS  WS/48  OBPM  DBPM  BPM  VORP  PlayerID  Hall of Fame  \
        0    ...     0.5  0.5  0.079  -4.2  -0.7 -5.0  -0.2         0             0
```

```
1    ...    -0.3 -1.0 -0.031  -1.7  -4.4 -6.1  -1.6         3             0
2    ...     0.6 -0.2 -0.008  -4.2  -1.7 -5.9  -0.9         4             0
3    ...     1.2  2.9  0.049  -0.8  -1.2 -2.0   0.0         5             0
4    ...     0.9  2.0  0.094  -0.4  -2.3 -2.7  -0.2         9             0

   All Star
0         0
1         0
2         0
3         1
4         0

[5 rows x 55 columns]
```

```
In [5]: pastDf.columns.values
```

```
Out[5]: array(['SeasonID', 'Player', 'Season', 'Age', 'Tm', 'Lg', 'Pos', 'G',
               'GS', 'MPG', 'FG/G', 'FGA/G', 'FG%', '3P/G', '3PA/G', '3P%',
               '2P/G', '2PA/G', '2P%', 'eFG%', 'FT/G', 'FTA/G', 'FT%', 'ORB/G',
               'DRB/G', 'TRB/G', 'AST/G', 'STL/G', 'BLK/G', 'TOV/G', 'PF/G',
               'PTS/G', 'PER', 'TS%', '3PAr', 'FTr', 'ORB%', 'DRB%', 'TRB%',
               'AST%', 'STL%', 'BLK%', 'TOV%', 'USG%', 'OWS', 'DWS', 'WS',
               'WS/48', 'OBPM', 'DBPM', 'BPM', 'VORP', 'PlayerID', 'Hall of Fame',
               'All Star'], dtype=object)
```

```
In [6]: # Preview the rookies dataset

        rookieDf.head()
```

```
Out[6]:    SeasonID        Player     Season   Tm    Lg Pos   G  GS   MPG  FG/G  \
        0         0   Ben Simmons  2017-2018  PHI  NBA  PG  81  81  33.7   6.7
        1         1    Lonzo Ball    2017-18  LAL  NBA  PG  52  50  34.2   3.9
        2         2  Jayson Tatum    2017-18  BOS  NBA  SF  80  80  30.5   5.0
        3         3  Josh Jackson    2017-18  PHO  NBA  SF  77  35  25.4   5.1
        4         4  De'Aaron Fox    2017-18  SAC  NBA  PG  73  60  27.8   4.5

             ...     USG%  OWS  DWS   WS  WS/48   OBPM   DBPM  BPM  VORP  PlayerID
        0    ...     22.3  4.2  5.0  9.2  0.162    1.0    3.6  4.6   4.6         0
        1    ...     17.4 -0.5  2.5  2.0  0.053   -0.8    2.5  1.7   1.7         1
        2    ...     19.5  3.0  4.0  7.1  0.139   -0.5    1.5  1.0   1.8         2
        3    ...     26.0 -2.0  1.2 -0.7 -0.018   -3.1   -1.2 -4.3  -1.1         3
        4    ...     23.4 -1.7  1.1 -0.6 -0.014   -2.8   -1.5 -4.4  -1.2         4

        [5 rows x 52 columns]
```

```
In [18]: pastDf.dtypes
```

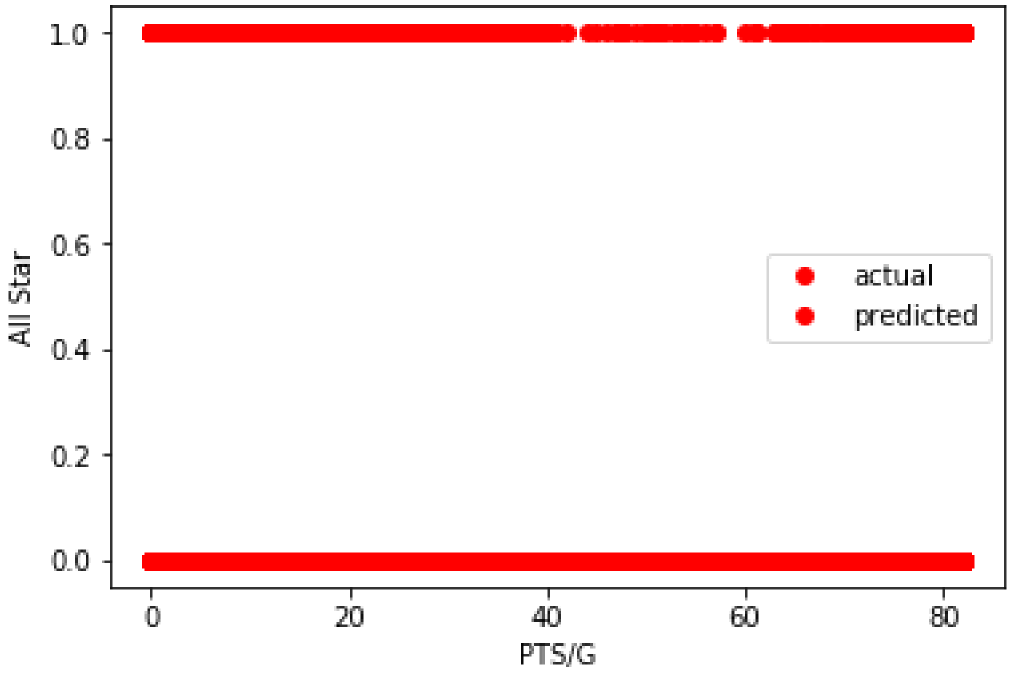
```
Out[18]: SeasonID           int64
         Player            object
```

```
Season           object
Age               int64
Tm               object
Lg               object
Pos              object
G                 int64
GS                int64
MPG             float64
FG/G            float64
FGA/G           float64
FG%             float64
3P/G            float64
3PA/G           float64
3P%             float64
2P/G            float64
2PA/G           float64
2P%             float64
eFG%            float64
FT/G            float64
FTA/G           float64
FT%             float64
ORB/G           float64
DRB/G           float64
TRB/G           float64
AST/G           float64
STL/G           float64
BLK/G           float64
TOV/G           float64
PF/G            float64
PTS/G           float64
PER             float64
TS%             float64
3PAr            float64
FTr             float64
ORB%            float64
DRB%            float64
TRB%            float64
AST%            float64
STL%            float64
BLK%            float64
TOV%            float64
USG%            float64
OWS             float64
DWS             float64
WS              float64
WS/48           float64
OBPM            float64
DBPM            float64
```

```
BPM                float64
VORP               float64
PlayerID             int64
Hall of Fame         int64
All Star             int64
dtype: object
```

1 Logistic Regression

```
In [9]: ytrain = np.array(pastDf['All Star'])
        Xtrain = np.array(pastDf[['G', 'MPG', 'FG/G', 'FGA/G', '2P%', '3P%', 'FT%', 'TRB/G', '
                                'TS%', '3PAr', 'FTr']])
        from sklearn import linear_model

        regr = linear_model.LogisticRegression()
        regr.fit(Xtrain, ytrain)
        ytrain_pred = regr.predict(Xtrain)
        plt.plot(Xtrain,ytrain, 'ro')
        plt.plot(Xtrain,ytrain_pred, 'ro')
        plt.legend(['actual', 'predicted'])
        plt.xlabel('PTS/G')
        plt.ylabel('All Star')

Out[9]: Text(0,0.5,'All Star')
```



2 Prepare Rookie Dataset for Predictions

```
In [56]: # Prepare rookies dataframe to be plugged into machine learning models by skipping co
         rookieNames = rookieDf.iloc[:, 1]
         rookieFeatures = rookieDf[['G', 'MPG', 'FG/G', 'FGA/G', '2P%', '3P%', 'FT%', 'TRB/G',
                                    'TS%', '3PAr', 'FTr']]
```

3 Cross Validation - Hall of Fame

```
In [45]: vals, y = np.unique(pastDf['Hall of Fame'].values, return_inverse=True)

         xnames = pastDf.columns[9:25]
         X= np.array(pastDf[xnames].values)
         Xs = preprocessing.scale(X)

         logreg= linear_model.LogisticRegression(C=1e5)
         logreg.fit(Xs, y)

Out[45]: LogisticRegression(C=100000.0, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='ovr', n_jobs=1, penalty='l2', random_state=None,
                   solver='liblinear', tol=0.0001, verbose=0, warm_start=False)
```

```
In [46]: from sklearn.model_selection import KFold
         from sklearn.metrics import precision_recall_fscore_support

         nfold = 10
         kf = KFold(n_splits = nfold, shuffle=True)

         rec = []
         f1 = []
         prec = []
         err_rate = []

         for Itr, Its in kf.split(Xs):
             Xtr = Xs[Itr,:]
             ytr = y [Itr]
             Xts = Xs[Its,:]
             yts = y[Its]

             logreg.fit(Xtr,ytr)

             yhat = logreg.predict(Xts)

             preci,reci,f1i,_= precision_recall_fscore_support(yts,yhat,average='binary')

             prec.append(preci)
             rec.append(reci)
             f1.append(f1i)
             err_rate.append(np.mean(yts!=yhat))

         prec = np.mean(prec)
         rec = np.mean(rec)
         f1 = np.mean(f1)
         err_mean= np.mean(err_rate)

         print('Precision ' + str(prec))
         print('Recall ' + str(rec))
         print('f1 ' + str(f1))
         print('error rate ' + str(err_mean))
```

```
Precision 0.275
Recall 0.09916666666666665
f1 0.13071428571428573
error rate 0.02140475563744845


/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: UndefinedMetricW
  'precision', 'predicted', average, warn_for)
/anaconda3/lib/python3.6/site-packages/sklearn/metrics/classification.py:1135: UndefinedMetricW
  'precision', 'predicted', average, warn_for)
```

4 Make Prediction - Hall of Fame

```
In [58]: ynew = logreg.predict(rookieFeatures)
         for i in range(len(rookieFeatures)):
             print("Name = %s, Predicted = %s" % (rookieNames[i], ynew[i]))
```

```
Name = Ben Simmons, Predicted = 1
Name = Lonzo Ball, Predicted = 0
Name = Jayson Tatum, Predicted = 1
Name = Josh Jackson, Predicted = 1
Name = De'Aaron Fox, Predicted = 1
Name = Lauri Markkanen, Predicted = 1
Name = Frank Ntilikina, Predicted = 0
Name = Dennis Smith, Predicted = 1
Name = Zach Collins, Predicted = 1
Name = Malik Monk, Predicted = 1
Name = Luke Kennard, Predicted = 1
Name = Donovan Mitchell, Predicted = 1
Name = Bam Adebayo, Predicted = 1
Name = Justin Jackson, Predicted = 1
Name = T.J. Leaf, Predicted = 1
Name = John Collins, Predicted = 1
Name = Terrance Ferguson, Predicted = 1
Name = Jarrett Allen, Predicted = 1
Name = OG Anunoby, Predicted = 1
Name = Kyle Kuzma, Predicted = 1
Name = Josh Hart, Predicted = 1
Name = Wesley Iwundu, Predicted = 1
Name = Frank Mason, Predicted = 1
Name = Semi Ojeleye, Predicted = 1
Name = Jordan Bell, Predicted = 1
Name = Dwayne Bacon, Predicted = 1
Name = Tyler Dorsey, Predicted = 1
Name = Dillon Brooks, Predicted = 1
Name = Sterling Brown, Predicted = 1
Name = Sindarius Thornwell, Predicted = 1
```

5 Cross Validation - All Stars

```
In [59]: vals, y = np.unique(pastDf['All Star'].values, return_inverse=True)

         xnames = pastDf.columns[9:25]
         X= np.array(pastDf[xnames].values)
         Xs = preprocessing.scale(X)

         logreg= linear_model.LogisticRegression(C=1e5)
         logreg.fit(Xs, y)
```

```
Out[59]: LogisticRegression(C=100000.0, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, max_iter=100,
                   multi_class='ovr', n_jobs=1, penalty='l2', random_state=None,
                   solver='liblinear', tol=0.0001, verbose=0, warm_start=False)
```

```
In [60]: nfold = 10
         kf = KFold(n_splits = nfold, shuffle=True)

         rec = []
         f1 = []
         prec = []
         err_rate = []

         for Itr, Its in kf.split(Xs):
             Xtr = Xs[Itr,:]
             ytr = y [Itr]
             Xts = Xs[Its,:]
             yts = y[Its]

             logreg.fit(Xtr,ytr)

             yhat = logreg.predict(Xts)
             preci,reci,f1i,_= precision_recall_fscore_support(yts,yhat,average='binary')

             prec.append(preci)
             rec.append(reci)
             f1.append(f1i)
             err_rate.append(np.mean(yts!=yhat))

         prec = np.mean(prec)
         rec = np.mean(rec)
         f1 = np.mean(f1)
         err_mean= np.mean(err_rate)

         print('Precision ' + str(prec))
         print('Recall ' + str(rec))
         print('f1 ' + str(f1))
         print('error rate ' + str(err_mean))
```

```
Precision 0.6427114552114552
Recall 0.2845761950940979
f1 0.39168541010646274
error rate 0.07489105320113448
```

6 Make Prediction - All Star

```
In [62]: ynew = logreg.predict(rookieFeatures)
         for i in range(len(rookieFeatures)):
             print("Name = %s, Predicted = %s" % (rookieNames[i], ynew[i]))
```

```
Name = Ben Simmons, Predicted = 1
Name = Lonzo Ball, Predicted = 1
Name = Jayson Tatum, Predicted = 1
Name = Josh Jackson, Predicted = 1
Name = De'Aaron Fox, Predicted = 1
Name = Lauri Markkanen, Predicted = 1
Name = Frank Ntilikina, Predicted = 1
Name = Dennis Smith, Predicted = 1
Name = Zach Collins, Predicted = 1
Name = Malik Monk, Predicted = 1
Name = Luke Kennard, Predicted = 1
Name = Donovan Mitchell, Predicted = 1
Name = Bam Adebayo, Predicted = 1
Name = Justin Jackson, Predicted = 1
Name = T.J. Leaf, Predicted = 1
Name = John Collins, Predicted = 1
Name = Terrance Ferguson, Predicted = 1
Name = Jarrett Allen, Predicted = 1
Name = OG Anunoby, Predicted = 1
Name = Kyle Kuzma, Predicted = 1
Name = Josh Hart, Predicted = 1
Name = Wesley Iwundu, Predicted = 1
Name = Frank Mason, Predicted = 1
Name = Semi Ojeleye, Predicted = 1
Name = Jordan Bell, Predicted = 1
Name = Dwayne Bacon, Predicted = 1
Name = Tyler Dorsey, Predicted = 1
Name = Dillon Brooks, Predicted = 1
Name = Sterling Brown, Predicted = 1
Name = Sindarius Thornwell, Predicted = 1
```

7 Creating data splits for HOF models

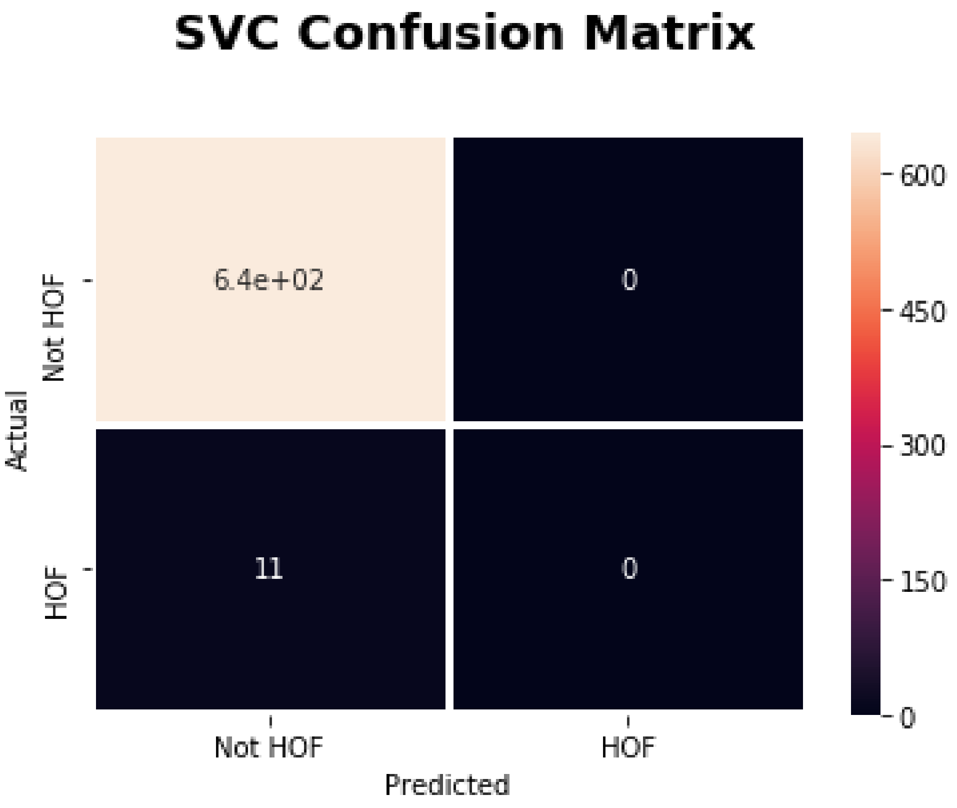
```
In [63]: trainData, testData = train_test_split(pastDf, test_size = 0.25, random_state = 0)

         xtrainData = trainData[['G', 'MPG', 'FG/G', 'FGA/G', '2P%', '3P%', 'FT%', 'TRB/G', 'AS
                         'TS%', '3PAr', 'FTr']]

         xtestData = testData[['G', 'MPG', 'FG/G', 'FGA/G', '2P%', '3P%', 'FT%', 'TRB/G', 'AST/
                         'TS%', '3PAr', 'FTr']]

         ytrainData = trainData[['Hall of Fame']]


         ytestData = testData[['Hall of Fame']]
```

8 Create models and confusion matrices for HOF models

```
In [66]: svcModel = SVC(kernel='rbf', gamma=1e-4, C=10, probability = True)

         svcModel.fit(xtrainData, ytrainData.values.ravel())

         ysvc = svcModel.predict(xtestData)


         probability = svcModel.predict_proba(xtestData)

         posProbability = probability[:, 1]


         fprSVC, tprSVC, thresholdSVC = metrics.roc_curve(ytestData, posProbability)
         roc_aucSVC = metrics.auc(fprSVC, tprSVC)

         cvScoreSVC = cross_val_score(svcModel, xtestData, ytestData.values.ravel(), cv = 3, s
         print("Accuracy score: %.3f" % metrics.accuracy_score(ytestData, ysvc))
         print("Log loss: %.3f" % metrics.log_loss(ytestData, probability))
         print("Area under ROC curve: %.3f" % metrics.roc_auc_score(ytestData, posProbability)
         print("Accuracy (cross validation score): %0.2f (+/- %0.2f)" % (cvScoreSVC.mean(), cvS
```

```
Accuracy score: 0.983
Log loss: 0.075
Area under ROC curve: 0.951
Accuracy (cross validation score): 0.98 (+/- 0.00)
```

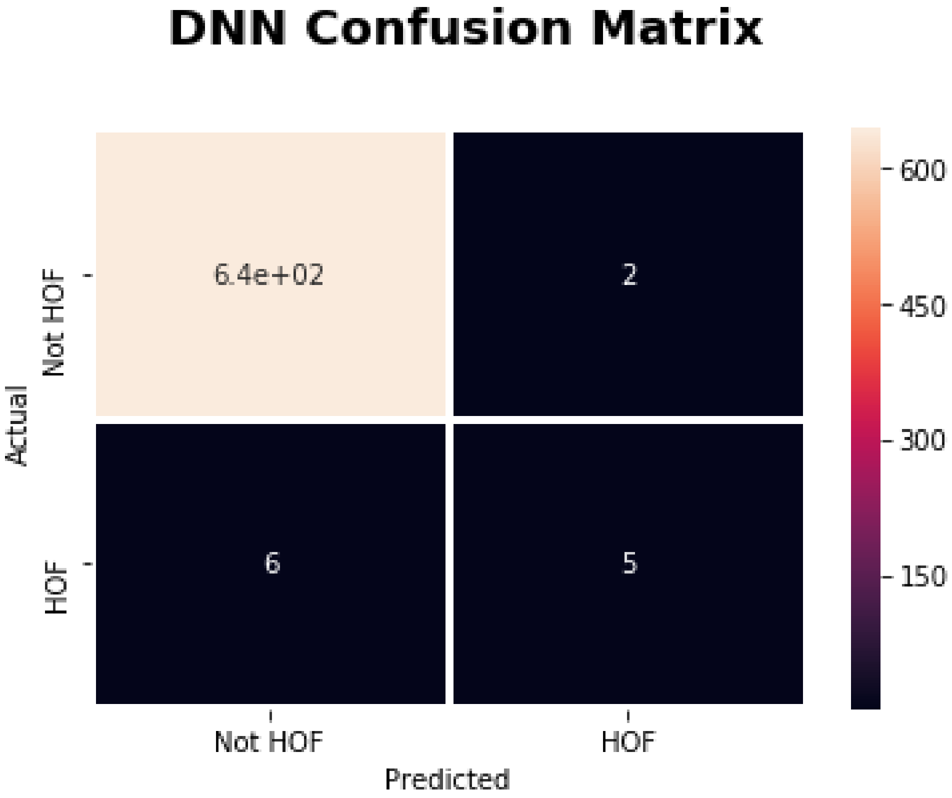
```
In [68]: confusionmatrix = metrics.confusion_matrix(ytestData, ysvc)

         svcHofconfusionmatrix, ax = plt.subplots()

         sns.heatmap(confusionmatrix, annot=True, ax = ax, linewidth = 2)

         ax.set_xlabel("Predicted")
         ax.set_ylabel("Actual")

         labels = ["Not HOF", "HOF"]
         ax.set_xticklabels(labels)
         ax.set_yticklabels(labels)

         svcHofconfusionmatrix.suptitle("SVC Confusion Matrix", weight = 'bold', size = 18, y

         svcHofconfusionmatrix.savefig('svc-hof-cm.png', dpi = 400, bbox_inches = 'tight')
```



```
In [69]: deepneuralnet = MLPClassifier(
             solver='lbfgs',
             hidden_layer_sizes=100,
             max_iter=10000,
             shuffle=False,
             random_state=0,
             activation='identity')

         deepneuralnet.fit(xtrainData, ytrainData.values.ravel())

         y_deepneuralnet = deepneuralnet.predict(xtestData)

         print("Accuracy score: %.3f" % metrics.accuracy_score(ytestData, y_deepneuralnet))

         proba = deepneuralnet.predict_proba(xtestData)
         print("Log loss: %.3f" % metrics.log_loss(ytestData, proba))

         posProb = proba[:, 1]
         print("Area under ROC curve: %.3f" % metrics.roc_auc_score(ytestData, posProb))

         fprDNN, tprDNN, thresholdDNN = metrics.roc_curve(ytestData, posProb)
         roc_aucDNN = metrics.auc(fprDNN, tprDNN)

         cvScoreDNN = cross_val_score(deepneuralnet, xtestData, ytestData.values.ravel(), cv =
         print("Accuracy (cross validation score): %0.2f (+/- %0.2f)" % (cvScoreDNN.mean(), cvS
```

```
Accuracy score: 0.988
Log loss: 0.045
Area under ROC curve: 0.971
Accuracy (cross validation score): 0.98 (+/- 0.00)
```

```
In [71]: confusionmatrix = metrics.confusion_matrix(ytestData, y_deepneuralnet)

         deepneuralnetHofCM, ax = plt.subplots()

         sns.heatmap(confusionmatrix, annot=True, ax = ax, linewidth = 2)

         ax.set_xlabel("Predicted")
         ax.set_ylabel("Actual")

         labels = ["Not HOF", "HOF"]
         ax.set_xticklabels(labels)
         ax.set_yticklabels(labels)

         deepneuralnetHofCM.suptitle("DNN Confusion Matrix", weight = 'bold', size = 18, y = 1

         deepneuralnetHofCM.savefig('dnn-hof-cm.png', dpi = 400, bbox_inches = 'tight')
```



9 Randomized search CV

```
In [73]: # SVC

         C = [int(x) for x in np.linspace(start = 1, stop = 100, num = 10)]

         kernel = ['rbf', 'linear']

         gamma = [float(x) for x in np.linspace(start = 1e-5, stop = 10, num = 10)]

         random_grid = {'C': C,
                        'kernel': kernel,
                        'gamma': gamma}

         svc_random = RandomizedSearchCV(estimator = svcModel, param_distributions = random_gr
                                         verbose=2, random_state=42, n_jobs = 20)

In [74]: svc_random.fit(xtrainData, ytrainData.values.ravel())

         y_svcrand = svc_random.predict(xtestData)
```

```
    searchScore = metrics.accuracy_score(ytestData, y_svcrand)
    nonSearchScore = metrics.accuracy_score(ytestData, y_svc)
    improvement = (searchScore - nonSearchScore) / nonSearchScore

    print("Percent improvement: %.5f" % improvement)
```

```
Fitting 3 folds for each of 25 candidates, totalling 75 fits
[CV] kernel=linear, gamma=7.77778, C=45 ...
[CV] kernel=linear, gamma=7.77778, C=45 ...
[CV] kernel=linear, gamma=7.77778, C=45 ...
[CV] kernel=linear, gamma=7.77778, C=1 ...
[CV] kernel=linear, gamma=7.77778, C=1 ...
[CV] kernel=linear, gamma=7.77778, C=1 ...
[CV] kernel=rbf, gamma=5.55556, C=12 ...
[CV] kernel=rbf, gamma=5.55556, C=12 ...
[CV] kernel=rbf, gamma=5.55556, C=12 ...
[CV] kernel=rbf, gamma=10.0, C=78 ...
[CV] kernel=rbf, gamma=10.0, C=78 ...
[CV] kernel=rbf, gamma=10.0, C=78 ...
[CV] kernel=rbf, gamma=4.44445, C=67 ...
[CV] kernel=rbf, gamma=4.44445, C=67 ...
[CV] kernel=linear, gamma=7.77778, C=56 ...
[CV] kernel=rbf, gamma=4.44445, C=67 ...
[CV] kernel=linear, gamma=7.77778, C=56 ...
[CV] kernel=linear, gamma=7.77778, C=56 ...
[CV] kernel=linear, gamma=4.44445, C=34 ...
[CV] kernel=linear, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=10.0, C=78, total=   3.1s
[CV] kernel=linear, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=10.0, C=78, total=   3.1s
[CV] kernel=rbf, gamma=5.55556, C=89 ...
[CV] ... kernel=rbf, gamma=10.0, C=78, total=   3.2s
[CV] kernel=rbf, gamma=5.55556, C=89 ...


[Parallel(n_jobs=20)]: Done   1 tasks      | elapsed:    3.5s


[CV] ... kernel=rbf, gamma=5.55556, C=12, total=   3.3s
[CV] kernel=rbf, gamma=5.55556, C=89 ...
[CV] ... kernel=rbf, gamma=5.55556, C=12, total=   3.3s
[CV] ... kernel=rbf, gamma=4.44445, C=67, total=   3.3s
[CV] ... kernel=rbf, gamma=5.55556, C=12, total=   3.4s
[CV] kernel=rbf, gamma=7.77778, C=89 ...
[CV] kernel=rbf, gamma=7.77778, C=89 ...
[CV] kernel=rbf, gamma=7.77778, C=89 ...
[CV] ... kernel=rbf, gamma=4.44445, C=67, total=   3.3s
[CV] kernel=linear, gamma=2.22223, C=23 ...
```

```
[CV] ... kernel=rbf, gamma=4.44445, C=67, total=   3.3s
[CV] kernel=linear, gamma=2.22223, C=23 ...
[CV] ... kernel=rbf, gamma=5.55556, C=89, total=   3.0s
[CV] kernel=linear, gamma=2.22223, C=23 ...
[CV] ... kernel=rbf, gamma=5.55556, C=89, total=   3.0s
[CV] kernel=rbf, gamma=3.33334, C=34 ...
[CV] ... kernel=rbf, gamma=7.77778, C=89, total=   2.9s
[CV] kernel=rbf, gamma=3.33334, C=34 ...
[CV] ... kernel=rbf, gamma=5.55556, C=89, total=   3.0s
[CV] kernel=rbf, gamma=3.33334, C=34 ...
[CV] ... kernel=rbf, gamma=7.77778, C=89, total=   2.9s
[CV] ... kernel=rbf, gamma=7.77778, C=89, total=   2.9s
[CV] kernel=rbf, gamma=1.11112, C=100 ...
[CV] kernel=rbf, gamma=1.11112, C=100 ...
[CV] ... kernel=rbf, gamma=3.33334, C=34, total=   3.1s
[CV] ... kernel=rbf, gamma=3.33334, C=34, total=   3.2s
[CV] kernel=rbf, gamma=1.11112, C=100 ...
[CV] kernel=linear, gamma=2.22223, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=34, total=   3.3s
[CV] kernel=linear, gamma=2.22223, C=89 ...
[CV] ... kernel=rbf, gamma=1.11112, C=100, total=   3.2s
[CV] kernel=linear, gamma=2.22223, C=89 ...
[CV] ... kernel=rbf, gamma=1.11112, C=100, total=   3.3s
[CV] kernel=rbf, gamma=10.0, C=34 ...
[CV] ... kernel=rbf, gamma=10.0, C=34, total=   3.0s
[CV] kernel=rbf, gamma=10.0, C=34 ...
[CV] ... kernel=rbf, gamma=1.11112, C=100, total=   3.6s
[CV] kernel=rbf, gamma=10.0, C=34 ...
[CV] ... kernel=linear, gamma=7.77778, C=1, total=  15.1s
[CV] kernel=rbf, gamma=3.33334, C=100 ...
[CV] ... kernel=rbf, gamma=10.0, C=34, total=   3.1s
[CV] kernel=rbf, gamma=3.33334, C=100 ...
[CV] ... kernel=rbf, gamma=10.0, C=34, total=   2.9s
[CV] kernel=rbf, gamma=3.33334, C=100 ...
[CV] ... kernel=rbf, gamma=3.33334, C=100, total=   3.3s
[CV] kernel=linear, gamma=8.88889, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=100, total=   3.4s
[CV] kernel=linear, gamma=8.88889, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=100, total=   3.4s
[CV] kernel=linear, gamma=8.88889, C=89 ...
[CV] ... kernel=linear, gamma=7.77778, C=1, total=  32.7s
[CV] kernel=rbf, gamma=8.88889, C=23 ...
[CV] ... kernel=rbf, gamma=8.88889, C=23, total=   3.2s
[CV] kernel=rbf, gamma=8.88889, C=23 ...
[CV] ... kernel=rbf, gamma=8.88889, C=23, total=   2.9s
[CV] kernel=rbf, gamma=8.88889, C=23 ...
[CV] ... kernel=rbf, gamma=8.88889, C=23, total=   2.9s
[CV] kernel=rbf, gamma=6.66667, C=78 ...
```

```
[CV] ... kernel=linear, gamma=7.77778, C=1, total=  44.3s
[CV] kernel=rbf, gamma=6.66667, C=78 ...
[CV] ... kernel=rbf, gamma=6.66667, C=78, total=   3.7s
[CV] kernel=rbf, gamma=6.66667, C=78 ...
[CV] ... kernel=rbf, gamma=6.66667, C=78, total=   3.8s
[CV] kernel=rbf, gamma=1.11112, C=45 ...
[CV] ... kernel=rbf, gamma=6.66667, C=78, total=   3.6s
[CV] kernel=rbf, gamma=1.11112, C=45 ...
[CV] ... kernel=rbf, gamma=1.11112, C=45, total=   3.8s
[CV] kernel=rbf, gamma=1.11112, C=45 ...
[CV] ... kernel=rbf, gamma=1.11112, C=45, total=   3.6s
[CV] kernel=rbf, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=1.11112, C=45, total=   3.5s
[CV] kernel=rbf, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=4.44445, C=34, total=   3.3s
[CV] kernel=rbf, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=4.44445, C=34, total=   3.2s
[CV] kernel=rbf, gamma=2.22223, C=67 ...
[CV] ... kernel=rbf, gamma=4.44445, C=34, total=   3.1s
[CV] kernel=rbf, gamma=2.22223, C=67 ...
[CV] ... kernel=rbf, gamma=2.22223, C=67, total=   3.5s
[CV] kernel=rbf, gamma=2.22223, C=67 ...
[CV] ... kernel=rbf, gamma=2.22223, C=67, total=   3.6s
[CV] kernel=rbf, gamma=8.88889, C=1 ...
[CV] ... kernel=rbf, gamma=2.22223, C=67, total=   3.5s
[CV] kernel=rbf, gamma=8.88889, C=1 ...
[CV] ... kernel=rbf, gamma=8.88889, C=1, total=   2.8s
[CV] kernel=rbf, gamma=8.88889, C=1 ...
[CV] ... kernel=rbf, gamma=8.88889, C=1, total=   2.7s
[CV] kernel=rbf, gamma=4.44445, C=78 ...
[CV] ... kernel=rbf, gamma=8.88889, C=1, total=   2.6s
[CV] kernel=rbf, gamma=4.44445, C=78 ...
[CV] ... kernel=rbf, gamma=4.44445, C=78, total=   3.3s
[CV] kernel=rbf, gamma=4.44445, C=78 ...
[CV] ... kernel=rbf, gamma=4.44445, C=78, total=   3.3s
[CV] kernel=linear, gamma=6.66667, C=45 ...
[CV] ... kernel=rbf, gamma=4.44445, C=78, total=   3.3s
[CV] kernel=linear, gamma=6.66667, C=45 ...
[CV] ... kernel=linear, gamma=4.44445, C=34, total= 1.8min
[CV] kernel=linear, gamma=6.66667, C=45 ...
[CV] ... kernel=linear, gamma=2.22223, C=23, total= 2.1min
[CV] kernel=linear, gamma=2.22223, C=34 ...
[CV] ... kernel=linear, gamma=2.22223, C=23, total= 3.0min
[CV] kernel=linear, gamma=2.22223, C=34 ...
[CV] ... kernel=linear, gamma=7.77778, C=56, total= 3.0min
[CV] kernel=linear, gamma=2.22223, C=34 ...
[CV] ... kernel=linear, gamma=7.77778, C=45, total= 3.1min
[CV] ... kernel=linear, gamma=2.22223, C=23, total= 3.1min
```

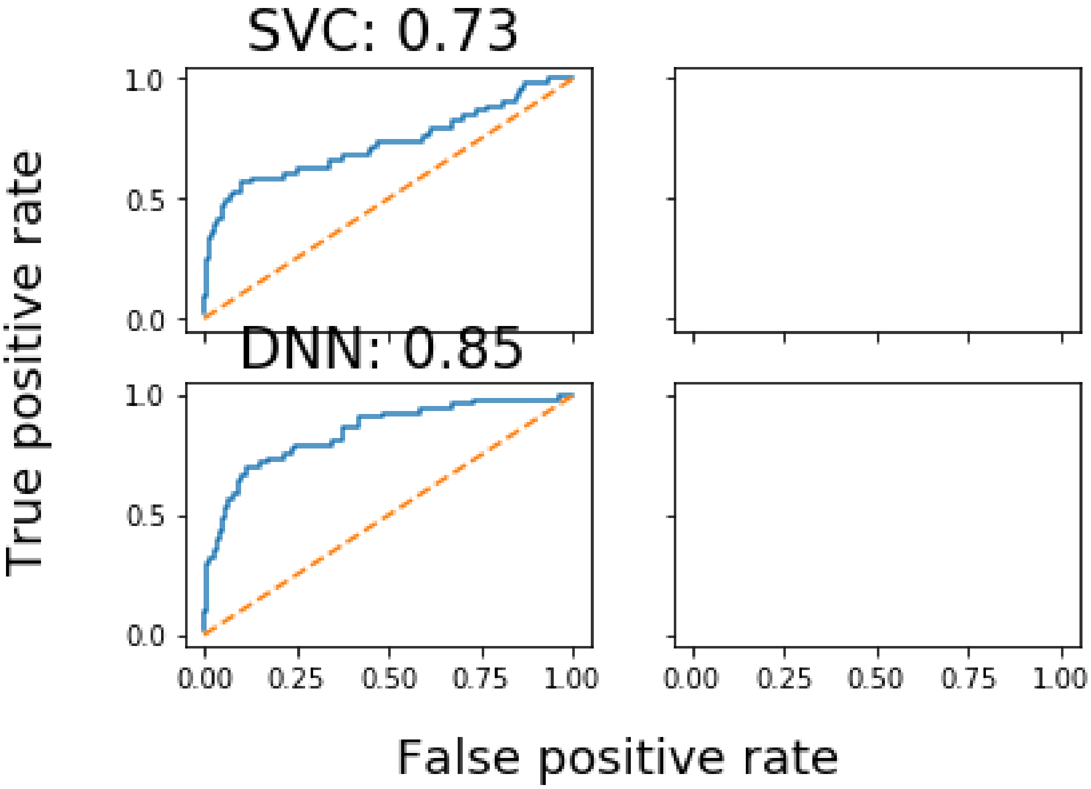
```
[CV] ... kernel=linear, gamma=4.44445, C=34, total= 3.9min
[CV] ... kernel=linear, gamma=7.77778, C=45, total= 4.2min
[CV] ... kernel=linear, gamma=4.44445, C=34, total= 4.3min
[CV] ... kernel=linear, gamma=2.22223, C=34, total= 1.5min
[CV] ... kernel=linear, gamma=2.22223, C=34, total= 2.4min
[CV] ... kernel=linear, gamma=8.88889, C=89, total= 4.3min
[CV] ... kernel=linear, gamma=2.22223, C=89, total= 4.5min
[CV] ... kernel=linear, gamma=6.66667, C=45, total= 2.9min
[CV] ... kernel=linear, gamma=6.66667, C=45, total= 3.5min
[CV] ... kernel=linear, gamma=8.88889, C=89, total= 4.5min
[CV] ... kernel=linear, gamma=7.77778, C=45, total= 4.9min
[CV] ... kernel=linear, gamma=7.77778, C=56, total= 5.0min
[CV] ... kernel=linear, gamma=2.22223, C=34, total= 1.9min
[CV] ... kernel=linear, gamma=2.22223, C=89, total= 4.8min
[CV] ... kernel=linear, gamma=6.66667, C=45, total= 3.7min
[CV] ... kernel=linear, gamma=7.77778, C=56, total= 5.0min
[CV] ... kernel=linear, gamma=8.88889, C=89, total= 4.7min
[CV] ... kernel=linear, gamma=2.22223, C=89, total= 5.0min


[Parallel(n_jobs=20)]: Done  75 out of  75 | elapsed:  5.1min finished
```

```
        ---------------------------------------------------------------------------

        NameError                                 Traceback (most recent call last)

        <ipython-input-74-e1c77ee7c201> in <module>()
          4
          5 searchScore = metrics.accuracy_score(ytestData, y_svcrand)
    ----> 6 nonSearchScore = metrics.accuracy_score(ytestData, y_svc)
          7 improvement = (searchScore - nonSearchScore) / nonSearchScore
          8


        NameError: name 'y_svc' is not defined
```

```
In [ ]: # DNN

        hidden_layers = [int(x) for x in np.linspace(start = 10, stop = 500, num = 10)]

        activation = ['identity', 'logistic', 'relu', 'tanh']

        solver = ['lbfgs', 'adam', 'sgd']

        random_grid = {'hidden_layers': hidden_layers,
                       'activation': activation,
                       'solver': solver}

        dnn_random = RandomizedSearchCV(estimator = dnn, param_distributions = random_grid, n_
                                       verbose=2, random_state=42, n_jobs = 20)
```

10 ROC curves for HOF

```
In [61]: rocHOF, ((ax1, ax2), (ax3, ax4)) = plt.subplots(2, 2, sharey = True, sharex = True)

         ax1.plot(fprSVC, tprSVC, label = 'ROC curve')
         ax1.plot([0, 1], [0, 1], linestyle = '--', label = 'Reference line')
         ax1.set_title("SVC: %.2f" % roc_aucSVC, size = 21, x = .485, ha = 'center')

         ax3.plot(fprDNN, tprDNN)
         ax3.plot([0, 1], [0, 1], linestyle = '--')
         ax3.set_title("DNN: %.2f" % roc_aucDNN, size = 21, x = .485, ha = 'center')

         rocHOF.text(-0.03, 0.5, "True positive rate", va='center', rotation='vertical', size =
         rocHOF.text(0.5, -0.04, "False positive rate", ha = 'center', size = 18)

         rocHOF.savefig('roc-hof.png', dpi = 400, bbox_inches = 'tight')
```



11 Predict rookies

```
In [37]: svcPred = svc.predict(rookieFeatures)

         for i, j in zip(svcPred, rookieNames):
             print(i, j)
```

```
0 Ben Simmons
0 Lonzo Ball
0 Jayson Tatum
0 Josh Jackson
0 De'Aaron Fox
0 Lauri Markkanen
0 Frank Ntilikina
0 Dennis Smith
0 Zach Collins
0 Malik Monk
0 Luke Kennard
0 Donovan Mitchell
0 Bam Adebayo
0 Justin Jackson
0 T.J. Leaf
0 John Collins
0 Terrance Ferguson
0 Jarrett Allen
0 OG Anunoby
0 Kyle Kuzma
0 Josh Hart
0 Wesley Iwundu
0 Frank Mason
0 Semi Ojeleye
0 Jordan Bell
0 Dwayne Bacon
0 Tyler Dorsey
0 Dillon Brooks
0 Sterling Brown
0 Sindarius Thornwell
```

```
In [39]: dnnPred = dnn.predict(rookieFeatures)

         for i, j in zip(dnnPred, rookieNames):
             print(i, j)
```

```
0 Ben Simmons
0 Lonzo Ball
```

```
0 Jayson Tatum
0 Josh Jackson
0 De'Aaron Fox
0 Lauri Markkanen
0 Frank Ntilikina
0 Dennis Smith
0 Zach Collins
0 Malik Monk
0 Luke Kennard
0 Donovan Mitchell
0 Bam Adebayo
0 Justin Jackson
0 T.J. Leaf
0 John Collins
0 Terrance Ferguson
0 Jarrett Allen
0 OG Anunoby
0 Kyle Kuzma
0 Josh Hart
0 Wesley Iwundu
0 Frank Mason
0 Semi Ojeleye
0 Jordan Bell
0 Dwayne Bacon
0 Tyler Dorsey
0 Dillon Brooks
0 Sterling Brown
0 Sindarius Thornwell
```

12 Create data splits for All Star models

```
In [40]: trainData, testData = train_test_split(pastDf, test_size = 0.25, random_state = 0)

         xtrainData = trainData[['G', 'MPG', 'FG/G', 'FGA/G', '2P%', '3P%', 'FT%', 'TRB/G', 'AS
                          'TS%', '3PAr', 'FTr']]
         ytrainData = trainData[['All Star']]

         xtestData = testData[['G', 'MPG', 'FG/G', 'FGA/G', '2P%', '3P%', 'FT%', 'TRB/G', 'AST/
                         'TS%', '3PAr', 'FTr']]
         ytestData = testData[['All Star']]
```

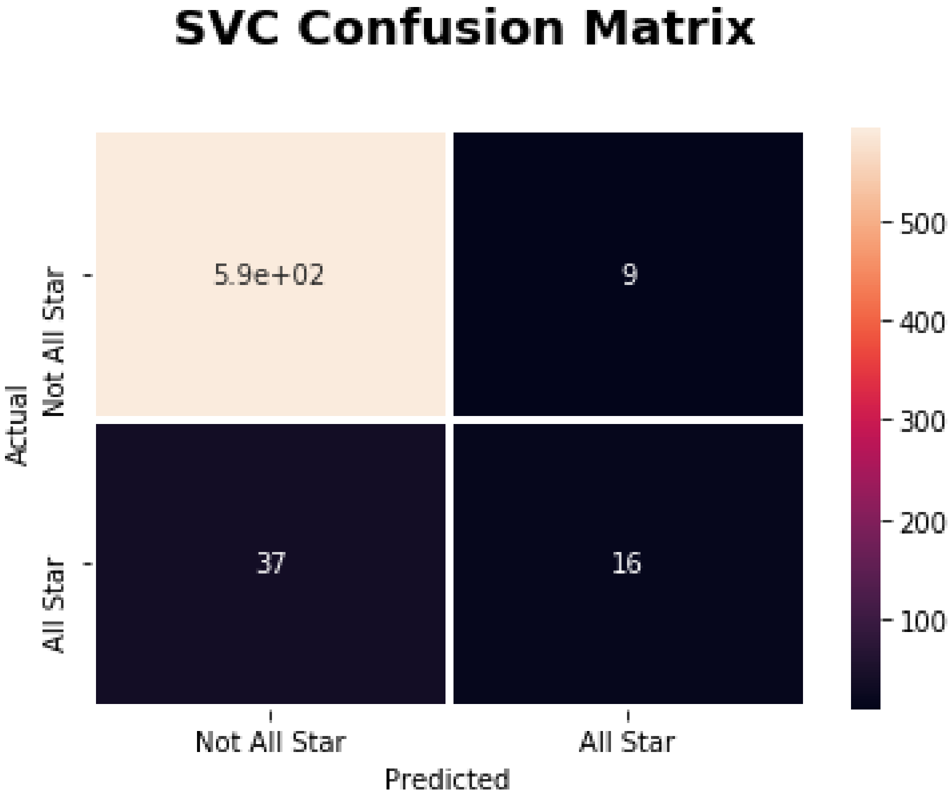
13 Create models and confusion matrices for All Star models

```
In [71]: svcModel = SVC(kernel='rbf', gamma=1e-4, C=100, probability = True)
         svcModel.fit(xtrainData, ytrainData.values.ravel())
```

```
          Ysvc = svcModel.predict(xtestData)

          print("Accuracy score: %.3f" % metrics.accuracy_score(ytestData, Ysvc))

          proba = svc.predict_proba(xtestData)
          print("Log loss: %.3f" % metrics.log_loss(ytestData, proba))

          posProb = proba[:, 1]
          print("Area under ROC curve: %.3f" % metrics.roc_auc_score(ytestData, posProb))

          fprSVC, tprSVC, thresholdSVC = metrics.roc_curve(ytestData, posProb)
          roc_aucSVC = metrics.auc(fprSVC, tprSVC)

          cvScoreSVC = cross_val_score(svcModel, xtestData, ytestData.values.ravel(), cv = 3, s
          print("Accuracy (cross validation score): %0.2f (+/- %0.2f)" % (cvScoreSVC.mean(), cv
```

```
Accuracy score: 0.927
Log loss: 0.231
Area under ROC curve: 0.729
Accuracy (cross validation score): 0.92 (+/- 0.00)
```

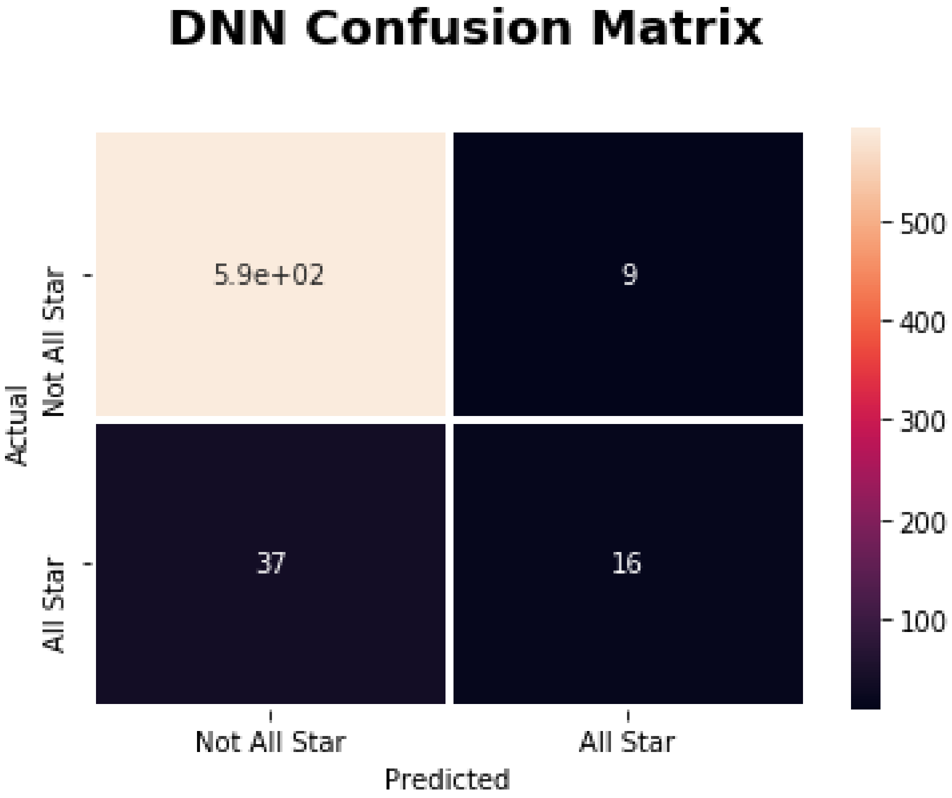
```
In [72]: cconfusionmatrix = metrics.confusion_matrix(ytestData, y_svc)
         svcHofAS, ax = plt.subplots()

         sns.heatmap(confusionmatrix, annot=True, ax = ax, linewidth = 2)

         ax.set_xlabel("Predicted")
         ax.set_ylabel("Actual")

         labels = ["Not All Star", "All Star"]
         ax.set_xticklabels(labels)
         ax.set_yticklabels(labels)

         svcHofAS.suptitle("SVC Confusion Matrix", weight = 'bold', size = 18, y = 1.04, x = .

         svcHofAS.savefig('svc-hof-as.png', dpi = 400, bbox_inches = 'tight')
```



```
In [46]: dnn = MLPClassifier(
             solver='lbfgs',
             hidden_layer_sizes=100,
             max_iter=10000,
             shuffle=False,
             random_state=0,
             activation='identity')

         dnn.fit(xtrainData, ytrainData.values.ravel())

         y_dnn = dnn.predict(xtestData)

         print("Accuracy score: %.3f" % metrics.accuracy_score(ytestData, y_dnn))

         proba = dnn.predict_proba(xtestData)
         print("Log loss: %.3f" % metrics.log_loss(ytestData, proba))

         posProb = proba[:, 1]
         print("Area under ROC curve: %.3f" % metrics.roc_auc_score(ytestData, posProb))

         fprDNN, tprDNN, thresholdDNN = metrics.roc_curve(ytestData, posProb)
         roc_aucDNN = metrics.auc(fprDNN, tprDNN)

         cvScoreDNN = cross_val_score(dnn, xtestData, ytestData.values.ravel(), cv = 3, scoring
         print("Accuracy (cross validation score): %0.2f (+/- %0.2f)" % (cvScoreDNN.mean(), cvS
```

```
Accuracy score: 0.930
Log loss: 0.208
Area under ROC curve: 0.846
Accuracy (cross validation score): 0.93 (+/- 0.01)
```

```
In [73]: confusionmatrix = metrics.confusion_matrix(ytestData, y_dnn)

         dnnHofAS, ax = plt.subplots()

         sns.heatmap(confusionmatrix, annot=True, ax = ax, linewidth = 2)

         ax.set_xlabel("Predicted")
         ax.set_ylabel("Actual")

         labels = ["Not All Star", "All Star"]
         ax.set_xticklabels(labels)
         ax.set_yticklabels(labels)

         dnnHofAS.suptitle("DNN Confusion Matrix", weight = 'bold', size = 18, y = 1.04, x = .4

         dnnHofAS.savefig('dnn-hof-as.png', dpi = 400, bbox_inches = 'tight')
```



14 Randomized search CV

```
In [48]: # SVC

         C = [int(x) for x in np.linspace(start = 1, stop = 100, num = 10)]

         kernel = ['rbf', 'linear']

         gamma = [float(x) for x in np.linspace(start = 1e-5, stop = 10, num = 10)]

         random_grid = {'C': C,
                        'kernel': kernel,
                        'gamma': gamma}

         svc_random = RandomizedSearchCV(estimator = svc, param_distributions = random_grid, n
                                         verbose=2, random_state=42, n_jobs = 20)

In [49]: svc_random.fit(xtrainData, ytrainData.values.ravel())

         y_svcrand = svc_random.predict(xtestData)
```

```
searchScore = metrics.accuracy_score(ytestData, y_svcrand)
nonSearchScore = metrics.accuracy_score(ytestData, y_svc)
improvement = (searchScore - nonSearchScore) / nonSearchScore

print("Percent improvement: %.5f" % improvement)
```

```
Fitting 3 folds for each of 25 candidates, totalling 75 fits
[CV] kernel=linear, gamma=7.77778, C=45 ...
[CV] kernel=linear, gamma=7.77778, C=45 ...
[CV] kernel=linear, gamma=7.77778, C=45 ...
[CV] kernel=linear, gamma=7.77778, C=1 ...
[CV] kernel=linear, gamma=7.77778, C=1 ...
[CV] kernel=linear, gamma=7.77778, C=1 ...
[CV] kernel=rbf, gamma=5.55556, C=12 ...
[CV] kernel=rbf, gamma=5.55556, C=12 ...
[CV] kernel=rbf, gamma=5.55556, C=12 ...
[CV] kernel=rbf, gamma=10.0, C=78 ...
[CV] kernel=rbf, gamma=10.0, C=78 ...
[CV] kernel=rbf, gamma=10.0, C=78 ...
[CV] kernel=rbf, gamma=4.44445, C=67 ...
[CV] kernel=rbf, gamma=4.44445, C=67 ...
[CV] kernel=rbf, gamma=4.44445, C=67 ...
[CV] kernel=linear, gamma=7.77778, C=56 ...
[CV] kernel=linear, gamma=7.77778, C=56 ...
[CV] kernel=linear, gamma=7.77778, C=56 ...
[CV] kernel=linear, gamma=4.44445, C=34 ...
[CV] kernel=linear, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=10.0, C=78, total=   3.1s
[CV] kernel=linear, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=10.0, C=78, total=   3.2s
[CV] kernel=rbf, gamma=5.55556, C=89 ...
[CV] ... kernel=rbf, gamma=5.55556, C=12, total=   3.3s
[CV] kernel=rbf, gamma=5.55556, C=89 ...
[CV] ... kernel=rbf, gamma=4.44445, C=67, total=   3.3s
[CV] ... kernel=rbf, gamma=10.0, C=78, total=   3.3s
[CV] ... kernel=rbf, gamma=5.55556, C=12, total=   3.4s


[Parallel(n_jobs=20)]: Done   1 tasks      | elapsed:    3.6s


[CV] kernel=rbf, gamma=7.77778, C=89 ...
[CV] kernel=rbf, gamma=7.77778, C=89 ...
[CV] kernel=rbf, gamma=5.55556, C=89 ...
[CV] ... kernel=rbf, gamma=5.55556, C=12, total=   3.4s
[CV] kernel=rbf, gamma=7.77778, C=89 ...
[CV] ... kernel=rbf, gamma=4.44445, C=67, total=   3.4s
[CV] kernel=linear, gamma=2.22223, C=23 ...
```

```
[CV] ... kernel=rbf, gamma=4.44445, C=67, total=   3.5s
[CV] kernel=linear, gamma=2.22223, C=23 ...
[CV] ... kernel=rbf, gamma=7.77778, C=89, total=   3.1s
[CV] kernel=linear, gamma=2.22223, C=23 ...
[CV] ... kernel=rbf, gamma=5.55556, C=89, total=   3.3s
[CV] kernel=rbf, gamma=3.33334, C=34 ...
[CV] ... kernel=rbf, gamma=7.77778, C=89, total=   3.2s
[CV] kernel=rbf, gamma=3.33334, C=34 ...
[CV] ... kernel=rbf, gamma=7.77778, C=89, total=   3.3s
[CV] ... kernel=rbf, gamma=5.55556, C=89, total=   3.4s
[CV] kernel=rbf, gamma=3.33334, C=34 ...
[CV] kernel=rbf, gamma=1.11112, C=100 ...
[CV] ... kernel=rbf, gamma=5.55556, C=89, total=   3.3s
[CV] kernel=rbf, gamma=1.11112, C=100 ...
[CV] ... kernel=linear, gamma=7.77778, C=1, total=  10.0s
[CV] kernel=rbf, gamma=1.11112, C=100 ...
[CV] ... kernel=rbf, gamma=3.33334, C=34, total=   3.3s
[CV] kernel=linear, gamma=2.22223, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=34, total=   3.3s
[CV] ... kernel=rbf, gamma=3.33334, C=34, total=   3.4s
[CV] kernel=linear, gamma=2.22223, C=89 ...
[CV] kernel=linear, gamma=2.22223, C=89 ...
[CV] ... kernel=rbf, gamma=1.11112, C=100, total=   3.3s
[CV] kernel=rbf, gamma=10.0, C=34 ...
[CV] ... kernel=rbf, gamma=1.11112, C=100, total=   3.3s
[CV] kernel=rbf, gamma=10.0, C=34 ...
[CV] ... kernel=linear, gamma=7.77778, C=1, total=  11.9s
[CV] kernel=rbf, gamma=10.0, C=34 ...
[CV] ... kernel=rbf, gamma=1.11112, C=100, total=   3.6s
[CV] kernel=rbf, gamma=3.33334, C=100 ...
[CV] ... kernel=rbf, gamma=10.0, C=34, total=   3.1s
[CV] kernel=rbf, gamma=3.33334, C=100 ...
[CV] ... kernel=rbf, gamma=10.0, C=34, total=   3.3s
[CV] kernel=rbf, gamma=3.33334, C=100 ...
[CV] ... kernel=rbf, gamma=10.0, C=34, total=   3.1s
[CV] kernel=linear, gamma=8.88889, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=100, total=   3.3s
[CV] kernel=linear, gamma=8.88889, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=100, total=   3.3s
[CV] kernel=linear, gamma=8.88889, C=89 ...
[CV] ... kernel=rbf, gamma=3.33334, C=100, total=   3.2s
[CV] kernel=rbf, gamma=8.88889, C=23 ...
[CV] ... kernel=rbf, gamma=8.88889, C=23, total=   2.9s
[CV] kernel=rbf, gamma=8.88889, C=23 ...
[CV] ... kernel=rbf, gamma=8.88889, C=23, total=   2.7s
[CV] kernel=rbf, gamma=8.88889, C=23 ...
[CV] ... kernel=rbf, gamma=8.88889, C=23, total=   2.8s
[CV] kernel=rbf, gamma=6.66667, C=78 ...
```

```
[CV] ... kernel=rbf, gamma=6.66667, C=78, total=   2.9s
[CV] kernel=rbf, gamma=6.66667, C=78 ...
[CV] ... kernel=linear, gamma=7.77778, C=1, total=  33.5s
[CV] kernel=rbf, gamma=6.66667, C=78 ...
[CV] ... kernel=rbf, gamma=6.66667, C=78, total=   3.1s
[CV] kernel=rbf, gamma=1.11112, C=45 ...
[CV] ... kernel=rbf, gamma=6.66667, C=78, total=   2.9s
[CV] kernel=rbf, gamma=1.11112, C=45 ...
[CV] ... kernel=rbf, gamma=1.11112, C=45, total=   3.1s
[CV] kernel=rbf, gamma=1.11112, C=45 ...
[CV] ... kernel=rbf, gamma=1.11112, C=45, total=   3.1s
[CV] kernel=rbf, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=1.11112, C=45, total=   3.2s
[CV] kernel=rbf, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=4.44445, C=34, total=   2.9s
[CV] kernel=rbf, gamma=4.44445, C=34 ...
[CV] ... kernel=rbf, gamma=4.44445, C=34, total=   3.0s
[CV] kernel=rbf, gamma=2.22223, C=67 ...
[CV] ... kernel=rbf, gamma=4.44445, C=34, total=   3.0s
[CV] kernel=rbf, gamma=2.22223, C=67 ...
[CV] ... kernel=rbf, gamma=2.22223, C=67, total=   3.2s
[CV] kernel=rbf, gamma=2.22223, C=67 ...
[CV] ... kernel=rbf, gamma=2.22223, C=67, total=   3.1s
[CV] kernel=rbf, gamma=8.88889, C=1 ...
[CV] ... kernel=rbf, gamma=2.22223, C=67, total=   3.1s
[CV] kernel=rbf, gamma=8.88889, C=1 ...
[CV] ... kernel=rbf, gamma=8.88889, C=1, total=   2.7s
[CV] kernel=rbf, gamma=8.88889, C=1 ...
[CV] ... kernel=rbf, gamma=8.88889, C=1, total=   2.7s
[CV] kernel=rbf, gamma=4.44445, C=78 ...
[CV] ... kernel=rbf, gamma=8.88889, C=1, total=   2.7s
[CV] kernel=rbf, gamma=4.44445, C=78 ...
[CV] ... kernel=rbf, gamma=4.44445, C=78, total=   2.9s
[CV] kernel=rbf, gamma=4.44445, C=78 ...
[CV] ... kernel=rbf, gamma=4.44445, C=78, total=   3.0s
[CV] kernel=linear, gamma=6.66667, C=45 ...
[CV] ... kernel=rbf, gamma=4.44445, C=78, total=   3.1s
[CV] kernel=linear, gamma=6.66667, C=45 ...
[CV] ... kernel=linear, gamma=2.22223, C=23, total= 2.6min
[CV] kernel=linear, gamma=6.66667, C=45 ...
[CV] ... kernel=linear, gamma=4.44445, C=34, total= 3.8min
[CV] kernel=linear, gamma=2.22223, C=34 ...
[CV] ... kernel=linear, gamma=2.22223, C=23, total= 3.8min
[CV] kernel=linear, gamma=2.22223, C=34 ...
[CV] ... kernel=linear, gamma=4.44445, C=34, total= 4.3min
[CV] kernel=linear, gamma=2.22223, C=34 ...
[CV] ... kernel=linear, gamma=7.77778, C=45, total= 4.8min
[CV] ... kernel=linear, gamma=2.22223, C=23, total= 4.9min
```

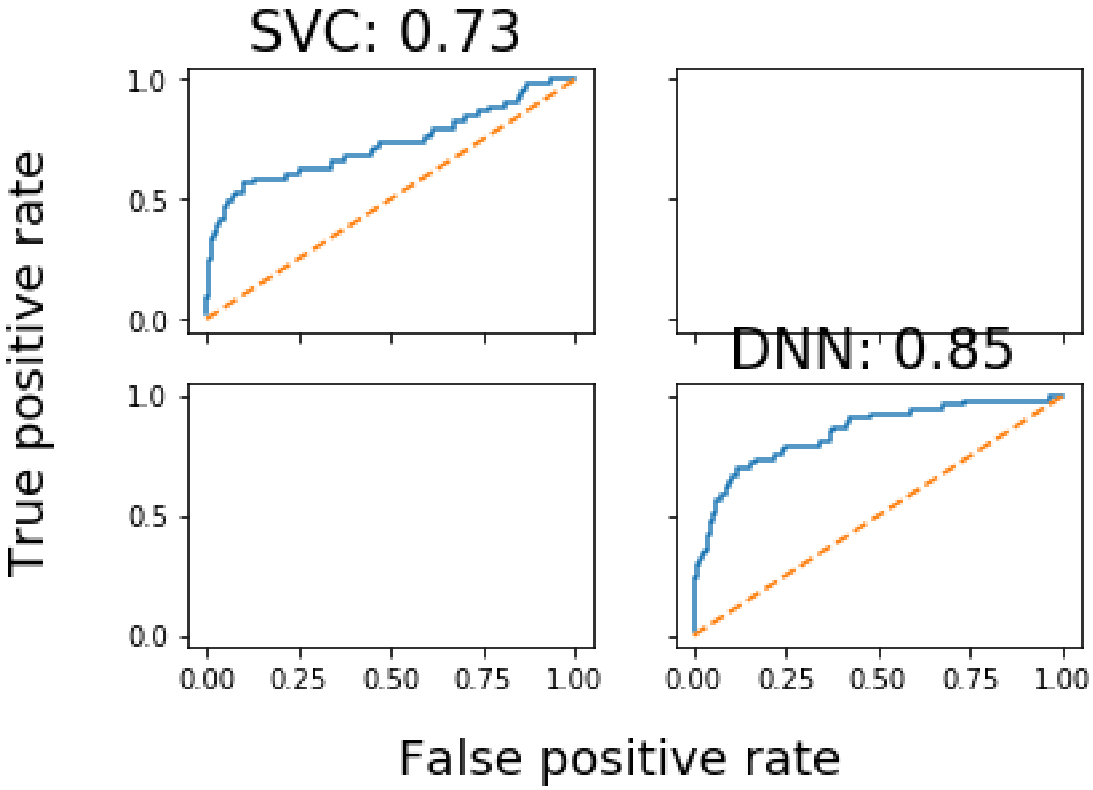
```
[CV] ... kernel=linear, gamma=7.77778, C=45, total= 5.1min
[CV] ... kernel=linear, gamma=4.44445, C=34, total= 5.6min
[CV] ... kernel=linear, gamma=7.77778, C=56, total= 6.2min
[CV] ... kernel=linear, gamma=7.77778, C=56, total= 6.3min
[CV] ... kernel=linear, gamma=6.66667, C=45, total= 5.3min
[CV] ... kernel=linear, gamma=2.22223, C=34, total= 2.8min
[CV] ... kernel=linear, gamma=6.66667, C=45, total= 4.4min
[CV] ... kernel=linear, gamma=6.66667, C=45, total= 6.3min
[CV] ... kernel=linear, gamma=2.22223, C=34, total= 3.0min
[CV] ... kernel=linear, gamma=8.88889, C=89, total= 7.2min
[CV] ... kernel=linear, gamma=2.22223, C=89, total= 7.4min
[CV] ... kernel=linear, gamma=7.77778, C=45, total= 7.6min
[CV] ... kernel=linear, gamma=2.22223, C=89, total= 7.5min
[CV] ... kernel=linear, gamma=2.22223, C=34, total= 3.9min
[CV] ... kernel=linear, gamma=7.77778, C=56, total= 7.8min
[CV] ... kernel=linear, gamma=8.88889, C=89, total= 7.6min
[CV] ... kernel=linear, gamma=2.22223, C=89, total= 8.0min
[CV] ... kernel=linear, gamma=8.88889, C=89, total= 7.9min


[Parallel(n_jobs=20)]: Done  75 out of  75 | elapsed:  8.2min finished


Percent improvement: 0.00000
```

```
In [52]: # DNN

         hidden_layers = [int(x) for x in np.linspace(start = 10, stop = 500, num = 10)]

         activation = ['identity', 'logistic', 'relu', 'tanh']

         solver = ['lbfgs', 'adam', 'sgd']

         random_grid = {'hidden_layers': hidden_layers,
                        'activation': activation,
                        'solver': solver}

         dnn_random = RandomizedSearchCV(estimator = dnn, param_distributions = random_grid, n_
                                         verbose=2, random_state=42, n_jobs = 20)
```

15 ROC curves for All Star

```
In [74]: rocAS, ((ax1, ax2), (ax3, ax4)) = plt.subplots(2, 2, sharey = True, sharex = True)

         ax1.plot(fprSVC, tprSVC, label = 'ROC curve')
         ax1.plot([0, 1], [0, 1], linestyle = '--', label = 'Reference line')
         ax1.set_title("SVC: %.2f" % roc_aucSVC, size = 21, x = .485, ha = 'center')
```

```
ax4.plot(fprDNN, tprDNN)
ax4.plot([0, 1], [0, 1], linestyle = '--')
ax4.set_title("DNN: %.2f" % roc_aucDNN, size = 21, x = .485, ha = 'center')

rocAS.text(-0.03, 0.5, "True positive rate", va='center', rotation='vertical', size =
rocAS.text(0.5, -0.04, "False positive rate", ha = 'center', size = 18)

rocAS.savefig('roc-as.png', dpi = 400, bbox_inches = 'tight')
```



16 Predict rookies

```
In [56]: svcPred = svc.predict(rookieFeatures)

         for i, j in zip(svcPred, rookieNames):
             print(i, j)
```

```
1 Ben Simmons
0 Lonzo Ball
0 Jayson Tatum
0 Josh Jackson
```

```
0 De'Aaron Fox
0 Lauri Markkanen
0 Frank Ntilikina
0 Dennis Smith
0 Zach Collins
0 Malik Monk
0 Luke Kennard
0 Donovan Mitchell
0 Bam Adebayo
0 Justin Jackson
0 T.J. Leaf
0 John Collins
0 Terrance Ferguson
0 Jarrett Allen
0 OG Anunoby
0 Kyle Kuzma
0 Josh Hart
0 Wesley Iwundu
0 Frank Mason
0 Semi Ojeleye
0 Jordan Bell
0 Dwayne Bacon
0 Tyler Dorsey
0 Dillon Brooks
0 Sterling Brown
0 Sindarius Thornwell
```

```
In [58]: dnnPred = dnn.predict(rookieFeatures)

         for i, j in zip(dnnPred, rookieNames):
             print(i, j)
```

```
1 Ben Simmons
0 Lonzo Ball
0 Jayson Tatum
0 Josh Jackson
0 De'Aaron Fox
0 Lauri Markkanen
0 Frank Ntilikina
0 Dennis Smith
0 Zach Collins
0 Malik Monk
0 Luke Kennard
1 Donovan Mitchell
0 Bam Adebayo
0 Justin Jackson
0 T.J. Leaf
```

```
0 John Collins
0 Terrance Ferguson
0 Jarrett Allen
0 OG Anunoby
0 Kyle Kuzma
0 Josh Hart
0 Wesley Iwundu
0 Frank Mason
0 Semi Ojeleye
0 Jordan Bell
0 Dwayne Bacon
0 Tyler Dorsey
0 Dillon Brooks
0 Sterling Brown
0 Sindarius Thornwell
```