In [99]:

```
import sys
import pandas as pd
import numpy as np
import sklearn
import keras

print(sys.version)
print(pd.__version__)
print(np.__version__)
print(sklearn.__version__)
print(keras.__version__)
```

```
3.7.6 (default, Jan  8 2020, 20:23:39) [MSC v.1916 64 bit (AMD64)]
0.24.2
1.18.1
0.22.1
2.3.1
```

In [100]:

```
# import the uci pima indians diabetes dataset
url = "diabetes.csv"
names = ['n_pregnant', 'glucose_concentration', 'blood_pressuer (mm Hg)', 'skin_thickne
ss (mm)', 'serum_insulin (mu U/ml)',
        'BMI', 'pedigree_function', 'age', 'class']
df = pd.read_csv(url, names = names)
```

In [101]:

```
df.describe()
```

Out[101]:

| | n_pregnant | glucose_concentration | blood_pressuer (mm Hg) | skin_thickness (mm) | serum_insulin (mu U/ml) | |
|---|---|---|---|---|---|---|
| **count** | 768.000000 | 768.000000 | 768.000000 | 768.000000 | 768.000000 | 76 |
| **mean** | 3.845052 | 120.894531 | 69.105469 | 20.536458 | 79.799479 | 3 |
| **std** | 3.369578 | 31.972618 | 19.355807 | 15.952218 | 115.244002 | |
| **min** | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| **25%** | 1.000000 | 99.000000 | 62.000000 | 0.000000 | 0.000000 | 2 |
| **50%** | 3.000000 | 117.000000 | 72.000000 | 23.000000 | 30.500000 | 3 |
| **75%** | 6.000000 | 140.250000 | 80.000000 | 32.000000 | 127.250000 | 3 |
| **max** | 17.000000 | 199.000000 | 122.000000 | 99.000000 | 846.000000 | 6 |

In [102]:

```
df[df['glucose_concentration']==0]
```

Out[102]:

| | n_pregnant | glucose_concentration | blood_pressuer (mm Hg) | skin_thickness (mm) | serum_insulin (mu U/ml) | BMI |
|---|---|---|---|---|---|---|
| **75** | 1 | 0 | 48 | 20 | 0 | 24.7 |
| **182** | 1 | 0 | 74 | 20 | 23 | 27.7 |
| **342** | 1 | 0 | 68 | 35 | 0 | 32.0 |
| **349** | 5 | 0 | 80 | 32 | 0 | 41.0 |
| **502** | 6 | 0 | 68 | 41 | 0 | 39.0 |

In [103]:

```
columns = ['glucose_concentration', 'blood_pressuer (mm Hg)', 'skin_thickness (mm)', 's
erum_insulin (mu U/ml)', 'BMI']
for col in columns:
    df[col].replace(0,np.NaN,inplace=True)
```

In [104]:

```
# Drop the rows with missing values
df.dropna(inplace=True)

# summarize the number of rows and columns in df
df.describe()
```

Out[104]:

| | n_pregnant | glucose_concentration | blood_pressuer (mm Hg) | skin_thickness (mm) | serum_insulin (mu U/ml) | |
|---|---|---|---|---|---|---|
| **count** | 392.000000 | 392.000000 | 392.000000 | 392.000000 | 392.000000 | 39 |
| **mean** | 3.301020 | 122.627551 | 70.663265 | 29.145408 | 156.056122 | 3 |
| **std** | 3.211424 | 30.860781 | 12.496092 | 10.516424 | 118.841690 | |
| **min** | 0.000000 | 56.000000 | 24.000000 | 7.000000 | 14.000000 | 1 |
| **25%** | 1.000000 | 99.000000 | 62.000000 | 21.000000 | 76.750000 | 2 |
| **50%** | 2.000000 | 119.000000 | 70.000000 | 29.000000 | 125.500000 | 3 |
| **75%** | 5.000000 | 143.000000 | 78.000000 | 37.000000 | 190.000000 | 3 |
| **max** | 17.000000 | 198.000000 | 110.000000 | 63.000000 | 846.000000 | 6 |

In [105]:

```
dataset = df.values
print(dataset.shape)
```

```
(392, 9)
```

In [106]:

```
col = ['n_pregnant', 'glucose_concentration', 'blood_pressuer (mm Hg)', 'skin_thickness
(mm)', 'serum_insulin (mu U/ml)',
       'BMI', 'pedigree_function', 'age']
target='class'
X=df[col]
Y=df[target].astype(int)
```

In [107]:

```
print(X.shape)
print(Y.shape)
#print(X)
```

```
(392, 8)
(392,)
```

In [108]:

```
# Normalize the data using sklearn StandardScaler
from sklearn.preprocessing import StandardScaler

scaler=StandardScaler().fit(X)
print(scaler)
```

```
StandardScaler(copy=True, with_mean=True, with_std=True)
```

In [109]:

```
# Transform and display the training data
X_standardized = scaler.transform(X)
data = pd.DataFrame(X_standardized)
data.describe()
```

Out[109]:

| | 0 | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|---|
| **count** | 3.920000e+02 | 3.920000e+02 | 3.920000e+02 | 3.920000e+02 | 3.920000e+02 | 3.920000e |
| **mean** | -4.021726e-17 | 3.129583e-17 | -4.641624e-16 | 1.042250e-16 | 6.485742e-17 | 1.543550e |
| **std** | 1.001278e+00 | 1.001278e+00 | 1.001278e+00 | 1.001278e+00 | 1.001278e+00 | 1.001278e |
| **min** | -1.029213e+00 | -2.161731e+00 | -3.739001e+00 | -2.108484e+00 | -1.196867e+00 | -2.120941e |
| **25%** | -7.174265e-01 | -7.665958e-01 | -6.941640e-01 | -7.755315e-01 | -6.681786e-01 | -6.676780e |
| **50%** | -4.056403e-01 | -1.176959e-01 | -5.314565e-02 | -1.384444e-02 | -2.574448e-01 | 1.621036e |
| **75%** | 5.297185e-01 | 6.609841e-01 | 5.878727e-01 | 7.478426e-01 | 2.859877e-01 | 5.718696e |
| **max** | 4.271153e+00 | 2.445459e+00 | 3.151946e+00 | 3.223325e+00 | 5.812990e+00 | 4.846172e |

In [110]:

```
#import necessary packages
from sklearn.model_selection import GridSearchCV, KFold
from keras.models import Sequential
from keras.layers import Dense
from keras.wrappers.scikit_learn import KerasClassifier
from keras.optimizers import Adam
```

In [119]:

```
#Start defining the model
def create_model():
    model=Sequential()
    model.add(Dense(8,input_dim=8,kernel_initializer='normal',activation='relu'))
    model.add(Dense(4,input_dim=8,kernel_initializer='normal',activation='relu'))
    model.add(Dense(1,activation='sigmoid'))

    adam = Adam(lr = 0.01)
    model.compile(loss = 'binary_crossentropy', optimizer = adam, metrics = ['accuracy'
])
    return model
```

In [120]:

```
model = create_model()
print(model.summary())
```

```
Model: "sequential_328"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_982 (Dense)            (None, 8)                 72
_________________________________________________________________
dense_983 (Dense)            (None, 4)                 36
_________________________________________________________________
dense_984 (Dense)            (None, 1)                 5
=================================================================
Total params: 113
Trainable params: 113
Non-trainable params: 0
_________________________________________________________________
None
```

In [123]:

```
#define a random seed
seed=6
np.random.seed(seed)
#Start defining the model
def create_model():
    model=Sequential()
    model.add(Dense(8,input_dim=8,kernel_initializer='normal',activation='relu'))
    model.add(Dense(4,input_dim=8,kernel_initializer='normal',activation='relu'))
    model.add(Dense(1,activation='sigmoid'))

    adam = Adam(lr = 0.01)
    model.compile(loss = 'binary_crossentropy', optimizer = adam, metrics = ['accuracy'
])
    return model

#create model
model=KerasClassifier(build_fn=create_model, verbose=0)

# Define the grid search parameters
batch_size = [5, 10, 15, 20, 25, 30, 35, 40]
epochs = [10, 20, 30, 40, 50, 60, 70, 80, 90]

# make a dictionary of the grid search parameters
param_grid = dict(batch_size=batch_size, epochs=epochs)

# build and fit the GridSearchCV
grid = GridSearchCV(estimator=model, param_grid=param_grid, cv = KFold(random_state=see
d), verbose=10)
grid_result = grid.fit(X_standardized, Y)

# summarize the results
print("Best: {0}, using {1}".format(grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print('{0} ({1}) with: {2}'.format(mean, stdev, param))
```

```
Fitting 5 folds for each of 72 candidates, totalling 360 fits
[CV] batch_size=5, epochs=10 .....................................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent wo
rkers.

[CV] ............. batch_size=5, epochs=10, score=0.722, total=   1.1s
[CV] batch_size=5, epochs=10 .....................................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    1.0s remaining:
0.0s

[CV] ............. batch_size=5, epochs=10, score=0.582, total=   1.1s
[CV] batch_size=5, epochs=10 .....................................

[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:    2.0s remaining:
0.0s

[CV] ............. batch_size=5, epochs=10, score=0.821, total=   1.0s
[CV] batch_size=5, epochs=10 .....................................

[Parallel(n_jobs=1)]: Done   3 out of   3 | elapsed:    3.1s remaining:
0.0s

[CV] ............. batch_size=5, epochs=10, score=0.821, total=   1.0s
[CV] batch_size=5, epochs=10 .....................................

[Parallel(n_jobs=1)]: Done   4 out of   4 | elapsed:    4.1s remaining:
0.0s

[CV] ............. batch_size=5, epochs=10, score=0.821, total=   1.1s
[CV] batch_size=5, epochs=20 .....................................

[Parallel(n_jobs=1)]: Done   5 out of   5 | elapsed:    5.2s remaining:
0.0s

[CV] ............. batch_size=5, epochs=20, score=0.785, total=   1.4s
[CV] batch_size=5, epochs=20 .....................................

[Parallel(n_jobs=1)]: Done   6 out of   6 | elapsed:    6.6s remaining:
0.0s


[CV] ............. batch_size=5, epochs=20, score=0.582, total=   1.5s
[CV] batch_size=5, epochs=20 .....................................

[Parallel(n_jobs=1)]: Done   7 out of   7 | elapsed:    8.1s remaining:
0.0s

[CV] ............. batch_size=5, epochs=20, score=0.821, total=   2.0s
[CV] batch_size=5, epochs=20 .....................................

[Parallel(n_jobs=1)]: Done   8 out of   8 | elapsed:   10.0s remaining:
0.0s

[CV] ............. batch_size=5, epochs=20, score=0.872, total=   1.6s
[CV] batch_size=5, epochs=20 .....................................

[Parallel(n_jobs=1)]: Done   9 out of   9 | elapsed:   11.7s remaining:
0.0s
```

```
[CV] ..... batch_size=5, epochs=20, score=0.821, total=   1.5s
[CV] batch_size=5, epochs=30 .....................................
[CV] ..... batch_size=5, epochs=30, score=0.722, total=   2.0s
[CV] batch_size=5, epochs=30 .....................................
[CV] ..... batch_size=5, epochs=30, score=0.658, total=   2.0s
[CV] batch_size=5, epochs=30 .....................................
[CV] ..... batch_size=5, epochs=30, score=0.782, total=   1.9s
[CV] batch_size=5, epochs=30 .....................................
[CV] ..... batch_size=5, epochs=30, score=0.859, total=   1.8s
[CV] batch_size=5, epochs=30 .....................................
[CV] ..... batch_size=5, epochs=30, score=0.679, total=   1.9s
[CV] batch_size=5, epochs=40 .....................................
[CV] ..... batch_size=5, epochs=40, score=0.734, total=   2.2s
[CV] batch_size=5, epochs=40 .....................................
[CV] ..... batch_size=5, epochs=40, score=0.608, total=   2.3s
[CV] batch_size=5, epochs=40 .....................................
[CV] ..... batch_size=5, epochs=40, score=0.808, total=   2.4s
[CV] batch_size=5, epochs=40 .....................................
[CV] ..... batch_size=5, epochs=40, score=0.833, total=   2.3s
[CV] batch_size=5, epochs=40 .....................................
[CV] ..... batch_size=5, epochs=40, score=0.808, total=   2.8s
[CV] batch_size=5, epochs=50 .....................................
[CV] ..... batch_size=5, epochs=50, score=0.759, total=   2.7s
[CV] batch_size=5, epochs=50 .....................................
[CV] ..... batch_size=5, epochs=50, score=0.646, total=   2.9s
[CV] batch_size=5, epochs=50 .....................................
[CV] ..... batch_size=5, epochs=50, score=0.705, total=   2.7s
[CV] batch_size=5, epochs=50 .....................................
[CV] ..... batch_size=5, epochs=50, score=0.833, total=   2.6s
[CV] batch_size=5, epochs=50 .....................................
[CV] ..... batch_size=5, epochs=50, score=0.846, total=   2.7s
[CV] batch_size=5, epochs=60 .....................................
[CV] ..... batch_size=5, epochs=60, score=0.772, total=   3.2s
[CV] batch_size=5, epochs=60 .....................................
[CV] ..... batch_size=5, epochs=60, score=0.684, total=   3.2s
[CV] batch_size=5, epochs=60 .....................................
[CV] ..... batch_size=5, epochs=60, score=0.782, total=   3.1s
[CV] batch_size=5, epochs=60 .....................................
[CV] ..... batch_size=5, epochs=60, score=0.808, total=   3.1s
[CV] batch_size=5, epochs=60 .....................................
[CV] ..... batch_size=5, epochs=60, score=0.808, total=   3.0s
[CV] batch_size=5, epochs=70 .....................................
[CV] ..... batch_size=5, epochs=70, score=0.810, total=   3.5s
[CV] batch_size=5, epochs=70 .....................................
[CV] ..... batch_size=5, epochs=70, score=0.570, total=   3.5s
[CV] batch_size=5, epochs=70 .....................................
[CV] ..... batch_size=5, epochs=70, score=0.769, total=   4.1s
[CV] batch_size=5, epochs=70 .....................................
[CV] ..... batch_size=5, epochs=70, score=0.782, total=   3.5s
[CV] batch_size=5, epochs=70 .....................................
[CV] ..... batch_size=5, epochs=70, score=0.808, total=   3.3s
[CV] batch_size=5, epochs=80 .....................................
[CV] ..... batch_size=5, epochs=80, score=0.734, total=   4.0s
[CV] batch_size=5, epochs=80 .....................................
[CV] ..... batch_size=5, epochs=80, score=0.671, total=   3.9s
[CV] batch_size=5, epochs=80 .....................................
[CV] ..... batch_size=5, epochs=80, score=0.744, total=   3.7s
[CV] batch_size=5, epochs=80 .....................................
[CV] ..... batch_size=5, epochs=80, score=0.859, total=   3.9s
[CV] batch_size=5, epochs=80 .....................................
[CV] ..... batch_size=5, epochs=80, score=0.782, total=   3.9s
```

```
[CV] batch_size=5, epochs=90 .....................................
[CV] ............. batch_size=5, epochs=90, score=0.759, total=   4.1s
[CV] batch_size=5, epochs=90 .....................................
[CV] ............. batch_size=5, epochs=90, score=0.608, total=   4.4s
[CV] batch_size=5, epochs=90 .....................................
[CV] ............. batch_size=5, epochs=90, score=0.821, total=   4.3s
[CV] batch_size=5, epochs=90 .....................................
[CV] ............. batch_size=5, epochs=90, score=0.744, total=   4.4s
[CV] batch_size=5, epochs=90 .....................................
[CV] ............. batch_size=5, epochs=90, score=0.833, total=   4.4s
[CV] batch_size=10, epochs=10 ....................................
[CV] ............ batch_size=10, epochs=10, score=0.810, total=   0.9s
[CV] batch_size=10, epochs=10 ....................................
[CV] ............ batch_size=10, epochs=10, score=0.608, total=   1.5s
[CV] batch_size=10, epochs=10 ....................................
[CV] ............ batch_size=10, epochs=10, score=0.821, total=   0.9s
[CV] batch_size=10, epochs=10 ....................................
[CV] ............ batch_size=10, epochs=10, score=0.821, total=   0.9s
[CV] batch_size=10, epochs=10 ....................................
[CV] ............ batch_size=10, epochs=10, score=0.833, total=   0.9s
[CV] batch_size=10, epochs=20 ....................................
[CV] ............ batch_size=10, epochs=20, score=0.722, total=   1.1s
[CV] batch_size=10, epochs=20 ....................................
[CV] ............ batch_size=10, epochs=20, score=0.620, total=   1.1s
[CV] batch_size=10, epochs=20 ....................................
[CV] ............ batch_size=10, epochs=20, score=0.795, total=   1.1s
[CV] batch_size=10, epochs=20 ....................................
[CV] ............ batch_size=10, epochs=20, score=0.808, total=   1.1s
[CV] batch_size=10, epochs=20 ....................................
[CV] ............ batch_size=10, epochs=20, score=0.833, total=   1.1s
[CV] batch_size=10, epochs=30 ....................................
[CV] ............ batch_size=10, epochs=30, score=0.747, total=   1.3s
[CV] batch_size=10, epochs=30 ....................................
[CV] ............ batch_size=10, epochs=30, score=0.709, total=   1.3s
[CV] batch_size=10, epochs=30 ....................................
[CV] ............ batch_size=10, epochs=30, score=0.821, total=   1.3s
[CV] batch_size=10, epochs=30 ....................................
[CV] ............ batch_size=10, epochs=30, score=0.808, total=   1.4s
[CV] batch_size=10, epochs=30 ....................................
[CV] ............ batch_size=10, epochs=30, score=0.808, total=   1.5s
[CV] batch_size=10, epochs=40 ....................................
[CV] ............ batch_size=10, epochs=40, score=0.747, total=   2.3s
[CV] batch_size=10, epochs=40 ....................................
[CV] ............ batch_size=10, epochs=40, score=0.620, total=   1.5s
[CV] batch_size=10, epochs=40 ....................................
[CV] ............ batch_size=10, epochs=40, score=0.795, total=   1.6s
[CV] batch_size=10, epochs=40 ....................................
[CV] ............ batch_size=10, epochs=40, score=0.821, total=   1.7s
[CV] batch_size=10, epochs=40 ....................................
[CV] ............ batch_size=10, epochs=40, score=0.821, total=   1.6s
[CV] batch_size=10, epochs=50 ....................................
[CV] ............ batch_size=10, epochs=50, score=0.734, total=   1.7s
[CV] batch_size=10, epochs=50 ....................................
[CV] ............ batch_size=10, epochs=50, score=0.696, total=   1.8s
[CV] batch_size=10, epochs=50 ....................................
[CV] ............ batch_size=10, epochs=50, score=0.769, total=   1.7s
[CV] batch_size=10, epochs=50 ....................................
[CV] ............ batch_size=10, epochs=50, score=0.833, total=   1.9s
[CV] batch_size=10, epochs=50 ....................................
[CV] ............ batch_size=10, epochs=50, score=0.846, total=   1.9s
[CV] batch_size=10, epochs=60 ....................................
```

```
[CV] ............ batch_size=10, epochs=60, score=0.734, total=   2.3s
[CV] batch_size=10, epochs=60 ....................................
[CV] ............ batch_size=10, epochs=60, score=0.633, total=   2.2s
[CV] batch_size=10, epochs=60 ....................................
[CV] ............ batch_size=10, epochs=60, score=0.821, total=   2.0s
[CV] batch_size=10, epochs=60 ....................................
[CV] ............ batch_size=10, epochs=60, score=0.808, total=   2.8s
[CV] batch_size=10, epochs=60 ....................................
[CV] ............ batch_size=10, epochs=60, score=0.833, total=   2.2s
[CV] batch_size=10, epochs=70 ....................................
[CV] ............ batch_size=10, epochs=70, score=0.759, total=   2.4s
[CV] batch_size=10, epochs=70 ....................................
[CV] ............ batch_size=10, epochs=70, score=0.671, total=   2.3s
[CV] batch_size=10, epochs=70 ....................................
[CV] ............ batch_size=10, epochs=70, score=0.821, total=   2.4s
[CV] batch_size=10, epochs=70 ....................................
[CV] ............ batch_size=10, epochs=70, score=0.782, total=   2.3s
[CV] batch_size=10, epochs=70 ....................................
[CV] ............ batch_size=10, epochs=70, score=0.846, total=   2.4s
[CV] batch_size=10, epochs=80 ....................................
[CV] ............ batch_size=10, epochs=80, score=0.747, total=   2.5s
[CV] batch_size=10, epochs=80 ....................................
[CV] ............ batch_size=10, epochs=80, score=0.658, total=   2.4s
[CV] batch_size=10, epochs=80 ....................................
[CV] ............ batch_size=10, epochs=80, score=0.782, total=   2.4s
[CV] batch_size=10, epochs=80 ....................................
[CV] ............ batch_size=10, epochs=80, score=0.808, total=   2.5s
[CV] batch_size=10, epochs=80 ....................................
[CV] ............ batch_size=10, epochs=80, score=0.833, total=   2.5s
[CV] batch_size=10, epochs=90 ....................................
[CV] ............ batch_size=10, epochs=90, score=0.759, total=   2.6s
[CV] batch_size=10, epochs=90 ....................................
[CV] ............ batch_size=10, epochs=90, score=0.620, total=   2.6s
[CV] batch_size=10, epochs=90 ....................................
[CV] ............ batch_size=10, epochs=90, score=0.756, total=   3.3s
[CV] batch_size=10, epochs=90 ....................................
[CV] ............ batch_size=10, epochs=90, score=0.846, total=   2.7s
[CV] batch_size=10, epochs=90 ....................................
[CV] ............ batch_size=10, epochs=90, score=0.769, total=   2.6s
[CV] batch_size=15, epochs=10 ....................................
[CV] ............ batch_size=15, epochs=10, score=0.759, total=   0.9s
[CV] batch_size=15, epochs=10 ....................................
[CV] ............ batch_size=15, epochs=10, score=0.633, total=   0.9s
[CV] batch_size=15, epochs=10 ....................................
[CV] ............ batch_size=15, epochs=10, score=0.821, total=   0.9s
[CV] batch_size=15, epochs=10 ....................................
[CV] ............ batch_size=15, epochs=10, score=0.833, total=   1.0s
[CV] batch_size=15, epochs=10 ....................................
[CV] ............ batch_size=15, epochs=10, score=0.846, total=   0.9s
[CV] batch_size=15, epochs=20 ....................................
[CV] ............ batch_size=15, epochs=20, score=0.734, total=   1.0s
[CV] batch_size=15, epochs=20 ....................................
[CV] ............ batch_size=15, epochs=20, score=0.582, total=   1.0s
[CV] batch_size=15, epochs=20 ....................................
[CV] ............ batch_size=15, epochs=20, score=0.833, total=   1.1s
[CV] batch_size=15, epochs=20 ....................................
[CV] ............ batch_size=15, epochs=20, score=0.833, total=   1.0s
[CV] batch_size=15, epochs=20 ....................................
[CV] ............ batch_size=15, epochs=20, score=0.846, total=   1.1s
[CV] batch_size=15, epochs=30 ....................................
[CV] ............ batch_size=15, epochs=30, score=0.734, total=   1.1s
```

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[CV] batch_size=15, epochs=30 ....................................
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[CV] batch_size=15, epochs=30 ....................................
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[CV] ............ batch_size=15, epochs=70, score=0.759, total=   1.8s
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[CV] ............ batch_size=15, epochs=80, score=0.658, total=   1.7s
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[CV] batch_size=15, epochs=90 ....................................
[CV] ............ batch_size=15, epochs=90, score=0.772, total=   2.7s
[CV] batch_size=15, epochs=90 ....................................
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[CV] ............ batch_size=20, epochs=60, score=0.620, total=   1.4s
```

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[CV] ............ batch_size=25, epochs=30, score=0.709, total=   1.1s
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[CV] ............ batch_size=25, epochs=30, score=0.633, total=   1.1s
[CV] batch_size=25, epochs=30 ....................................
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```

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```

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[CV] ............ batch_size=30, epochs=70, score=0.808, total=   1.3s
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[CV] ............ batch_size=30, epochs=80, score=0.846, total=   1.4s
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[CV] batch_size=30, epochs=90 ....................................
[CV] ............ batch_size=30, epochs=90, score=0.756, total=   1.5s
[CV] batch_size=30, epochs=90 ....................................
[CV] ............ batch_size=30, epochs=90, score=0.808, total=   1.5s
[CV] batch_size=30, epochs=90 ....................................
[CV] ............ batch_size=30, epochs=90, score=0.833, total=   1.5s
[CV] batch_size=35, epochs=10 ....................................
[CV] ............ batch_size=35, epochs=10, score=0.785, total=   1.0s
[CV] batch_size=35, epochs=10 ....................................
[CV] ............ batch_size=35, epochs=10, score=0.595, total=   1.0s
[CV] batch_size=35, epochs=10 ....................................
[CV] ............ batch_size=35, epochs=10, score=0.821, total=   1.0s
[CV] batch_size=35, epochs=10 ....................................
[CV] ............ batch_size=35, epochs=10, score=0.795, total=   1.1s
[CV] batch_size=35, epochs=10 ....................................
[CV] ............ batch_size=35, epochs=10, score=0.833, total=   1.0s
[CV] batch_size=35, epochs=20 ....................................
[CV] ............ batch_size=35, epochs=20, score=0.759, total=   1.0s
[CV] batch_size=35, epochs=20 ....................................
[CV] ............ batch_size=35, epochs=20, score=0.633, total=   1.1s
[CV] batch_size=35, epochs=20 ....................................
[CV] ............ batch_size=35, epochs=20, score=0.833, total=   0.9s
[CV] batch_size=35, epochs=20 ....................................
[CV] ............ batch_size=35, epochs=20, score=0.808, total=   0.9s
[CV] batch_size=35, epochs=20 ....................................
[CV] ............ batch_size=35, epochs=20, score=0.808, total=   0.9s
[CV] batch_size=35, epochs=30 ....................................
[CV] ............ batch_size=35, epochs=30, score=0.734, total=   1.9s
[CV] batch_size=35, epochs=30 ....................................
[CV] ............ batch_size=35, epochs=30, score=0.633, total=   1.3s
[CV] batch_size=35, epochs=30 ....................................
[CV] ............ batch_size=35, epochs=30, score=0.846, total=   1.1s
[CV] batch_size=35, epochs=30 ....................................
[CV] ............ batch_size=35, epochs=30, score=0.859, total=   1.0s
```

```
[CV] batch_size=35, epochs=30 ....................................
[CV] ............ batch_size=35, epochs=30, score=0.833, total=   1.0s
[CV] batch_size=35, epochs=40 ....................................
[CV] ............ batch_size=35, epochs=40, score=0.747, total=   1.2s
[CV] batch_size=35, epochs=40 ....................................
[CV] ............ batch_size=35, epochs=40, score=0.646, total=   1.3s
[CV] batch_size=35, epochs=40 ....................................
[CV] ............ batch_size=35, epochs=40, score=0.833, total=   1.4s
[CV] batch_size=35, epochs=40 ....................................
[CV] ............ batch_size=35, epochs=40, score=0.859, total=   1.3s
[CV] batch_size=35, epochs=40 ....................................
[CV] ............ batch_size=35, epochs=40, score=0.846, total=   1.2s
[CV] batch_size=35, epochs=50 ....................................
[CV] ............ batch_size=35, epochs=50, score=0.747, total=   1.3s
[CV] batch_size=35, epochs=50 ....................................
[CV] ............ batch_size=35, epochs=50, score=0.620, total=   1.3s
[CV] batch_size=35, epochs=50 ....................................
[CV] ............ batch_size=35, epochs=50, score=0.821, total=   1.6s
[CV] batch_size=35, epochs=50 ....................................
[CV] ............ batch_size=35, epochs=50, score=0.833, total=   1.5s
[CV] batch_size=35, epochs=50 ....................................
[CV] ............ batch_size=35, epochs=50, score=0.833, total=   1.3s
[CV] batch_size=35, epochs=60 ....................................
[CV] ............ batch_size=35, epochs=60, score=0.734, total=   1.3s
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[CV] ............ batch_size=35, epochs=60, score=0.671, total=   2.5s
[CV] batch_size=35, epochs=60 ....................................
[CV] ............ batch_size=35, epochs=60, score=0.808, total=   1.3s
[CV] batch_size=35, epochs=60 ....................................
[CV] ............ batch_size=35, epochs=60, score=0.821, total=   1.4s
[CV] batch_size=35, epochs=60 ....................................
[CV] ............ batch_size=35, epochs=60, score=0.846, total=   1.7s
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[CV] batch_size=35, epochs=70 ....................................
[CV] ............ batch_size=35, epochs=70, score=0.808, total=   1.4s
[CV] batch_size=35, epochs=70 ....................................
[CV] ............ batch_size=35, epochs=70, score=0.821, total=   1.4s
[CV] batch_size=35, epochs=80 ....................................
[CV] ............ batch_size=35, epochs=80, score=0.759, total=   1.4s
[CV] batch_size=35, epochs=80 ....................................
[CV] ............ batch_size=35, epochs=80, score=0.684, total=   1.5s
[CV] batch_size=35, epochs=80 ....................................
[CV] ............ batch_size=35, epochs=80, score=0.833, total=   1.4s
[CV] batch_size=35, epochs=80 ....................................
[CV] ............ batch_size=35, epochs=80, score=0.795, total=   1.3s
[CV] batch_size=35, epochs=80 ....................................
[CV] ............ batch_size=35, epochs=80, score=0.808, total=   1.4s
[CV] batch_size=35, epochs=90 ....................................
[CV] ............ batch_size=35, epochs=90, score=0.696, total=   1.5s
[CV] batch_size=35, epochs=90 ....................................
[CV] ............ batch_size=35, epochs=90, score=0.658, total=   1.4s
[CV] batch_size=35, epochs=90 ....................................
[CV] ............ batch_size=35, epochs=90, score=0.795, total=   2.3s
[CV] batch_size=35, epochs=90 ....................................
[CV] ............ batch_size=35, epochs=90, score=0.833, total=   1.4s
[CV] batch_size=35, epochs=90 ....................................
```

```
[CV] ............ batch_size=35, epochs=90, score=0.833, total=   1.5s
[CV] batch_size=40, epochs=10 ....................................
[CV] ............ batch_size=40, epochs=10, score=0.772, total=   1.0s
[CV] batch_size=40, epochs=10 ....................................
[CV] ............ batch_size=40, epochs=10, score=0.582, total=   0.9s
[CV] batch_size=40, epochs=10 ....................................
[CV] ............ batch_size=40, epochs=10, score=0.795, total=   0.9s
[CV] batch_size=40, epochs=10 ....................................
[CV] ............ batch_size=40, epochs=10, score=0.821, total=   1.0s
[CV] batch_size=40, epochs=10 ....................................
[CV] ............ batch_size=40, epochs=10, score=0.833, total=   0.9s
[CV] batch_size=40, epochs=20 ....................................
[CV] ............ batch_size=40, epochs=20, score=0.759, total=   1.0s
[CV] batch_size=40, epochs=20 ....................................
[CV] ............ batch_size=40, epochs=20, score=0.620, total=   1.0s
[CV] batch_size=40, epochs=20 ....................................
[CV] ............ batch_size=40, epochs=20, score=0.808, total=   1.0s
[CV] batch_size=40, epochs=20 ....................................
[CV] ............ batch_size=40, epochs=20, score=0.821, total=   1.1s
[CV] batch_size=40, epochs=20 ....................................
[CV] ............ batch_size=40, epochs=20, score=0.833, total=   1.1s
[CV] batch_size=40, epochs=30 ....................................
[CV] ............ batch_size=40, epochs=30, score=0.759, total=   1.2s
[CV] batch_size=40, epochs=30 ....................................
[CV] ............ batch_size=40, epochs=30, score=0.608, total=   1.1s
[CV] batch_size=40, epochs=30 ....................................
[CV] ............ batch_size=40, epochs=30, score=0.821, total=   1.1s
[CV] batch_size=40, epochs=30 ....................................
[CV] ............ batch_size=40, epochs=30, score=0.846, total=   2.2s
[CV] batch_size=40, epochs=30 ....................................
[CV] ............ batch_size=40, epochs=30, score=0.821, total=   1.2s
[CV] batch_size=40, epochs=40 ....................................
[CV] ............ batch_size=40, epochs=40, score=0.747, total=   1.3s
[CV] batch_size=40, epochs=40 ....................................
[CV] ............ batch_size=40, epochs=40, score=0.658, total=   1.2s
[CV] batch_size=40, epochs=40 ....................................
[CV] ............ batch_size=40, epochs=40, score=0.846, total=   1.1s
[CV] batch_size=40, epochs=40 ....................................
[CV] ............ batch_size=40, epochs=40, score=0.846, total=   1.2s
[CV] batch_size=40, epochs=40 ....................................
[CV] ............ batch_size=40, epochs=40, score=0.833, total=   1.3s
[CV] batch_size=40, epochs=50 ....................................
[CV] ............ batch_size=40, epochs=50, score=0.759, total=   1.3s
[CV] batch_size=40, epochs=50 ....................................
[CV] ............ batch_size=40, epochs=50, score=0.646, total=   1.2s
[CV] batch_size=40, epochs=50 ....................................
[CV] ............ batch_size=40, epochs=50, score=0.769, total=   1.2s
[CV] batch_size=40, epochs=50 ....................................
[CV] ............ batch_size=40, epochs=50, score=0.782, total=   1.2s
[CV] batch_size=40, epochs=50 ....................................
[CV] ............ batch_size=40, epochs=50, score=0.821, total=   1.4s
[CV] batch_size=40, epochs=60 ....................................
[CV] ............ batch_size=40, epochs=60, score=0.772, total=   1.4s
[CV] batch_size=40, epochs=60 ....................................
[CV] ............ batch_size=40, epochs=60, score=0.620, total=   1.3s
[CV] batch_size=40, epochs=60 ....................................
[CV] ............ batch_size=40, epochs=60, score=0.821, total=   1.2s
[CV] batch_size=40, epochs=60 ....................................
[CV] ............ batch_size=40, epochs=60, score=0.808, total=   1.3s
[CV] batch_size=40, epochs=60 ....................................
[CV] ............ batch_size=40, epochs=60, score=0.846, total=   2.1s
```

```
[CV] batch_size=40, epochs=70 ....................................
[CV] ............ batch_size=40, epochs=70, score=0.747, total=   1.4s
[CV] batch_size=40, epochs=70 ....................................
[CV] ............ batch_size=40, epochs=70, score=0.646, total=   1.4s
[CV] batch_size=40, epochs=70 ....................................
[CV] ............ batch_size=40, epochs=70, score=0.833, total=   1.3s
[CV] batch_size=40, epochs=70 ....................................
[CV] ............ batch_size=40, epochs=70, score=0.859, total=   1.3s
[CV] batch_size=40, epochs=70 ....................................
[CV] ............ batch_size=40, epochs=70, score=0.821, total=   1.4s
[CV] batch_size=40, epochs=80 ....................................
[CV] ............ batch_size=40, epochs=80, score=0.747, total=   1.4s
[CV] batch_size=40, epochs=80 ....................................
[CV] ............ batch_size=40, epochs=80, score=0.658, total=   1.4s
[CV] batch_size=40, epochs=80 ....................................
[CV] ............ batch_size=40, epochs=80, score=0.821, total=   1.4s
[CV] batch_size=40, epochs=80 ....................................
[CV] ............ batch_size=40, epochs=80, score=0.769, total=   1.4s
[CV] batch_size=40, epochs=80 ....................................
[CV] ............ batch_size=40, epochs=80, score=0.821, total=   1.5s
[CV] batch_size=40, epochs=90 ....................................
[CV] ............ batch_size=40, epochs=90, score=0.734, total=   1.4s
[CV] batch_size=40, epochs=90 ....................................
[CV] ............ batch_size=40, epochs=90, score=0.671, total=   1.5s
[CV] batch_size=40, epochs=90 ....................................
[CV] ............ batch_size=40, epochs=90, score=0.833, total=   1.6s
[CV] batch_size=40, epochs=90 ....................................
[CV] ............ batch_size=40, epochs=90, score=0.859, total=   1.4s
[CV] batch_size=40, epochs=90 ....................................
[CV] ............ batch_size=40, epochs=90, score=0.833, total=   1.4s

[Parallel(n_jobs=1)]: Done 360 out of 360 | elapsed:  9.5min finished
```

```
Best: 0.7937682509422302, using {'batch_size': 15, 'epochs': 40}
0.7530671954154968 (0.093606423166587) with: {'batch_size': 5, 'epochs': 1
0}
0.7759818315505982 (0.10074232803409805) with: {'batch_size': 5, 'epochs':
20}
0.7400519251823425 (0.07295645482704591) with: {'batch_size': 5, 'epochs':
30}
0.7580980062484741 (0.0822227748667059) with: {'batch_size': 5, 'epochs':
40}
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0.7706264019012451 (0.04574693631572146) with: {'batch_size': 5, 'epochs':
60}
0.7477442383766174 (0.09039040493870455) with: {'batch_size': 5, 'epochs':
70}
0.7579357385635376 (0.061868037926375026) with: {'batch_size': 5, 'epoch
s': 80}
0.7529048919677734 (0.0803551361221236) with: {'batch_size': 5, 'epochs':
90}
0.778416097164154 (0.08572701528850489) with: {'batch_size': 10, 'epochs':
10}
0.7555339097976684 (0.07717332908221937) with: {'batch_size': 10, 'epoch
s': 20}
0.778318727016449 (0.04317767964690455) with: {'batch_size': 10, 'epochs':
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s': 80}
0.7503083348274231 (0.0729114234134926) with: {'batch_size': 10, 'epochs':
90}
0.7784810066223145 (0.07862073396312258) with: {'batch_size': 15, 'epoch
s': 10}
0.7658552408218384 (0.10025803483055287) with: {'batch_size': 15, 'epoch
s': 20}
0.7632586836814881 (0.09337224488139984) with: {'batch_size': 15, 'epoch
s': 30}
0.7937682509422302 (0.07402694637842949) with: {'batch_size': 15, 'epoch
s': 40}
0.781045114994049 (0.07435777891765352) with: {'batch_size': 15, 'epochs':
50}
0.7836416602134705 (0.07709362744073893) with: {'batch_size': 15, 'epoch
s': 60}
0.7910743236541748 (0.04474778274100997) with: {'batch_size': 15, 'epoch
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s': 80}
0.7732229828834534 (0.05481711411886053) with: {'batch_size': 15, 'epoch
s': 90}
0.7709185361862183 (0.09624559941953788) with: {'batch_size': 20, 'epoch
s': 10}
0.7683219671249389 (0.08278535550554962) with: {'batch_size': 20, 'epoch
s': 20}
0.7709185242652893 (0.09107809099665788) with: {'batch_size': 20, 'epoch
s': 30}
```

```
0.7556312918663025 (0.08569165130931236) with: {'batch_size': 20, 'epoch
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0.783576774597168 (0.07426069240829508) with: {'batch_size': 20, 'epochs':
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0.7708536148071289 (0.08581159355934291) with: {'batch_size': 20, 'epoch
s': 60}
0.7808503627777099 (0.044648911605364786) with: {'batch_size': 20, 'epoch
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0.7733203530311584 (0.07367169006718428) with: {'batch_size': 20, 'epoch
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0.7834469199180603 (0.05396014746569153) with: {'batch_size': 20, 'epoch
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0.7758519887924195 (0.06826372973114277) with: {'batch_size': 25, 'epoch
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0.7786108374595642 (0.09675040502497012) with: {'batch_size': 25, 'epoch
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0.7709185242652893 (0.0882933176860976) with: {'batch_size': 25, 'epochs':
30}
0.7733852624893188 (0.07475308221624698) with: {'batch_size': 25, 'epoch
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0.7836092233657836 (0.08245082958184255) with: {'batch_size': 25, 'epoch
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0.7860759496688843 (0.06778822485238664) with: {'batch_size': 25, 'epoch
s': 60}
0.7554365396499634 (0.06114305851570362) with: {'batch_size': 25, 'epoch
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0.7581304907798767 (0.093852114598362) with: {'batch_size': 30, 'epochs':
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s': 30}
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0.7912041544914246 (0.0682580337145552) with: {'batch_size': 30, 'epochs':
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0.7656929612159729 (0.08712634211022303) with: {'batch_size': 35, 'epoch
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0.768224585056305 (0.07175017418186987) with: {'batch_size': 35, 'epochs':
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0.7861733198165893 (0.0805463642067587) with: {'batch_size': 35, 'epochs':
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0.7708536148071289 (0.08189119101576739) with: {'batch_size': 35, 'epoch
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0.7758844461402893 (0.06435117103970882) with: {'batch_size': 35, 'epochs':
60}
0.7530022621154785 (0.08083832030359636) with: {'batch_size': 35, 'epoch
```

```
s': 70}
0.77578706741333 (0.0518998045582321) with: {'batch_size': 35, 'epochs': 8
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0.7631937623023987 (0.07259239526950895) with: {'batch_size': 35, 'epoch
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0.760629665851593 (0.09163650102515235) with: {'batch_size': 40, 'epochs':
10}
0.7682570457458496 (0.07810592516055545) with: {'batch_size': 40, 'epoch
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0.7708536148071289 (0.08646925022778544) with: {'batch_size': 40, 'epoch
s': 30}
0.7861408710479736 (0.0739417282440526) with: {'batch_size': 40, 'epochs':
40}
0.755371630191803 (0.0586868418664545) with: {'batch_size': 40, 'epochs':
50}
0.7733528017997742 (0.08018005870351835) with: {'batch_size': 40, 'epoch
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0.781045114994049 (0.07731575378176402) with: {'batch_size': 40, 'epochs':
70}
0.7630639553070069 (0.05982097769598485) with: {'batch_size': 40, 'epoch
s': 80}
0.7861408591270447 (0.07175353551737342) with: {'batch_size': 40, 'epoch
s': 90}
```

In [125]:

```
# import necessary packages
from keras.layers import Dropout
# Define a random seed
seed = 6
np.random.seed(seed)
epochs=10
batch_size=5
# Start defining the model
def create_model(learn_rate, dropout_rate):
    # Create model
    model = Sequential()
    model.add(Dense(8, input_dim = 8, kernel_initializer = 'normal', activation = 'rel
u'))
    model.add(Dropout(dropout_rate))
    model.add(Dense(4, input_dim = 8, kernel_initializer = 'normal', activation = 'rel
u'))
    model.add(Dropout(dropout_rate))
    model.add(Dense(1, activation = 'sigmoid'))

    # Compile the model
    adam = Adam(lr = learn_rate)
    model.compile(loss = 'binary_crossentropy', optimizer = adam, metrics = ['accuracy'
])
    return model

# Create the model
model = KerasClassifier(build_fn = create_model, epochs=epochs, batch_size=batch_size,
verbose = 0) # This comes from the previous best

# define the grid search parameters
learn_rate = [0.0001, 0.001, 0.01, 0.1]
dropout_rate = [0.0, 0.1, 0.2, 0.3]

# make a dictionary of the grid search parameters
param_grid = dict(learn_rate=learn_rate, dropout_rate=dropout_rate)

# build and fit the GridSearchCV
grid = GridSearchCV(estimator=model, param_grid=param_grid, cv = KFold(random_state=see
d), verbose=10)
grid_result = grid.fit(X_standardized, Y)

# summarize the results
print("Best: {0}, using {1}".format(grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print('{0} ({1}) with: {2}'.format(mean, stdev, param))
```

```
Fitting 5 folds for each of 16 candidates, totalling 80 fits
[CV] dropout_rate=0.0, learn_rate=0.0001 .............................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent wo
rkers.

[CV] . dropout_rate=0.0, learn_rate=0.0001, score=0.671, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.0001 .............................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    1.2s remaining:
0.0s

[CV] . dropout_rate=0.0, learn_rate=0.0001, score=0.570, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.0001 .............................

[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:    2.5s remaining:
0.0s

[CV] . dropout_rate=0.0, learn_rate=0.0001, score=0.756, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.0001 .............................

[Parallel(n_jobs=1)]: Done   3 out of   3 | elapsed:    3.9s remaining:
0.0s

[CV] . dropout_rate=0.0, learn_rate=0.0001, score=0.744, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.0001 .............................

[Parallel(n_jobs=1)]: Done   4 out of   4 | elapsed:    5.3s remaining:
0.0s

[CV] . dropout_rate=0.0, learn_rate=0.0001, score=0.679, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.001 ..............................

[Parallel(n_jobs=1)]: Done   5 out of   5 | elapsed:    6.6s remaining:
0.0s

[CV] .. dropout_rate=0.0, learn_rate=0.001, score=0.797, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.001 ..............................

[Parallel(n_jobs=1)]: Done   6 out of   6 | elapsed:    8.0s remaining:
0.0s

[CV] .. dropout_rate=0.0, learn_rate=0.001, score=0.633, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.001 ..............................

[Parallel(n_jobs=1)]: Done   7 out of   7 | elapsed:    9.2s remaining:
0.0s

[CV] .. dropout_rate=0.0, learn_rate=0.001, score=0.808, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.001 ..............................

[Parallel(n_jobs=1)]: Done   8 out of   8 | elapsed:   10.6s remaining:
0.0s

[CV] .. dropout_rate=0.0, learn_rate=0.001, score=0.821, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.001 ..............................

[Parallel(n_jobs=1)]: Done   9 out of   9 | elapsed:   12.0s remaining:
0.0s
```

```
[CV] .. dropout_rate=0.0, learn_rate=0.001, score=0.833, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.0, learn_rate=0.01, score=0.747, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.0, learn_rate=0.01, score=0.658, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.0, learn_rate=0.01, score=0.821, total=   1.3s
[CV] dropout_rate=0.0, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.0, learn_rate=0.01, score=0.821, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.0, learn_rate=0.01, score=0.808, total=   1.6s
[CV] dropout_rate=0.0, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.0, learn_rate=0.1, score=0.671, total=   1.5s
[CV] dropout_rate=0.0, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.0, learn_rate=0.1, score=0.620, total=   2.3s
[CV] dropout_rate=0.0, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.0, learn_rate=0.1, score=0.731, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.0, learn_rate=0.1, score=0.718, total=   1.4s
[CV] dropout_rate=0.0, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.0, learn_rate=0.1, score=0.795, total=   1.4s
[CV] dropout_rate=0.1, learn_rate=0.0001 ............................
[CV] . dropout_rate=0.1, learn_rate=0.0001, score=0.684, total=   1.9s
[CV] dropout_rate=0.1, learn_rate=0.0001 ............................
[CV] . dropout_rate=0.1, learn_rate=0.0001, score=0.570, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.0001 ............................
[CV] . dropout_rate=0.1, learn_rate=0.0001, score=0.705, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.0001 ............................
[CV] . dropout_rate=0.1, learn_rate=0.0001, score=0.808, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.0001 ............................
[CV] . dropout_rate=0.1, learn_rate=0.0001, score=0.679, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.001 .............................
[CV] .. dropout_rate=0.1, learn_rate=0.001, score=0.797, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.001 .............................
[CV] .. dropout_rate=0.1, learn_rate=0.001, score=0.595, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.001 .............................
[CV] .. dropout_rate=0.1, learn_rate=0.001, score=0.833, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.001 .............................
[CV] .. dropout_rate=0.1, learn_rate=0.001, score=0.859, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.001 .............................
[CV] .. dropout_rate=0.1, learn_rate=0.001, score=0.833, total=   1.6s
[CV] dropout_rate=0.1, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.1, learn_rate=0.01, score=0.772, total=   2.7s
[CV] dropout_rate=0.1, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.1, learn_rate=0.01, score=0.595, total=   1.6s
[CV] dropout_rate=0.1, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.1, learn_rate=0.01, score=0.705, total=   1.8s
[CV] dropout_rate=0.1, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.1, learn_rate=0.01, score=0.846, total=   1.8s
[CV] dropout_rate=0.1, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.1, learn_rate=0.01, score=0.821, total=   1.8s
[CV] dropout_rate=0.1, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.1, learn_rate=0.1, score=0.696, total=   1.8s
[CV] dropout_rate=0.1, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.1, learn_rate=0.1, score=0.595, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.1, learn_rate=0.1, score=0.782, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.1, learn_rate=0.1, score=0.744, total=   1.7s
[CV] dropout_rate=0.1, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.1, learn_rate=0.1, score=0.821, total=   1.8s
```

```
[CV] dropout_rate=0.2, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.2, learn_rate=0.0001, score=0.646, total=   1.7s
[CV] dropout_rate=0.2, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.2, learn_rate=0.0001, score=0.582, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.2, learn_rate=0.0001, score=0.705, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.2, learn_rate=0.0001, score=0.744, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.2, learn_rate=0.0001, score=0.705, total=   1.7s
[CV] dropout_rate=0.2, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.2, learn_rate=0.001, score=0.785, total=   2.7s
[CV] dropout_rate=0.2, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.2, learn_rate=0.001, score=0.608, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.2, learn_rate=0.001, score=0.833, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.2, learn_rate=0.001, score=0.821, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.2, learn_rate=0.001, score=0.808, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.01 ...............................
[CV] ... dropout_rate=0.2, learn_rate=0.01, score=0.810, total=   1.8s
[CV] dropout_rate=0.2, learn_rate=0.01 ...............................
[CV] ... dropout_rate=0.2, learn_rate=0.01, score=0.646, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.01 ...............................
[CV] ... dropout_rate=0.2, learn_rate=0.01, score=0.808, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.01 ...............................
[CV] ... dropout_rate=0.2, learn_rate=0.01, score=0.821, total=   1.8s
[CV] dropout_rate=0.2, learn_rate=0.01 ...............................
[CV] ... dropout_rate=0.2, learn_rate=0.01, score=0.795, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.1 ................................
[CV] .... dropout_rate=0.2, learn_rate=0.1, score=0.646, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.1 ................................
[CV] .... dropout_rate=0.2, learn_rate=0.1, score=0.570, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.1 ................................
[CV] .... dropout_rate=0.2, learn_rate=0.1, score=0.705, total=   1.6s
[CV] dropout_rate=0.2, learn_rate=0.1 ................................
[CV] .... dropout_rate=0.2, learn_rate=0.1, score=0.744, total=   1.7s
[CV] dropout_rate=0.2, learn_rate=0.1 ................................
[CV] .... dropout_rate=0.2, learn_rate=0.1, score=0.705, total=   1.8s
[CV] dropout_rate=0.3, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.3, learn_rate=0.0001, score=0.646, total=   2.9s
[CV] dropout_rate=0.3, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.3, learn_rate=0.0001, score=0.570, total=   1.8s
[CV] dropout_rate=0.3, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.3, learn_rate=0.0001, score=0.705, total=   1.8s
[CV] dropout_rate=0.3, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.3, learn_rate=0.0001, score=0.744, total=   1.7s
[CV] dropout_rate=0.3, learn_rate=0.0001 .............................
[CV] . dropout_rate=0.3, learn_rate=0.0001, score=0.679, total=   1.7s
[CV] dropout_rate=0.3, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.3, learn_rate=0.001, score=0.797, total=   1.7s
[CV] dropout_rate=0.3, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.3, learn_rate=0.001, score=0.608, total=   1.8s
[CV] dropout_rate=0.3, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.3, learn_rate=0.001, score=0.821, total=   1.7s
[CV] dropout_rate=0.3, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.3, learn_rate=0.001, score=0.833, total=   1.8s
[CV] dropout_rate=0.3, learn_rate=0.001 ..............................
[CV] .. dropout_rate=0.3, learn_rate=0.001, score=0.821, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.01 ...............................
```

```
[CV] ... dropout_rate=0.3, learn_rate=0.01, score=0.734, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.3, learn_rate=0.01, score=0.620, total=   1.7s
[CV] dropout_rate=0.3, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.3, learn_rate=0.01, score=0.846, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.3, learn_rate=0.01, score=0.821, total=   1.7s
[CV] dropout_rate=0.3, learn_rate=0.01 ..............................
[CV] ... dropout_rate=0.3, learn_rate=0.01, score=0.833, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.3, learn_rate=0.1, score=0.646, total=   2.6s
[CV] dropout_rate=0.3, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.3, learn_rate=0.1, score=0.570, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.3, learn_rate=0.1, score=0.756, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.3, learn_rate=0.1, score=0.744, total=   1.6s
[CV] dropout_rate=0.3, learn_rate=0.1 ...............................
[CV] .... dropout_rate=0.3, learn_rate=0.1, score=0.679, total=   1.6s


[Parallel(n_jobs=1)]: Done  80 out of  80 | elapsed:  2.2min finished
```

```
Best: 0.7836092114448547, using {'dropout_rate': 0.1, 'learn_rate': 0.001}
0.683998703956604 (0.0664368109434011) with: {'dropout_rate': 0.0, 'learn_
rate': 0.0001}
0.7783836364746094 (0.07372887660494651) with: {'dropout_rate': 0.0, 'lear
n_rate': 0.001}
0.7707562565803527 (0.06253086886357516) with: {'dropout_rate': 0.0, 'lear
n_rate': 0.01}
0.70694580078125 (0.058712044451083654) with: {'dropout_rate': 0.0, 'learn
_rate': 0.1}
0.6890944361686706 (0.07578880753835449) with: {'dropout_rate': 0.1, 'lear
n_rate': 0.0001}
0.7836092114448547 (0.09634755505535177) with: {'dropout_rate': 0.1, 'lear
n_rate': 0.001}
0.7477766990661621 (0.0902681685728596) with: {'dropout_rate': 0.1, 'learn
_rate': 0.01}
0.7274586200714112 (0.07802390981609372) with: {'dropout_rate': 0.1, 'lear
n_rate': 0.1}
0.6763388514518738 (0.05652332959830523) with: {'dropout_rate': 0.2, 'lear
n_rate': 0.0001}
0.7707886934280396 (0.08315648762260007) with: {'dropout_rate': 0.2, 'lear
n_rate': 0.001}
0.7757546305656433 (0.06560235635714638) with: {'dropout_rate': 0.2, 'lear
n_rate': 0.01}
0.6738072037696838 (0.060801144237587465) with: {'dropout_rate': 0.2, 'lea
rn_rate': 0.1}
0.6686789989471436 (0.05899773033245815) with: {'dropout_rate': 0.3, 'lear
n_rate': 0.0001}
0.7758844494819641 (0.0849364377331393) with: {'dropout_rate': 0.3, 'learn
_rate': 0.001}
0.7708860754966735 (0.0849300062873271) with: {'dropout_rate': 0.3, 'learn
_rate': 0.01}
0.6789354085922241 (0.06818492258903203) with: {'dropout_rate': 0.3, 'lear
n_rate': 0.1}
```

In [129]:

```
# Define a random seed
seed = 6
np.random.seed(seed)
learn_rate = 0.001
# Start defining the model
def create_model(activation, init):
    # Create model
    model = Sequential()
    model.add(Dense(8, input_dim = 8, kernel_initializer = init, activation = activatio
n))
    #model.add(Dropout(dropout_rate))
    model.add(Dense(4, input_dim = 8, kernel_initializer = init, activation = activatio
n))
    #model.add(Dropout(dropout_rate))
    model.add(Dense(1, activation = 'sigmoid'))

    # Compile the model
    adam = Adam(lr = learn_rate)
    model.compile(loss = 'binary_crossentropy', optimizer = adam, metrics = ['accuracy'
])
    return model

# Create the model
model = KerasClassifier(build_fn = create_model, epochs=epochs, batch_size=batch_size,
verbose = 0) # This comes from the previous best

# define the grid search parameters
activations = ['softmax', 'relu', 'tanh', 'linear']
initializers = ['uniform', 'normal', 'zero']

# make a dictionary of the grid search parameters
param_grid = dict(activation = activations, init = initializers)

# build and fit the GridSearchCV
grid = GridSearchCV(estimator=model, param_grid=param_grid, cv = KFold(random_state=see
d), verbose=10)
grid_result = grid.fit(X_standardized, Y)

# summarize the results
print("Best: {0}, using {1}".format(grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print('{0} ({1}) with: {2}'.format(mean, stdev, param))
```

```
Fitting 5 folds for each of 12 candidates, totalling 60 fits
[CV] activation=softmax, init=uniform .............................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent wo
rkers.

[CV] .... activation=softmax, init=uniform, score=0.646, total=   1.5s
[CV] activation=softmax, init=uniform .............................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    1.4s remaining:
0.0s

[CV] .... activation=softmax, init=uniform, score=0.570, total=   1.5s
[CV] activation=softmax, init=uniform .............................

[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:    2.9s remaining:
0.0s

[CV] .... activation=softmax, init=uniform, score=0.705, total=   1.5s
[CV] activation=softmax, init=uniform .............................

[Parallel(n_jobs=1)]: Done   3 out of   3 | elapsed:    4.4s remaining:
0.0s

[CV] .... activation=softmax, init=uniform, score=0.744, total=   1.6s
[CV] activation=softmax, init=uniform .............................

[Parallel(n_jobs=1)]: Done   4 out of   4 | elapsed:    6.0s remaining:
0.0s

[CV] .... activation=softmax, init=uniform, score=0.679, total=   1.4s
[CV] activation=softmax, init=normal ..............................

[Parallel(n_jobs=1)]: Done   5 out of   5 | elapsed:    7.4s remaining:
0.0s

[CV] ..... activation=softmax, init=normal, score=0.646, total=   1.4s
[CV] activation=softmax, init=normal ..............................

[Parallel(n_jobs=1)]: Done   6 out of   6 | elapsed:    8.8s remaining:
0.0s

[CV] ..... activation=softmax, init=normal, score=0.570, total=   1.6s
[CV] activation=softmax, init=normal ..............................

[Parallel(n_jobs=1)]: Done   7 out of   7 | elapsed:   10.4s remaining:
0.0s

[CV] ..... activation=softmax, init=normal, score=0.705, total=   1.5s
[CV] activation=softmax, init=normal ..............................

[Parallel(n_jobs=1)]: Done   8 out of   8 | elapsed:   11.9s remaining:
0.0s

[CV] ..... activation=softmax, init=normal, score=0.744, total=   2.6s
[CV] activation=softmax, init=normal ..............................

[Parallel(n_jobs=1)]: Done   9 out of   9 | elapsed:   14.5s remaining:
0.0s
```

```
[CV] ..... activation=softmax, init=normal, score=0.679, total=   1.5s
[CV] activation=softmax, init=zero ...................................
[CV] ....... activation=softmax, init=zero, score=0.646, total=   1.6s
[CV] activation=softmax, init=zero ...................................
[CV] ....... activation=softmax, init=zero, score=0.570, total=   1.5s
[CV] activation=softmax, init=zero ...................................
[CV] ....... activation=softmax, init=zero, score=0.705, total=   1.6s
[CV] activation=softmax, init=zero ...................................
[CV] ....... activation=softmax, init=zero, score=0.744, total=   1.5s
[CV] activation=softmax, init=zero ...................................
[CV] ....... activation=softmax, init=zero, score=0.679, total=   1.6s
[CV] activation=relu, init=uniform ...................................
[CV] ....... activation=relu, init=uniform, score=0.810, total=   1.9s
[CV] activation=relu, init=uniform ...................................
[CV] ....... activation=relu, init=uniform, score=0.608, total=   2.1s
[CV] activation=relu, init=uniform ...................................
[CV] ....... activation=relu, init=uniform, score=0.833, total=   1.5s
[CV] activation=relu, init=uniform ...................................
[CV] ....... activation=relu, init=uniform, score=0.795, total=   1.4s
[CV] activation=relu, init=uniform ...................................
[CV] ....... activation=relu, init=uniform, score=0.833, total=   1.5s
[CV] activation=relu, init=normal ....................................
[CV] ........ activation=relu, init=normal, score=0.785, total=   1.6s
[CV] activation=relu, init=normal ....................................
[CV] ........ activation=relu, init=normal, score=0.620, total=   1.5s
[CV] activation=relu, init=normal ....................................
[CV] ........ activation=relu, init=normal, score=0.808, total=   1.5s
[CV] activation=relu, init=normal ....................................
[CV] ........ activation=relu, init=normal, score=0.808, total=   1.4s
[CV] activation=relu, init=normal ....................................
[CV] ........ activation=relu, init=normal, score=0.821, total=   1.5s
[CV] activation=relu, init=zero ......................................
[CV] .......... activation=relu, init=zero, score=0.646, total=   1.4s
[CV] activation=relu, init=zero ......................................
[CV] .......... activation=relu, init=zero, score=0.570, total=   1.4s
[CV] activation=relu, init=zero ......................................
[CV] .......... activation=relu, init=zero, score=0.705, total=   2.5s
[CV] activation=relu, init=zero ......................................
[CV] .......... activation=relu, init=zero, score=0.744, total=   1.4s
[CV] activation=relu, init=zero ......................................
[CV] .......... activation=relu, init=zero, score=0.679, total=   1.4s
[CV] activation=tanh, init=uniform ...................................
[CV] ....... activation=tanh, init=uniform, score=0.810, total=   1.5s
[CV] activation=tanh, init=uniform ...................................
[CV] ....... activation=tanh, init=uniform, score=0.620, total=   1.4s
[CV] activation=tanh, init=uniform ...................................
[CV] ....... activation=tanh, init=uniform, score=0.821, total=   1.5s
[CV] activation=tanh, init=uniform ...................................
[CV] ....... activation=tanh, init=uniform, score=0.833, total=   1.5s
[CV] activation=tanh, init=uniform ...................................
[CV] ....... activation=tanh, init=uniform, score=0.821, total=   1.4s
[CV] activation=tanh, init=normal ....................................
[CV] ........ activation=tanh, init=normal, score=0.810, total=   1.5s
[CV] activation=tanh, init=normal ....................................
[CV] ........ activation=tanh, init=normal, score=0.620, total=   1.5s
[CV] activation=tanh, init=normal ....................................
[CV] ........ activation=tanh, init=normal, score=0.821, total=   1.4s
[CV] activation=tanh, init=normal ....................................
[CV] ........ activation=tanh, init=normal, score=0.821, total=   1.4s
[CV] activation=tanh, init=normal ....................................
[CV] ........ activation=tanh, init=normal, score=0.821, total=   1.5s
```

```
[CV] activation=tanh, init=zero .....................................
[CV] .......... activation=tanh, init=zero, score=0.646, total=   1.4s
[CV] activation=tanh, init=zero .....................................
[CV] .......... activation=tanh, init=zero, score=0.570, total=   1.4s
[CV] activation=tanh, init=zero .....................................
[CV] .......... activation=tanh, init=zero, score=0.705, total=   1.4s
[CV] activation=tanh, init=zero .....................................
[CV] .......... activation=tanh, init=zero, score=0.744, total=   1.4s
[CV] activation=tanh, init=zero .....................................
[CV] .......... activation=tanh, init=zero, score=0.679, total=   1.5s
[CV] activation=linear, init=uniform ................................
[CV] ..... activation=linear, init=uniform, score=0.823, total=   1.4s
[CV] activation=linear, init=uniform ................................
[CV] ..... activation=linear, init=uniform, score=0.633, total=   1.5s
[CV] activation=linear, init=uniform ................................
[CV] ..... activation=linear, init=uniform, score=0.833, total=   2.6s
[CV] activation=linear, init=uniform ................................
[CV] ..... activation=linear, init=uniform, score=0.846, total=   1.4s
[CV] activation=linear, init=uniform ................................
[CV] ..... activation=linear, init=uniform, score=0.808, total=   1.4s
[CV] activation=linear, init=normal .................................
[CV] ...... activation=linear, init=normal, score=0.835, total=   1.4s
[CV] activation=linear, init=normal .................................
[CV] ...... activation=linear, init=normal, score=0.646, total=   1.4s
[CV] activation=linear, init=normal .................................
[CV] ...... activation=linear, init=normal, score=0.833, total=   1.4s
[CV] activation=linear, init=normal .................................
[CV] ...... activation=linear, init=normal, score=0.821, total=   1.5s
[CV] activation=linear, init=normal .................................
[CV] ...... activation=linear, init=normal, score=0.808, total=   1.5s
[CV] activation=linear, init=zero ...................................
[CV] ........ activation=linear, init=zero, score=0.646, total=   1.7s
[CV] activation=linear, init=zero ...................................
[CV] ........ activation=linear, init=zero, score=0.570, total=   1.5s
[CV] activation=linear, init=zero ...................................
[CV] ........ activation=linear, init=zero, score=0.705, total=   1.5s
[CV] activation=linear, init=zero ...................................
[CV] ........ activation=linear, init=zero, score=0.744, total=   1.5s
[CV] activation=linear, init=zero ...................................
[CV] ........ activation=linear, init=zero, score=0.679, total=   1.5s


[Parallel(n_jobs=1)]: Done  60 out of  60 | elapsed:  1.5min finished
```

```
Best: 0.7885751247406005, using {'activation': 'linear', 'init': 'unifor
m'}
0.6686789989471436 (0.05899773033245815) with: {'activation': 'softmax',
'init': 'uniform'}
0.6686789989471436 (0.05899773033245815) with: {'activation': 'softmax',
'init': 'normal'}
0.6686789989471436 (0.05899773033245815) with: {'activation': 'softmax',
'init': 'zero'}
0.7758519887924195 (0.08538753245470605) with: {'activation': 'relu', 'ini
t': 'uniform'}
0.7681921362876892 (0.07485997838038587) with: {'activation': 'relu', 'ini
t': 'normal'}
0.6686789989471436 (0.05899773033245815) with: {'activation': 'relu', 'ini
t': 'zero'}
0.780947744846344 (0.08068357931675665) with: {'activation': 'tanh', 'ini
t': 'uniform'}
0.7783836483955383 (0.07916751248246863) with: {'activation': 'tanh', 'ini
t': 'normal'}
0.6686789989471436 (0.05899773033245815) with: {'activation': 'tanh', 'ini
t': 'zero'}
0.7885751247406005 (0.07884868092404165) with: {'activation': 'linear', 'i
nit': 'uniform'}
0.7885102152824401 (0.07216083526263331) with: {'activation': 'linear', 'i
nit': 'normal'}
0.6686789989471436 (0.05899773033245815) with: {'activation': 'linear', 'i
nit': 'zero'}
```

In [130]:

```
# Define a random seed
seed = 6
np.random.seed(seed)
init = 'uniform'   # taken from previous results
activation = 'linear'
# Start defining the model
def create_model(neuron1, neuron2):
    # Create model
    model = Sequential()
    model.add(Dense(neuron1, input_dim = 8, kernel_initializer = init, activation = act
ivation))
#    model.add(Dropout(dropout_rate))
    model.add(Dense(neuron2, input_dim = neuron1, kernel_initializer = init, activation
= activation))
#    model.add(Dropout(dropout_rate))
    model.add(Dense(1, activation = 'sigmoid'))

    # Compile the model
    adam = Adam(lr = learn_rate)
    model.compile(loss = 'binary_crossentropy', optimizer = adam, metrics = ['accuracy'
])
    return model

# Create the model
model = KerasClassifier(build_fn = create_model, epochs=50, batch_size=10, verbose = 0)

# define the grid search parameters
neuron1 = [4, 8, 16]
neuron2 = [2, 4, 8]

# make a dictionary of the grid search parameters
param_grid = dict(neuron1 = neuron1, neuron2 = neuron2)

# build and fit the GridSearchCV
grid = GridSearchCV(estimator=model, param_grid=param_grid, cv = KFold(random_state=see
d), refit=True, verbose=10) # To retrain with the best parameters found so far
grid_result = grid.fit(X_standardized, Y)

# summarize the results
print("Best: {0}, using {1}".format(grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print('{0} ({1}) with: {2}'.format(mean, stdev, param))
```

```
Fitting 5 folds for each of 9 candidates, totalling 45 fits
[CV] neuron1=4, neuron2=2 ............................................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent wo
rkers.

[CV] ................ neuron1=4, neuron2=2, score=0.835, total=   2.0s
[CV] neuron1=4, neuron2=2 ............................................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    2.0s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=2, score=0.633, total=   2.2s
[CV] neuron1=4, neuron2=2 ............................................

[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:    4.2s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=2, score=0.833, total=   2.3s
[CV] neuron1=4, neuron2=2 ............................................

[Parallel(n_jobs=1)]: Done   3 out of   3 | elapsed:    6.4s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=2, score=0.833, total=   2.2s
[CV] neuron1=4, neuron2=2 ............................................

[Parallel(n_jobs=1)]: Done   4 out of   4 | elapsed:    8.6s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=2, score=0.808, total=   2.5s
[CV] neuron1=4, neuron2=4 ............................................

[Parallel(n_jobs=1)]: Done   5 out of   5 | elapsed:   11.1s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=4, score=0.835, total=   3.4s
[CV] neuron1=4, neuron2=4 ............................................

[Parallel(n_jobs=1)]: Done   6 out of   6 | elapsed:   14.5s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=4, score=0.633, total=   3.3s
[CV] neuron1=4, neuron2=4 ............................................

[Parallel(n_jobs=1)]: Done   7 out of   7 | elapsed:   17.8s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=4, score=0.833, total=   2.1s
[CV] neuron1=4, neuron2=4 ............................................


[Parallel(n_jobs=1)]: Done   8 out of   8 | elapsed:   19.9s remaining:
0.0s

[CV] ................ neuron1=4, neuron2=4, score=0.846, total=   2.0s
[CV] neuron1=4, neuron2=4 ............................................

[Parallel(n_jobs=1)]: Done   9 out of   9 | elapsed:   21.9s remaining:
0.0s
```

```
[CV] ............... neuron1=4, neuron2=4, score=0.808, total=   2.0s
[CV] neuron1=4, neuron2=8 .....................................
[CV] ............... neuron1=4, neuron2=8, score=0.835, total=   2.0s
[CV] neuron1=4, neuron2=8 .....................................
[CV] ............... neuron1=4, neuron2=8, score=0.633, total=   2.2s
[CV] neuron1=4, neuron2=8 .....................................
[CV] ............... neuron1=4, neuron2=8, score=0.821, total=   2.1s
[CV] neuron1=4, neuron2=8 .....................................
[CV] ............... neuron1=4, neuron2=8, score=0.859, total=   2.1s
[CV] neuron1=4, neuron2=8 .....................................
[CV] ............... neuron1=4, neuron2=8, score=0.821, total=   2.2s
[CV] neuron1=8, neuron2=2 .....................................
[CV] ............... neuron1=8, neuron2=2, score=0.835, total=   2.2s
[CV] neuron1=8, neuron2=2 .....................................
[CV] ............... neuron1=8, neuron2=2, score=0.620, total=   2.1s
[CV] neuron1=8, neuron2=2 .....................................
[CV] ............... neuron1=8, neuron2=2, score=0.833, total=   2.1s
[CV] neuron1=8, neuron2=2 .....................................
[CV] ............... neuron1=8, neuron2=2, score=0.833, total=   2.1s
[CV] neuron1=8, neuron2=2 .....................................
[CV] ............... neuron1=8, neuron2=2, score=0.833, total=   2.0s
[CV] neuron1=8, neuron2=4 .....................................
[CV] ............... neuron1=8, neuron2=4, score=0.835, total=   2.2s
[CV] neuron1=8, neuron2=4 .....................................
[CV] ............... neuron1=8, neuron2=4, score=0.633, total=   2.1s
[CV] neuron1=8, neuron2=4 .....................................
[CV] ............... neuron1=8, neuron2=4, score=0.821, total=   2.3s
[CV] neuron1=8, neuron2=4 .....................................
[CV] ............... neuron1=8, neuron2=4, score=0.846, total=   2.3s
[CV] neuron1=8, neuron2=4 .....................................
[CV] ............... neuron1=8, neuron2=4, score=0.833, total=   2.2s
[CV] neuron1=8, neuron2=8 .....................................
[CV] ............... neuron1=8, neuron2=8, score=0.835, total=   3.4s
[CV] neuron1=8, neuron2=8 .....................................
[CV] ............... neuron1=8, neuron2=8, score=0.608, total=   2.1s
[CV] neuron1=8, neuron2=8 .....................................
[CV] ............... neuron1=8, neuron2=8, score=0.821, total=   2.1s
[CV] neuron1=8, neuron2=8 .....................................
[CV] ............... neuron1=8, neuron2=8, score=0.833, total=   2.1s
[CV] neuron1=8, neuron2=8 .....................................
[CV] ............... neuron1=8, neuron2=8, score=0.821, total=   2.2s
[CV] neuron1=16, neuron2=2 ....................................
[CV] ............... neuron1=16, neuron2=2, score=0.835, total=   2.1s
[CV] neuron1=16, neuron2=2 ....................................
[CV] ............... neuron1=16, neuron2=2, score=0.620, total=   2.3s
[CV] neuron1=16, neuron2=2 ....................................
[CV] ............... neuron1=16, neuron2=2, score=0.821, total=   2.1s
[CV] neuron1=16, neuron2=2 ....................................
[CV] ............... neuron1=16, neuron2=2, score=0.846, total=   2.1s
[CV] neuron1=16, neuron2=2 ....................................
[CV] ............... neuron1=16, neuron2=2, score=0.821, total=   3.2s
[CV] neuron1=16, neuron2=4 ....................................
[CV] ............... neuron1=16, neuron2=4, score=0.835, total=   3.2s
[CV] neuron1=16, neuron2=4 ....................................
[CV] ............... neuron1=16, neuron2=4, score=0.633, total=   3.4s
[CV] neuron1=16, neuron2=4 ....................................
[CV] ............... neuron1=16, neuron2=4, score=0.821, total=   2.1s
[CV] neuron1=16, neuron2=4 ....................................
[CV] ............... neuron1=16, neuron2=4, score=0.846, total=   2.1s
[CV] neuron1=16, neuron2=4 ....................................
[CV] ............... neuron1=16, neuron2=4, score=0.833, total=   2.1s
```

```
[CV] neuron1=16, neuron2=8 ...........................................
[CV] ............... neuron1=16, neuron2=8, score=0.835, total=   2.1s
[CV] neuron1=16, neuron2=8 ...........................................
[CV] ............... neuron1=16, neuron2=8, score=0.620, total=   2.1s
[CV] neuron1=16, neuron2=8 ...........................................
[CV] ............... neuron1=16, neuron2=8, score=0.833, total=   2.1s
[CV] neuron1=16, neuron2=8 ...........................................
[CV] ............... neuron1=16, neuron2=8, score=0.846, total=   2.1s
[CV] neuron1=16, neuron2=8 ...........................................
[CV] ............... neuron1=16, neuron2=8, score=0.821, total=   2.2s

[Parallel(n_jobs=1)]: Done  45 out of  45 | elapsed:  1.7min finished

Best: 0.7936708807945252, using {'neuron1': 4, 'neuron2': 8}
0.7885426640510559 (0.07848547811173927) with: {'neuron1': 4, 'neuron2':
2}
0.7911067724227905 (0.08009971934827462) with: {'neuron1': 4, 'neuron2':
4}
0.7936708807945252 (0.08160153117498936) with: {'neuron1': 4, 'neuron2':
8}
0.7911392211914062 (0.08544694452599808) with: {'neuron1': 8, 'neuron2':
2}
0.7936708807945252 (0.08079181748331918) with: {'neuron1': 8, 'neuron2':
4}
0.783479380607605 (0.08816341112960173) with: {'neuron1': 8, 'neuron2': 8}
0.7885751366615296 (0.08471627072558463) with: {'neuron1': 16, 'neuron2':
2}
0.7936708807945252 (0.08079181748331918) with: {'neuron1': 16, 'neuron2':
4}
0.7911392331123352 (0.0858308076774859) with: {'neuron1': 16, 'neuron2':
8}
```

In [131]:

```
# generate predictions with optimal hyperparameters
y_pred = grid.predict(X_standardized)
```

In [132]:

```
from sklearn.metrics import classification_report, accuracy_score

print(accuracy_score(Y, y_pred))
print(classification_report(Y, y_pred))
```

```
0.7831632653061225
              precision    recall  f1-score   support

           0       0.81      0.89      0.85       262
           1       0.71      0.58      0.64       130

    accuracy                           0.78       392
   macro avg       0.76      0.73      0.74       392
weighted avg       0.78      0.78      0.78       392
```

In [133]:

```
# example datapoint
example = df.iloc[1]
print(example)
```

```
n_pregnant                   0.000
glucose_concentration      137.000
blood_pressuer (mm Hg)      40.000
skin_thickness (mm)         35.000
serum_insulin (mu U/ml)    168.000
BMI                         43.100
pedigree_function            2.288
age                         33.000
class                        1.000
Name: 4, dtype: float64
```

In [134]:

```
# make a prediction using our optimized deep neural network
prediction = grid.predict(X_standardized[1].reshape(1, -1))
print(prediction)
```

```
[[1]]
```