Benchmark results:

- Excerpted from the Jupyter Notebook File: MLND Capstone Project Analysis -Rubric-OASIS_BENCHMARK_ANN_4-8-8-1_Keras_Py27_Tensorflow.ipynb
- In the Python 2.7 compatible code below, the input array X and the label array Y have been defined earlier in the Jupyter Notebook. This code ids using the previously defined X and Y.

Appendix 1: Neural Network Model with Keras+TensorFlow

A neural network model has been formulated based on the combined cross-sectional and the longitudinal MRI clinical/demographic dataset described earlier. The model is based on recommendations in Reference 24. The model is comprised of an input layer with 8 nodes, a hidden (dense) layer with 12 nodes with Relu activation function, followed by another hidden (dense) layer with 8 nodes with Relu activation followed by an output layer with Sigmoid activation.

In [43]:

```
from keras.models import Sequential
from keras.layers import Dense
import numpy
# fix random seed for reproducibility
numpy.random.seed(3445)
```

```
Using TensorFlow backend.
```

In [44]:

```
# Keras Model withT ensorflow backend
from keras.models import Sequential
from keras.layers import Dense
import numpy
# fix random seed for reproducibility
numpy.random.seed(33456)
# load dataset arrays
```

```
array = dfoas_merge.values
#X = array[:,[1, 3, 4, 5, 6, 8, 9, 10]] # Original feature set
X = array[:,[3, 6, 9, 10]] # Reduced feature Extraction based on RFE analysis
Y = array[:,7] # all rows and CDR column
# create model
model = Sequential()
model.add(Dense(8, input_dim=4, activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(1, activation='sigmoid'))
# Compile model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
# Fit the model
model.fit(X, Y, epochs=150, batch_size=10)
# evaluate the model
scores = model.evaluate(X, Y)
print("\n%s: %.2f%%" % (model.metrics_names[1], scores[1]*100))
```

```
Epoch 1/150
570/570 [==============================] - 1s - loss: 3.6370 - acc: 0.5947
Epoch 2/150
570/570 [==============================] - 0s - loss: 0.7934 - acc: 0.5947
Epoch 3/150
570/570 [==============================] - 0s - loss: 0.6658 - acc: 0.5947
Epoch 4/150
570/570 [==============================] - 0s - loss: 0.6610 - acc: 0.5947
Epoch 5/150
570/570 [==============================] - 0s - loss: 0.6581 - acc: 0.6105
Epoch 6/150
570/570 [==============================] - 0s - loss: 0.6559 - acc: 0.6018
Epoch 7/150
570/570 [==============================] - 0s - loss: 0.6472 - acc: 0.6000
Epoch 8/150
570/570 [==============================] - 0s - loss: 0.6444 - acc: 0.6000
Epoch 9/150
570/570 [==============================] - 0s - loss: 0.6451 - acc: 0.6702
Epoch 10/150
570/570 [==============================] - 0s - loss: 0.6370 - acc: 0.6140
Epoch 11/150
570/570 [==============================] - 0s - loss: 0.6293 - acc: 0.6561
Epoch 12/150
570/570 [==============================] - 0s - loss: 0.6268 - acc: 0.6526
Epoch 13/150
570/570 [==============================] - 0s - loss: 0.6284 - acc: 0.6719
Epoch 14/150
570/570 [==============================] - 0s - loss: 0.6196 - acc: 0.6614
```

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Epoch 15/150
570/570 [==============================] - 0s - loss: 0.6146 - acc: 0.6860
Epoch 16/150
570/570 [==============================] - 0s - loss: 0.6091 - acc: 0.6737
Epoch 17/150
570/570 [==============================] - 0s - loss: 0.6066 - acc: 0.7140
Epoch 18/150
570/570 [==============================] - 0s - loss: 0.6035 - acc: 0.6912
Epoch 19/150
570/570 [==============================] - 0s - loss: 0.5992 - acc: 0.7053
Epoch 20/150
570/570 [==============================] - 0s - loss: 0.5920 - acc: 0.6965
Epoch 21/150
570/570 [==============================] - 0s - loss: 0.5905 - acc: 0.7140
Epoch 22/150
570/570 [==============================] - 0s - loss: 0.5833 - acc: 0.7211
Epoch 23/150
570/570 [==============================] - 0s - loss: 0.5786 - acc: 0.7351
Epoch 24/150
570/570 [==============================] - 0s - loss: 0.5807 - acc: 0.7140
Epoch 25/150
570/570 [==============================] - 0s - loss: 0.5762 - acc: 0.7228
Epoch 26/150
570/570 [==============================] - 0s - loss: 0.5699 - acc: 0.7263
Epoch 27/150
570/570 [==============================] - 0s - loss: 0.5735 - acc: 0.7175
Epoch 28/150
570/570 [==============================] - 0s - loss: 0.5668 - acc: 0.7368
Epoch 29/150
570/570 [==============================] - 0s - loss: 0.5629 - acc: 0.7439
Epoch 30/150
570/570 [==============================] - 0s - loss: 0.5575 - acc: 0.7333
Epoch 31/150
570/570 [==============================] - 0s - loss: 0.5533 - acc: 0.7263
Epoch 32/150
570/570 [==============================] - 0s - loss: 0.5505 - acc: 0.7368
Epoch 33/150
570/570 [==============================] - 0s - loss: 0.5539 - acc: 0.7333
Epoch 34/150
570/570 [==============================] - 0s - loss: 0.5528 - acc: 0.7333
- ETA: 0s - loss: 0.5535 - acc: 0.72
Epoch 35/150
570/570 [==============================] - 0s - loss: 0.5417 - acc: 0.7368
Epoch 36/150
```

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570/570 [==============================] - 0s - loss: 0.5431 - acc: 0.7263
Epoch 37/150
570/570 [==============================] - 0s - loss: 0.5339 - acc: 0.7614
Epoch 38/150
570/570 [==============================] - 0s - loss: 0.5412 - acc: 0.7456
Epoch 39/150
570/570 [==============================] - 0s - loss: 0.5355 - acc: 0.7351
Epoch 40/150
570/570 [==============================] - 0s - loss: 0.5328 - acc: 0.7368
Epoch 41/150
570/570 [==============================] - 0s - loss: 0.5329 - acc: 0.7298
Epoch 42/150
570/570 [==============================] - 0s - loss: 0.5341 - acc: 0.7456
Epoch 43/150
570/570 [==============================] - 0s - loss: 0.5293 - acc: 0.7404
Epoch 44/150
570/570 [==============================] - 0s - loss: 0.5296 - acc: 0.7421
Epoch 45/150
570/570 [==============================] - 0s - loss: 0.5321 - acc: 0.7474
Epoch 46/150
570/570 [==============================] - 0s - loss: 0.5325 - acc: 0.7404
Epoch 47/150
570/570 [==============================] - 0s - loss: 0.5264 - acc: 0.7439
Epoch 48/150
570/570 [==============================] - 0s - loss: 0.5229 - acc: 0.7491
Epoch 49/150
570/570 [==============================] - 0s - loss: 0.5199 - acc: 0.7404
Epoch 50/150
570/570 [==============================] - 0s - loss: 0.5242 - acc: 0.7351
Epoch 51/150
570/570 [==============================] - 0s - loss: 0.5273 - acc: 0.7386
Epoch 52/150
570/570 [==============================] - 0s - loss: 0.5183 - acc: 0.7544
Epoch 53/150
570/570 [==============================] - 0s - loss: 0.5240 - acc: 0.7474
Epoch 54/150
570/570 [==============================] - 0s - loss: 0.5194 - acc: 0.7421
Epoch 55/150
570/570 [==============================] - 0s - loss: 0.5188 - acc: 0.7474
Epoch 56/150
570/570 [==============================] - 0s - loss: 0.5147 - acc: 0.7474
Epoch 57/150
570/570 [==============================] - 0s - loss: 0.5231 - acc: 0.7404
Epoch 58/150
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570/570 [==============================] - 0s - loss: 0.5304 - acc: 0.7351
Epoch 59/150
570/570 [==============================] - 0s - loss: 0.5205 - acc: 0.7386
Epoch 60/150
570/570 [==============================] - 0s - loss: 0.5208 - acc: 0.7439
Epoch 61/150
570/570 [==============================] - 0s - loss: 0.5178 - acc: 0.7211
Epoch 62/150
570/570 [==============================] - 0s - loss: 0.5191 - acc: 0.7421
Epoch 63/150
570/570 [==============================] - 0s - loss: 0.5091 - acc: 0.7491
Epoch 64/150
570/570 [==============================] - 0s - loss: 0.5177 - acc: 0.7404
Epoch 65/150
570/570 [==============================] - 0s - loss: 0.5156 - acc: 0.7316
Epoch 66/150
570/570 [==============================] - 0s - loss: 0.5121 - acc: 0.7561
Epoch 67/150
570/570 [==============================] - 0s - loss: 0.5209 - acc: 0.7351
Epoch 68/150
570/570 [==============================] - 0s - loss: 0.5170 - acc: 0.7404
Epoch 69/150
570/570 [==============================] - 0s - loss: 0.5135 - acc: 0.7456
Epoch 70/150
570/570 [==============================] - 0s - loss: 0.5133 - acc: 0.7351
Epoch 71/150
570/570 [==============================] - 0s - loss: 0.5144 - acc: 0.7474
Epoch 72/150
570/570 [==============================] - 0s - loss: 0.5139 - acc: 0.7456
Epoch 73/150
570/570 [==============================] - 0s - loss: 0.5120 - acc: 0.7596
Epoch 74/150
570/570 [==============================] - 0s - loss: 0.5175 - acc: 0.7333
Epoch 75/150
570/570 [==============================] - 0s - loss: 0.5131 - acc: 0.7561
Epoch 76/150
570/570 [==============================] - 0s - loss: 0.5113 - acc: 0.7561
Epoch 77/150
570/570 [==============================] - 0s - loss: 0.5114 - acc: 0.7491
Epoch 78/150
570/570 [==============================] - 0s - loss: 0.5088 - acc: 0.7579
Epoch 79/150
570/570 [==============================] - 0s - loss: 0.5133 - acc: 0.7439
Epoch 80/150
```

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570/570 [==============================] - 0s - loss: 0.5115 - acc: 0.7614
Epoch 81/150
570/570 [==============================] - 0s - loss: 0.5089 - acc: 0.7491
Epoch 82/150
570/570 [==============================] - 0s - loss: 0.5096 - acc: 0.7474
Epoch 83/150
570/570 [==============================] - 0s - loss: 0.5195 - acc: 0.7368
Epoch 84/150
570/570 [==============================] - 0s - loss: 0.5046 - acc: 0.7544
Epoch 85/150
570/570 [==============================] - 0s - loss: 0.5190 - acc: 0.7298
Epoch 86/150
570/570 [==============================] - 0s - loss: 0.5081 - acc: 0.7526
Epoch 87/150
570/570 [==============================] - 0s - loss: 0.5117 - acc: 0.7509
Epoch 88/150
570/570 [==============================] - 0s - loss: 0.5088 - acc: 0.7456
Epoch 89/150
570/570 [==============================] - 0s - loss: 0.5087 - acc: 0.7544
Epoch 90/150
570/570 [==============================] - 0s - loss: 0.5094 - acc: 0.7421
Epoch 91/150
570/570 [==============================] - 0s - loss: 0.5028 - acc: 0.7439
Epoch 92/150
570/570 [==============================] - 0s - loss: 0.5088 - acc: 0.7526
Epoch 93/150
570/570 [==============================] - 0s - loss: 0.5046 - acc: 0.7579
Epoch 94/150
570/570 [==============================] - 0s - loss: 0.5094 - acc: 0.7614
Epoch 95/150
570/570 [==============================] - 0s - loss: 0.5069 - acc: 0.7509
Epoch 96/150
570/570 [==============================] - 0s - loss: 0.5078 - acc: 0.7579
Epoch 97/150
570/570 [==============================] - 0s - loss: 0.5068 - acc: 0.7526
Epoch 98/150
570/570 [==============================] - 0s - loss: 0.5052 - acc: 0.7439
Epoch 99/150
570/570 [==============================] - 0s - loss: 0.5081 - acc: 0.7509
Epoch 100/150
570/570 [==============================] - 0s - loss: 0.5068 - acc: 0.7561
Epoch 101/150
570/570 [==============================] - 0s - loss: 0.5132 - acc: 0.7456
Epoch 102/150
```

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570/570 [==============================] - 0s - loss: 0.5029 - acc: 0.7509
Epoch 103/150
570/570 [==============================] - 0s - loss: 0.5084 - acc: 0.7439
Epoch 104/150
570/570 [==============================] - 0s - loss: 0.5044 - acc: 0.7439
Epoch 105/150
570/570 [==============================] - 0s - loss: 0.5072 - acc: 0.7544
Epoch 106/150
570/570 [==============================] - 0s - loss: 0.5129 - acc: 0.7368
Epoch 107/150
570/570 [==============================] - 0s - loss: 0.5033 - acc: 0.7561
Epoch 108/150
570/570 [==============================] - 0s - loss: 0.5072 - acc: 0.7456
Epoch 109/150
570/570 [==============================] - 0s - loss: 0.5018 - acc: 0.7579
Epoch 110/150
570/570 [==============================] - 0s - loss: 0.5044 - acc: 0.7509
Epoch 111/150
570/570 [==============================] - 0s - loss: 0.5039 - acc: 0.7526
Epoch 112/150
570/570 [==============================] - 0s - loss: 0.5015 - acc: 0.7561
Epoch 113/150
570/570 [==============================] - 0s - loss: 0.5038 - acc: 0.7667
Epoch 114/150
570/570 [==============================] - 0s - loss: 0.5049 - acc: 0.7614
Epoch 115/150
570/570 [==============================] - 0s - loss: 0.5185 - acc: 0.7333
Epoch 116/150
570/570 [==============================] - 0s - loss: 0.5135 - acc: 0.7526
Epoch 117/150
570/570 [==============================] - 0s - loss: 0.5030 - acc: 0.7509
Epoch 118/150
570/570 [==============================] - 0s - loss: 0.5015 - acc: 0.7561
Epoch 119/150
570/570 [==============================] - 0s - loss: 0.5050 - acc: 0.7526
Epoch 120/150
570/570 [==============================] - 0s - loss: 0.5043 - acc: 0.7596
Epoch 121/150
570/570 [==============================] - 0s - loss: 0.5015 - acc: 0.7491
Epoch 122/150
570/570 [==============================] - 0s - loss: 0.5005 - acc: 0.7579
Epoch 123/150
570/570 [==============================] - 0s - loss: 0.4999 - acc: 0.7561
Epoch 124/150
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570/570 [==============================] - 0s - loss: 0.5005 - acc: 0.7561
Epoch 125/150
570/570 [==============================] - 0s - loss: 0.4996 - acc: 0.7667
Epoch 126/150
570/570 [==============================] - 0s - loss: 0.5027 - acc: 0.7561
Epoch 127/150
570/570 [==============================] - 0s - loss: 0.5024 - acc: 0.7544
Epoch 128/150
570/570 [==============================] - 0s - loss: 0.4992 - acc: 0.7614
Epoch 129/150
570/570 [==============================] - 0s - loss: 0.5129 - acc: 0.7386
Epoch 130/150
570/570 [==============================] - 0s - loss: 0.4979 - acc: 0.7614
Epoch 131/150
570/570 [==============================] - 0s - loss: 0.5052 - acc: 0.7456
Epoch 132/150
570/570 [==============================] - 0s - loss: 0.4999 - acc: 0.7509
Epoch 133/150
570/570 [==============================] - 0s - loss: 0.5017 - acc: 0.7649
Epoch 134/150
570/570 [==============================] - 0s - loss: 0.4989 - acc: 0.7561
Epoch 135/150
570/570 [==============================] - 0s - loss: 0.4993 - acc: 0.7614
Epoch 136/150
570/570 [==============================] - 0s - loss: 0.4966 - acc: 0.7667
Epoch 137/150
570/570 [==============================] - 0s - loss: 0.4976 - acc: 0.7614
Epoch 138/150
570/570 [==============================] - 0s - loss: 0.5018 - acc: 0.7561
Epoch 139/150
570/570 [==============================] - 0s - loss: 0.5016 - acc: 0.7614
Epoch 140/150
570/570 [==============================] - 0s - loss: 0.4976 - acc: 0.7632
Epoch 141/150
570/570 [==============================] - 0s - loss: 0.5074 - acc: 0.7421
Epoch 142/150
570/570 [==============================] - 0s - loss: 0.4982 - acc: 0.7632
Epoch 143/150
570/570 [==============================] - 0s - loss: 0.4983 - acc: 0.7649
Epoch 144/150
570/570 [==============================] - 0s - loss: 0.4960 - acc: 0.7649
Epoch 145/150
570/570 [==============================] - 0s - loss: 0.5015 - acc: 0.7561
Epoch 146/150
```

```
570/570 [==============================] - 0s - loss: 0.4950 - acc: 0.7684
Epoch 147/150
570/570 [==============================] - 0s - loss: 0.4989 - acc: 0.7596
Epoch 148/150
570/570 [==============================] - 0s - loss: 0.4971 - acc: 0.7544
Epoch 149/150
570/570 [==============================] - 0s - loss: 0.4947 - acc: 0.7596
Epoch 150/150
570/570 [==============================] - 0s - loss: 0.4978 - acc: 0.7614
 32/570 [>.............................] - ETA: 0s
acc: 75.61%
```