shiny-results

September 18, 2018

In [1]:
```
# automatically show plots inside the notebook
%matplotlib inline

# reload all modules before executing code
%load_ext autoreload
%autoreload 2
```

In [2]:
```
# you will use this notebook as a basis to walk us through what you did
```

In [3]:
```
# import independent features
import pandas as pd
import numpy as np
features = pd.read_csv('../data/features.csv')
features.shape
```

Out[3]:
```
(288, 688)
```

There are 688 independent features for 288 patients. However, it is quiet possible that many of these features are redundant. Therefore, I employ exploratory data analysis namely univariate and bivariate analysis to eliminate redundant features.

In [4]:
```
# bivariate analysis
corr_matrix = features.corr().abs()
upper = corr_matrix.where(np.triu(np.ones(corr_matrix.shape), k=1).astype(np.bool))
to_drop = [column for column in upper.columns if any(upper[column] > 0.90)]
features = features.drop(features[to_drop], axis=1)
features.shape
```

Out[4]:
```
(288, 237)
```

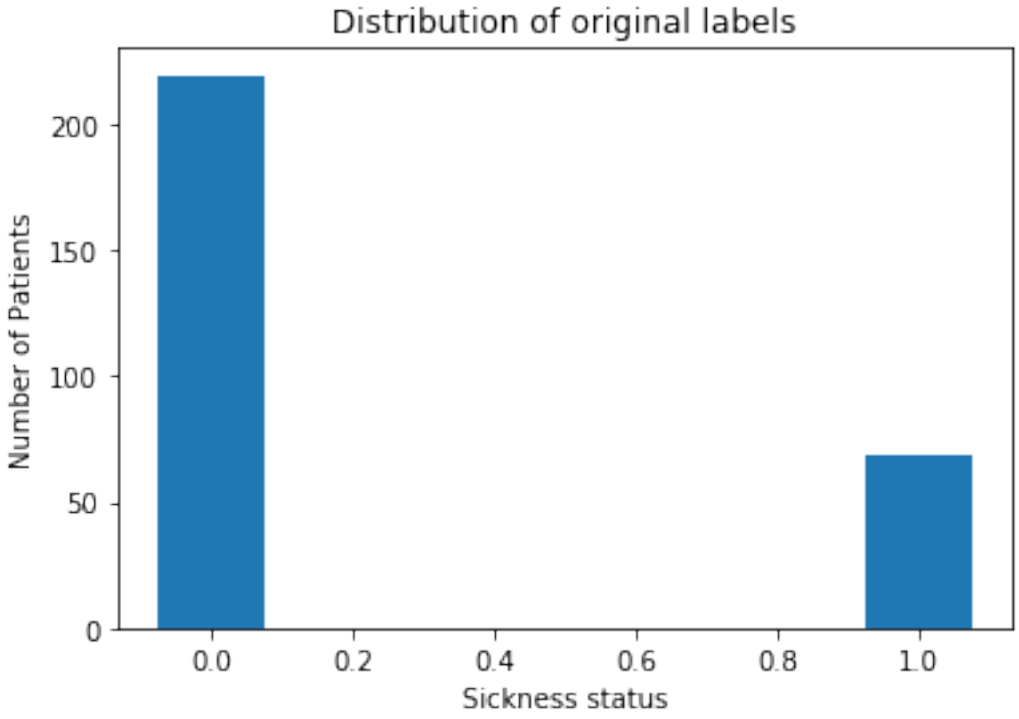
As one can see, more than half of features had a correlation of more than 90% with other features. One can adjust correlation threshold on a need basis.

In [5]:
```
# univariate analysis
X = features.iloc[:, 1:].values
from sklearn.feature_selection import VarianceThreshold
vt = VarianceThreshold(0.2)
X = vt.fit_transform(X)
X.shape
```

```
Out[5]: (288, 171)
```

With univariate analysis, I try to remove those features which have variance below 0.2 . Reason being, features with lesser variance will not be able to distinguish the data effectively.

```
In [6]: # import labels - 1-sick or 0-healthy
        from matplotlib import pyplot as plt
        labels = pd.read_csv('../data/labels.csv')
        y = labels.iloc[:, 1].values
        x_1 = [0,1]
        x_2 = [y.size - np.count_nonzero(y), np.count_nonzero(y)]
        plt.figure(1)
        plt.bar(x_1, x_2,width=0.15, align = 'center')
        plt.title('Distribution of original labels')
        plt.ylabel('Number of Patients')
        plt.xlabel('Sickness status')
        plt.show()
```



Distribution of labels is skewed towards helathy patients. Number of healthy patients is more than double the size of sick patients.

```
In [7]: # feature Scaling
        from sklearn.preprocessing import StandardScaler
        sc = StandardScaler()
        X = sc.fit_transform(X)
```

Feature scaling is an important preprocessing step since we do not wish to see one feature influencing the result more than the others. Feature scaling essentially standardizes features by removing the mean and scaling to unit variance

```
In [8]: from sklearn.decomposition import PCA
        pca = PCA(n_components = 50)
        X = pca.fit_transform(X)
        explained_variance = pca.explained_variance_ratio_
        print(sum(explained_variance))
```

```
0.9088261438680943
```

PCA is a feature extraction technique. It is a unsupervised, generates topN eigen vectors with a highest variance. I selected top 50 features that account for 90% of the variance. Instead of using 688 features with 100% variance, I rather choose small subset of features to account for lesser variance.

```
In [9]: # create ANN model
        import keras
        from keras.models import Sequential
        from keras.layers import Dense, Dropout

        classifier = Sequential()
        classifier.add(Dropout(0.3, input_shape = (50,)))
        classifier.add(Dense(21,  activation='relu', kernel_initializer = 'uniform'))
        classifier.add(Dropout(0.5))
        classifier.add(Dense(21, activation='relu', kernel_initializer='uniform'))
        classifier.add(Dropout(0.5))
        classifier.add(Dense(1, activation='sigmoid', kernel_initializer='uniform'))
```

```
Using TensorFlow backend.
```

ANN has been used for binary classification task in here. It is a sequential model with 2 hidden layers and 3 regularization layers. DropOut layer reduces overfitting in this case.

```
In [10]: # compile, fit and predict
         classifier.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
         classifier.fit(X, y, batch_size=10, epochs=500)
         y_pred = classifier.predict(X)
         y_pred = (y_pred > 0.4)
```

```
Epoch 1/500
288/288 [==============================] - 0s 1ms/step - loss: 0.6881 - acc: 0.7535
Epoch 2/500
288/288 [==============================] - 0s 139us/step - loss: 0.6721 - acc: 0.7604
Epoch 3/500
288/288 [==============================] - 0s 139us/step - loss: 0.6446 - acc: 0.7604
```

```
Epoch 4/500
288/288 [==============================] - 0s 159us/step - loss: 0.5722 - acc: 0.7604
Epoch 5/500
288/288 [==============================] - 0s 163us/step - loss: 0.5086 - acc: 0.7604
Epoch 6/500
288/288 [==============================] - 0s 156us/step - loss: 0.4986 - acc: 0.7604
Epoch 7/500
288/288 [==============================] - 0s 142us/step - loss: 0.4745 - acc: 0.7604
Epoch 8/500
288/288 [==============================] - 0s 152us/step - loss: 0.4677 - acc: 0.7604
Epoch 9/500
288/288 [==============================] - 0s 145us/step - loss: 0.4932 - acc: 0.7604
Epoch 10/500
288/288 [==============================] - 0s 149us/step - loss: 0.4518 - acc: 0.7604
Epoch 11/500
288/288 [==============================] - 0s 149us/step - loss: 0.4549 - acc: 0.7604
Epoch 12/500
288/288 [==============================] - 0s 142us/step - loss: 0.4548 - acc: 0.7708
Epoch 13/500
288/288 [==============================] - 0s 152us/step - loss: 0.4443 - acc: 0.7708
Epoch 14/500
288/288 [==============================] - 0s 156us/step - loss: 0.4275 - acc: 0.7708
Epoch 15/500
288/288 [==============================] - 0s 138us/step - loss: 0.4309 - acc: 0.7951
Epoch 16/500
288/288 [==============================] - 0s 163us/step - loss: 0.4270 - acc: 0.7986
Epoch 17/500
288/288 [==============================] - 0s 156us/step - loss: 0.3951 - acc: 0.8021
Epoch 18/500
288/288 [==============================] - 0s 152us/step - loss: 0.4404 - acc: 0.7986
Epoch 19/500
288/288 [==============================] - 0s 149us/step - loss: 0.3974 - acc: 0.7986
Epoch 20/500
288/288 [==============================] - 0s 152us/step - loss: 0.4044 - acc: 0.8125
Epoch 21/500
288/288 [==============================] - 0s 149us/step - loss: 0.4039 - acc: 0.7986
Epoch 22/500
288/288 [==============================] - 0s 152us/step - loss: 0.3810 - acc: 0.7951
Epoch 23/500
288/288 [==============================] - 0s 149us/step - loss: 0.3638 - acc: 0.8229
Epoch 24/500
288/288 [==============================] - 0s 156us/step - loss: 0.4165 - acc: 0.7847
Epoch 25/500
288/288 [==============================] - 0s 142us/step - loss: 0.3868 - acc: 0.7882
Epoch 26/500
288/288 [==============================] - 0s 149us/step - loss: 0.3733 - acc: 0.8333
Epoch 27/500
288/288 [==============================] - 0s 135us/step - loss: 0.3652 - acc: 0.8299
```

```
Epoch 28/500
288/288 [==============================] - 0s 194us/step - loss: 0.4008 - acc: 0.8160
Epoch 29/500
288/288 [==============================] - 0s 149us/step - loss: 0.3388 - acc: 0.8507
Epoch 30/500
288/288 [==============================] - 0s 152us/step - loss: 0.3717 - acc: 0.8333
Epoch 31/500
288/288 [==============================] - 0s 156us/step - loss: 0.3838 - acc: 0.8056
Epoch 32/500
288/288 [==============================] - 0s 132us/step - loss: 0.3812 - acc: 0.8160
Epoch 33/500
288/288 [==============================] - 0s 156us/step - loss: 0.3600 - acc: 0.8368
Epoch 34/500
288/288 [==============================] - 0s 166us/step - loss: 0.3583 - acc: 0.8299
Epoch 35/500
288/288 [==============================] - 0s 125us/step - loss: 0.3687 - acc: 0.8229
Epoch 36/500
288/288 [==============================] - 0s 152us/step - loss: 0.4210 - acc: 0.8264
Epoch 37/500
288/288 [==============================] - 0s 163us/step - loss: 0.3617 - acc: 0.8715
Epoch 38/500
288/288 [==============================] - 0s 149us/step - loss: 0.4060 - acc: 0.8125
Epoch 39/500
288/288 [==============================] - 0s 145us/step - loss: 0.4032 - acc: 0.8403
Epoch 40/500
288/288 [==============================] - 0s 149us/step - loss: 0.3850 - acc: 0.8403
Epoch 41/500
288/288 [==============================] - 0s 142us/step - loss: 0.3719 - acc: 0.8229
Epoch 42/500
288/288 [==============================] - 0s 166us/step - loss: 0.3611 - acc: 0.8472
Epoch 43/500
288/288 [==============================] - 0s 156us/step - loss: 0.3769 - acc: 0.8125
Epoch 44/500
288/288 [==============================] - 0s 145us/step - loss: 0.3840 - acc: 0.8056
Epoch 45/500
288/288 [==============================] - 0s 163us/step - loss: 0.3359 - acc: 0.8681
Epoch 46/500
288/288 [==============================] - 0s 139us/step - loss: 0.3402 - acc: 0.8576
Epoch 47/500
288/288 [==============================] - 0s 132us/step - loss: 0.4196 - acc: 0.8090
Epoch 48/500
288/288 [==============================] - 0s 145us/step - loss: 0.3469 - acc: 0.8333
Epoch 49/500
288/288 [==============================] - 0s 135us/step - loss: 0.3684 - acc: 0.8646
Epoch 50/500
288/288 [==============================] - 0s 166us/step - loss: 0.3598 - acc: 0.8472
Epoch 51/500
288/288 [==============================] - 0s 135us/step - loss: 0.3623 - acc: 0.8368
```

```
Epoch 52/500
288/288 [==============================] - 0s 152us/step - loss: 0.3585 - acc: 0.8681
Epoch 53/500
288/288 [==============================] - 0s 184us/step - loss: 0.3601 - acc: 0.8611
Epoch 54/500
288/288 [==============================] - 0s 156us/step - loss: 0.3961 - acc: 0.8368
Epoch 55/500
288/288 [==============================] - 0s 121us/step - loss: 0.3499 - acc: 0.8194
Epoch 56/500
288/288 [==============================] - 0s 132us/step - loss: 0.3590 - acc: 0.8437
Epoch 57/500
288/288 [==============================] - 0s 132us/step - loss: 0.3510 - acc: 0.8437
Epoch 58/500
288/288 [==============================] - 0s 118us/step - loss: 0.3543 - acc: 0.8681
Epoch 59/500
288/288 [==============================] - 0s 121us/step - loss: 0.3683 - acc: 0.8125
Epoch 60/500
288/288 [==============================] - 0s 132us/step - loss: 0.3655 - acc: 0.8542
Epoch 61/500
288/288 [==============================] - 0s 125us/step - loss: 0.3180 - acc: 0.8472
Epoch 62/500
288/288 [==============================] - 0s 121us/step - loss: 0.3561 - acc: 0.8472
Epoch 63/500
288/288 [==============================] - 0s 125us/step - loss: 0.3672 - acc: 0.8437
Epoch 64/500
288/288 [==============================] - 0s 132us/step - loss: 0.3335 - acc: 0.8368
Epoch 65/500
288/288 [==============================] - 0s 128us/step - loss: 0.3151 - acc: 0.8750
Epoch 66/500
288/288 [==============================] - 0s 121us/step - loss: 0.3476 - acc: 0.8889
Epoch 67/500
288/288 [==============================] - 0s 125us/step - loss: 0.3178 - acc: 0.8750
Epoch 68/500
288/288 [==============================] - 0s 125us/step - loss: 0.3567 - acc: 0.8681
Epoch 69/500
288/288 [==============================] - 0s 128us/step - loss: 0.3167 - acc: 0.8785
Epoch 70/500
288/288 [==============================] - 0s 121us/step - loss: 0.3385 - acc: 0.8542
Epoch 71/500
288/288 [==============================] - 0s 128us/step - loss: 0.2908 - acc: 0.8958
Epoch 72/500
288/288 [==============================] - 0s 118us/step - loss: 0.3408 - acc: 0.8368
Epoch 73/500
288/288 [==============================] - 0s 128us/step - loss: 0.3222 - acc: 0.8646
Epoch 74/500
288/288 [==============================] - 0s 125us/step - loss: 0.3755 - acc: 0.8542
Epoch 75/500
288/288 [==============================] - 0s 132us/step - loss: 0.3514 - acc: 0.8681
```

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Epoch 76/500
288/288 [==============================] - 0s 125us/step - loss: 0.3756 - acc: 0.8368
Epoch 77/500
288/288 [==============================] - 0s 125us/step - loss: 0.3485 - acc: 0.8750
Epoch 78/500
288/288 [==============================] - 0s 135us/step - loss: 0.3433 - acc: 0.8437
Epoch 79/500
288/288 [==============================] - 0s 114us/step - loss: 0.3188 - acc: 0.8507
Epoch 80/500
288/288 [==============================] - 0s 135us/step - loss: 0.3624 - acc: 0.8681
Epoch 81/500
288/288 [==============================] - 0s 125us/step - loss: 0.3182 - acc: 0.8681
Epoch 82/500
288/288 [==============================] - 0s 125us/step - loss: 0.3163 - acc: 0.8576
Epoch 83/500
288/288 [==============================] - 0s 132us/step - loss: 0.3480 - acc: 0.8507
Epoch 84/500
288/288 [==============================] - 0s 121us/step - loss: 0.4131 - acc: 0.8299
Epoch 85/500
288/288 [==============================] - 0s 132us/step - loss: 0.3653 - acc: 0.8542
Epoch 86/500
288/288 [==============================] - 0s 118us/step - loss: 0.3634 - acc: 0.8646
Epoch 87/500
288/288 [==============================] - 0s 128us/step - loss: 0.3684 - acc: 0.8681
Epoch 88/500
288/288 [==============================] - 0s 128us/step - loss: 0.3093 - acc: 0.8576
Epoch 89/500
288/288 [==============================] - 0s 125us/step - loss: 0.3677 - acc: 0.8472
Epoch 90/500
288/288 [==============================] - 0s 128us/step - loss: 0.3921 - acc: 0.8437
Epoch 91/500
288/288 [==============================] - 0s 118us/step - loss: 0.3490 - acc: 0.8750
Epoch 92/500
288/288 [==============================] - 0s 128us/step - loss: 0.3238 - acc: 0.8646
Epoch 93/500
288/288 [==============================] - 0s 132us/step - loss: 0.3214 - acc: 0.8542
Epoch 94/500
288/288 [==============================] - 0s 128us/step - loss: 0.4035 - acc: 0.8264
Epoch 95/500
288/288 [==============================] - 0s 118us/step - loss: 0.3722 - acc: 0.8576
Epoch 96/500
288/288 [==============================] - 0s 145us/step - loss: 0.3108 - acc: 0.8681
Epoch 97/500
288/288 [==============================] - 0s 118us/step - loss: 0.3252 - acc: 0.8646
Epoch 98/500
288/288 [==============================] - 0s 121us/step - loss: 0.3514 - acc: 0.8646
Epoch 99/500
288/288 [==============================] - 0s 132us/step - loss: 0.3322 - acc: 0.8750
```

```
Epoch 100/500
288/288 [==============================] - 0s 132us/step - loss: 0.3185 - acc: 0.8611
Epoch 101/500
288/288 [==============================] - 0s 128us/step - loss: 0.3632 - acc: 0.8542
Epoch 102/500
288/288 [==============================] - 0s 132us/step - loss: 0.3378 - acc: 0.8715
Epoch 103/500
288/288 [==============================] - 0s 132us/step - loss: 0.3284 - acc: 0.8611
Epoch 104/500
288/288 [==============================] - 0s 135us/step - loss: 0.3110 - acc: 0.8819
Epoch 105/500
288/288 [==============================] - 0s 159us/step - loss: 0.3447 - acc: 0.8785
Epoch 106/500
288/288 [==============================] - 0s 291us/step - loss: 0.3373 - acc: 0.8750
Epoch 107/500
288/288 [==============================] - 0s 336us/step - loss: 0.3276 - acc: 0.8750
Epoch 108/500
288/288 [==============================] - 0s 370us/step - loss: 0.3604 - acc: 0.8437
Epoch 109/500
288/288 [==============================] - 0s 253us/step - loss: 0.3202 - acc: 0.8611
Epoch 110/500
288/288 [==============================] - 0s 377us/step - loss: 0.3261 - acc: 0.8611 0s - loss
Epoch 111/500
288/288 [==============================] - 0s 287us/step - loss: 0.2764 - acc: 0.9167
Epoch 112/500
288/288 [==============================] - 0s 232us/step - loss: 0.3066 - acc: 0.8750
Epoch 113/500
288/288 [==============================] - 0s 263us/step - loss: 0.3153 - acc: 0.8715
Epoch 114/500
288/288 [==============================] - 0s 284us/step - loss: 0.2912 - acc: 0.8924
Epoch 115/500
288/288 [==============================] - 0s 332us/step - loss: 0.3441 - acc: 0.8368
Epoch 116/500
288/288 [==============================] - 0s 308us/step - loss: 0.3105 - acc: 0.8611
Epoch 117/500
288/288 [==============================] - 0s 294us/step - loss: 0.3348 - acc: 0.8646
Epoch 118/500
288/288 [==============================] - 0s 183us/step - loss: 0.3469 - acc: 0.8507
Epoch 119/500
288/288 [==============================] - 0s 190us/step - loss: 0.3838 - acc: 0.8611
Epoch 120/500
288/288 [==============================] - 0s 132us/step - loss: 0.3858 - acc: 0.8576
Epoch 121/500
288/288 [==============================] - 0s 135us/step - loss: 0.3427 - acc: 0.8611
Epoch 122/500
288/288 [==============================] - 0s 125us/step - loss: 0.2751 - acc: 0.8819
Epoch 123/500
288/288 [==============================] - 0s 128us/step - loss: 0.3130 - acc: 0.8576
```

```
Epoch 124/500
288/288 [==============================] - 0s 139us/step - loss: 0.3820 - acc: 0.8715
Epoch 125/500
288/288 [==============================] - 0s 128us/step - loss: 0.3370 - acc: 0.8681
Epoch 126/500
288/288 [==============================] - 0s 142us/step - loss: 0.3423 - acc: 0.8611
Epoch 127/500
288/288 [==============================] - 0s 128us/step - loss: 0.3448 - acc: 0.8785
Epoch 128/500
288/288 [==============================] - 0s 132us/step - loss: 0.3107 - acc: 0.8715
Epoch 129/500
288/288 [==============================] - 0s 142us/step - loss: 0.2927 - acc: 0.8785
Epoch 130/500
288/288 [==============================] - 0s 121us/step - loss: 0.3361 - acc: 0.8819
Epoch 131/500
288/288 [==============================] - 0s 125us/step - loss: 0.3629 - acc: 0.8507
Epoch 132/500
288/288 [==============================] - 0s 139us/step - loss: 0.2958 - acc: 0.8715
Epoch 133/500
288/288 [==============================] - 0s 142us/step - loss: 0.3076 - acc: 0.8646
Epoch 134/500
288/288 [==============================] - 0s 132us/step - loss: 0.3059 - acc: 0.8785
Epoch 135/500
288/288 [==============================] - 0s 145us/step - loss: 0.2976 - acc: 0.8854
Epoch 136/500
288/288 [==============================] - 0s 170us/step - loss: 0.3360 - acc: 0.8785
Epoch 137/500
288/288 [==============================] - 0s 291us/step - loss: 0.3210 - acc: 0.8611
Epoch 138/500
288/288 [==============================] - 0s 222us/step - loss: 0.3322 - acc: 0.8958
Epoch 139/500
288/288 [==============================] - 0s 197us/step - loss: 0.3271 - acc: 0.8542
Epoch 140/500
288/288 [==============================] - ETA: 0s - loss: 0.6355 - acc: 0.700 - 0s 166us/step
Epoch 141/500
288/288 [==============================] - 0s 253us/step - loss: 0.3441 - acc: 0.8750
Epoch 142/500
288/288 [==============================] - 0s 194us/step - loss: 0.3086 - acc: 0.8924
Epoch 143/500
288/288 [==============================] - 0s 156us/step - loss: 0.3094 - acc: 0.8785
Epoch 144/500
288/288 [==============================] - 0s 235us/step - loss: 0.3289 - acc: 0.8715
Epoch 145/500
288/288 [==============================] - 0s 291us/step - loss: 0.3356 - acc: 0.8403
Epoch 146/500
288/288 [==============================] - 0s 149us/step - loss: 0.2846 - acc: 0.9132
Epoch 147/500
288/288 [==============================] - 0s 211us/step - loss: 0.3407 - acc: 0.8715
```

```
Epoch 148/500
288/288 [==============================] - 0s 190us/step - loss: 0.3117 - acc: 0.8576
Epoch 149/500
288/288 [==============================] - 0s 149us/step - loss: 0.2730 - acc: 0.9028
Epoch 150/500
288/288 [==============================] - 0s 156us/step - loss: 0.3278 - acc: 0.8507
Epoch 151/500
288/288 [==============================] - 0s 152us/step - loss: 0.2675 - acc: 0.8993
Epoch 152/500
288/288 [==============================] - 0s 180us/step - loss: 0.3286 - acc: 0.8715
Epoch 153/500
288/288 [==============================] - 0s 180us/step - loss: 0.3166 - acc: 0.8889
Epoch 154/500
288/288 [==============================] - 0s 270us/step - loss: 0.2863 - acc: 0.8889
Epoch 155/500
288/288 [==============================] - 0s 166us/step - loss: 0.3288 - acc: 0.8750
Epoch 156/500
288/288 [==============================] - 0s 180us/step - loss: 0.3131 - acc: 0.8507
Epoch 157/500
288/288 [==============================] - 0s 180us/step - loss: 0.2794 - acc: 0.9167
Epoch 158/500
288/288 [==============================] - 0s 152us/step - loss: 0.3296 - acc: 0.8785
Epoch 159/500
288/288 [==============================] - 0s 132us/step - loss: 0.3051 - acc: 0.8646
Epoch 160/500
288/288 [==============================] - 0s 132us/step - loss: 0.2606 - acc: 0.8958
Epoch 161/500
288/288 [==============================] - 0s 132us/step - loss: 0.2938 - acc: 0.8750
Epoch 162/500
288/288 [==============================] - 0s 128us/step - loss: 0.3391 - acc: 0.8646
Epoch 163/500
288/288 [==============================] - 0s 149us/step - loss: 0.3371 - acc: 0.8646
Epoch 164/500
288/288 [==============================] - 0s 128us/step - loss: 0.2994 - acc: 0.8889
Epoch 165/500
288/288 [==============================] - 0s 132us/step - loss: 0.2863 - acc: 0.8889
Epoch 166/500
288/288 [==============================] - 0s 139us/step - loss: 0.2694 - acc: 0.8924
Epoch 167/500
288/288 [==============================] - 0s 135us/step - loss: 0.3614 - acc: 0.8403
Epoch 168/500
288/288 [==============================] - 0s 132us/step - loss: 0.2961 - acc: 0.8750
Epoch 169/500
288/288 [==============================] - 0s 132us/step - loss: 0.3716 - acc: 0.8299
Epoch 170/500
288/288 [==============================] - 0s 132us/step - loss: 0.3449 - acc: 0.8785
Epoch 171/500
288/288 [==============================] - 0s 132us/step - loss: 0.2754 - acc: 0.8715
```

```
Epoch 172/500
288/288 [==============================] - 0s 132us/step - loss: 0.3035 - acc: 0.8646
Epoch 173/500
288/288 [==============================] - 0s 132us/step - loss: 0.3233 - acc: 0.8750
Epoch 174/500
288/288 [==============================] - 0s 128us/step - loss: 0.2750 - acc: 0.8750
Epoch 175/500
288/288 [==============================] - 0s 139us/step - loss: 0.3113 - acc: 0.8611
Epoch 176/500
288/288 [==============================] - 0s 132us/step - loss: 0.2454 - acc: 0.9062
Epoch 177/500
288/288 [==============================] - 0s 132us/step - loss: 0.3406 - acc: 0.8576
Epoch 178/500
288/288 [==============================] - 0s 128us/step - loss: 0.3024 - acc: 0.8819
Epoch 179/500
288/288 [==============================] - 0s 132us/step - loss: 0.2629 - acc: 0.9132
Epoch 180/500
288/288 [==============================] - 0s 135us/step - loss: 0.2926 - acc: 0.8819
Epoch 181/500
288/288 [==============================] - 0s 132us/step - loss: 0.2446 - acc: 0.9028
Epoch 182/500
288/288 [==============================] - 0s 132us/step - loss: 0.2953 - acc: 0.8854
Epoch 183/500
288/288 [==============================] - 0s 132us/step - loss: 0.3208 - acc: 0.8437
Epoch 184/500
288/288 [==============================] - 0s 132us/step - loss: 0.2795 - acc: 0.8750
Epoch 185/500
288/288 [==============================] - 0s 128us/step - loss: 0.3058 - acc: 0.8750
Epoch 186/500
288/288 [==============================] - 0s 128us/step - loss: 0.2401 - acc: 0.8819
Epoch 187/500
288/288 [==============================] - 0s 135us/step - loss: 0.3316 - acc: 0.8611
Epoch 188/500
288/288 [==============================] - 0s 121us/step - loss: 0.2955 - acc: 0.8750
Epoch 189/500
288/288 [==============================] - 0s 132us/step - loss: 0.3671 - acc: 0.8403
Epoch 190/500
288/288 [==============================] - 0s 135us/step - loss: 0.3521 - acc: 0.8472
Epoch 191/500
288/288 [==============================] - 0s 135us/step - loss: 0.3586 - acc: 0.8542
Epoch 192/500
288/288 [==============================] - 0s 149us/step - loss: 0.3147 - acc: 0.8681
Epoch 193/500
288/288 [==============================] - 0s 170us/step - loss: 0.3281 - acc: 0.8646
Epoch 194/500
288/288 [==============================] - 0s 152us/step - loss: 0.3739 - acc: 0.8576
Epoch 195/500
288/288 [==============================] - 0s 152us/step - loss: 0.2812 - acc: 0.8819
```

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Epoch 196/500
288/288 [==============================] - 0s 145us/step - loss: 0.3007 - acc: 0.8750
Epoch 197/500
288/288 [==============================] - 0s 139us/step - loss: 0.3048 - acc: 0.8646
Epoch 198/500
288/288 [==============================] - 0s 145us/step - loss: 0.3354 - acc: 0.8542
Epoch 199/500
288/288 [==============================] - 0s 201us/step - loss: 0.3267 - acc: 0.8611
Epoch 200/500
288/288 [==============================] - 0s 232us/step - loss: 0.3383 - acc: 0.8646
Epoch 201/500
288/288 [==============================] - 0s 274us/step - loss: 0.3158 - acc: 0.8715
Epoch 202/500
288/288 [==============================] - 0s 222us/step - loss: 0.3341 - acc: 0.8715
Epoch 203/500
288/288 [==============================] - 0s 242us/step - loss: 0.3450 - acc: 0.8542
Epoch 204/500
288/288 [==============================] - 0s 201us/step - loss: 0.3429 - acc: 0.8785
Epoch 205/500
288/288 [==============================] - 0s 253us/step - loss: 0.3058 - acc: 0.8715
Epoch 206/500
288/288 [==============================] - 0s 187us/step - loss: 0.2903 - acc: 0.8924
Epoch 207/500
288/288 [==============================] - 0s 142us/step - loss: 0.2608 - acc: 0.8958
Epoch 208/500
288/288 [==============================] - 0s 184us/step - loss: 0.2693 - acc: 0.8819
Epoch 209/500
288/288 [==============================] - 0s 149us/step - loss: 0.2583 - acc: 0.8889
Epoch 210/500
288/288 [==============================] - 0s 208us/step - loss: 0.3248 - acc: 0.8750
Epoch 211/500
288/288 [==============================] - 0s 336us/step - loss: 0.3470 - acc: 0.8472
Epoch 212/500
288/288 [==============================] - 0s 315us/step - loss: 0.2852 - acc: 0.8889
Epoch 213/500
288/288 [==============================] - 0s 208us/step - loss: 0.3890 - acc: 0.8611
Epoch 214/500
288/288 [==============================] - 0s 177us/step - loss: 0.2961 - acc: 0.8854
Epoch 215/500
288/288 [==============================] - 0s 232us/step - loss: 0.2982 - acc: 0.8785
Epoch 216/500
288/288 [==============================] - 0s 173us/step - loss: 0.3911 - acc: 0.8333
Epoch 217/500
288/288 [==============================] - 0s 145us/step - loss: 0.3554 - acc: 0.8854
Epoch 218/500
288/288 [==============================] - 0s 173us/step - loss: 0.3180 - acc: 0.8715
Epoch 219/500
288/288 [==============================] - 0s 149us/step - loss: 0.3333 - acc: 0.8924
```

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Epoch 220/500
288/288 [==============================] - 0s 173us/step - loss: 0.3103 - acc: 0.8715
Epoch 221/500
288/288 [==============================] - 0s 197us/step - loss: 0.3312 - acc: 0.8681
Epoch 222/500
288/288 [==============================] - 0s 156us/step - loss: 0.2826 - acc: 0.8819
Epoch 223/500
288/288 [==============================] - 0s 132us/step - loss: 0.3097 - acc: 0.8785
Epoch 224/500
288/288 [==============================] - 0s 163us/step - loss: 0.3514 - acc: 0.8472
Epoch 225/500
288/288 [==============================] - 0s 156us/step - loss: 0.2929 - acc: 0.8854
Epoch 226/500
288/288 [==============================] - 0s 145us/step - loss: 0.3095 - acc: 0.8889
Epoch 227/500
288/288 [==============================] - 0s 145us/step - loss: 0.2909 - acc: 0.8958
Epoch 228/500
288/288 [==============================] - 0s 139us/step - loss: 0.3183 - acc: 0.8681
Epoch 229/500
288/288 [==============================] - 0s 139us/step - loss: 0.3458 - acc: 0.8993
Epoch 230/500
288/288 [==============================] - 0s 145us/step - loss: 0.3059 - acc: 0.8993
Epoch 231/500
288/288 [==============================] - 0s 135us/step - loss: 0.3069 - acc: 0.8681
Epoch 232/500
288/288 [==============================] - 0s 159us/step - loss: 0.2914 - acc: 0.8924
Epoch 233/500
288/288 [==============================] - 0s 145us/step - loss: 0.3028 - acc: 0.8715
Epoch 234/500
288/288 [==============================] - 0s 135us/step - loss: 0.2750 - acc: 0.8889
Epoch 235/500
288/288 [==============================] - 0s 139us/step - loss: 0.3233 - acc: 0.8681
Epoch 236/500
288/288 [==============================] - 0s 128us/step - loss: 0.2866 - acc: 0.8819
Epoch 237/500
288/288 [==============================] - 0s 142us/step - loss: 0.2905 - acc: 0.8576
Epoch 238/500
288/288 [==============================] - 0s 132us/step - loss: 0.3014 - acc: 0.8646
Epoch 239/500
288/288 [==============================] - 0s 156us/step - loss: 0.2648 - acc: 0.9028
Epoch 240/500
288/288 [==============================] - 0s 139us/step - loss: 0.3235 - acc: 0.8715
Epoch 241/500
288/288 [==============================] - 0s 149us/step - loss: 0.3089 - acc: 0.8819
Epoch 242/500
288/288 [==============================] - 0s 139us/step - loss: 0.3425 - acc: 0.8785
Epoch 243/500
288/288 [==============================] - 0s 139us/step - loss: 0.3163 - acc: 0.8681
```

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Epoch 244/500
288/288 [==============================] - 0s 135us/step - loss: 0.3281 - acc: 0.8715
Epoch 245/500
288/288 [==============================] - 0s 145us/step - loss: 0.2473 - acc: 0.8889
Epoch 246/500
288/288 [==============================] - 0s 139us/step - loss: 0.3169 - acc: 0.8646
Epoch 247/500
288/288 [==============================] - 0s 156us/step - loss: 0.2763 - acc: 0.8854
Epoch 248/500
288/288 [==============================] - 0s 149us/step - loss: 0.2584 - acc: 0.9028
Epoch 249/500
288/288 [==============================] - 0s 142us/step - loss: 0.2790 - acc: 0.8993
Epoch 250/500
288/288 [==============================] - 0s 145us/step - loss: 0.3191 - acc: 0.8472
Epoch 251/500
288/288 [==============================] - 0s 145us/step - loss: 0.3191 - acc: 0.8854
Epoch 252/500
288/288 [==============================] - 0s 159us/step - loss: 0.2970 - acc: 0.8750
Epoch 253/500
288/288 [==============================] - 0s 156us/step - loss: 0.2364 - acc: 0.9167
Epoch 254/500
288/288 [==============================] - 0s 145us/step - loss: 0.2854 - acc: 0.8889
Epoch 255/500
288/288 [==============================] - 0s 149us/step - loss: 0.3453 - acc: 0.8715
Epoch 256/500
288/288 [==============================] - 0s 128us/step - loss: 0.2500 - acc: 0.9167
Epoch 257/500
288/288 [==============================] - 0s 118us/step - loss: 0.2649 - acc: 0.8993
Epoch 258/500
288/288 [==============================] - 0s 128us/step - loss: 0.2523 - acc: 0.8750
Epoch 259/500
288/288 [==============================] - 0s 128us/step - loss: 0.2655 - acc: 0.8993
Epoch 260/500
288/288 [==============================] - 0s 152us/step - loss: 0.2759 - acc: 0.8993
Epoch 261/500
288/288 [==============================] - 0s 142us/step - loss: 0.2869 - acc: 0.9062
Epoch 262/500
288/288 [==============================] - 0s 135us/step - loss: 0.3034 - acc: 0.8854
Epoch 263/500
288/288 [==============================] - 0s 145us/step - loss: 0.3391 - acc: 0.8646
Epoch 264/500
288/288 [==============================] - 0s 132us/step - loss: 0.3533 - acc: 0.8785
Epoch 265/500
288/288 [==============================] - 0s 142us/step - loss: 0.2738 - acc: 0.9028
Epoch 266/500
288/288 [==============================] - 0s 128us/step - loss: 0.3259 - acc: 0.8611
Epoch 267/500
288/288 [==============================] - 0s 118us/step - loss: 0.3084 - acc: 0.8611
```

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Epoch 268/500
288/288 [==============================] - 0s 132us/step - loss: 0.2901 - acc: 0.8750
Epoch 269/500
288/288 [==============================] - 0s 132us/step - loss: 0.2703 - acc: 0.9028
Epoch 270/500
288/288 [==============================] - 0s 118us/step - loss: 0.2803 - acc: 0.8819
Epoch 271/500
288/288 [==============================] - 0s 128us/step - loss: 0.3205 - acc: 0.8715
Epoch 272/500
288/288 [==============================] - 0s 121us/step - loss: 0.3105 - acc: 0.8681
Epoch 273/500
288/288 [==============================] - 0s 139us/step - loss: 0.2556 - acc: 0.9097
Epoch 274/500
288/288 [==============================] - 0s 128us/step - loss: 0.2829 - acc: 0.8889
Epoch 275/500
288/288 [==============================] - 0s 121us/step - loss: 0.3233 - acc: 0.8785
Epoch 276/500
288/288 [==============================] - 0s 128us/step - loss: 0.3129 - acc: 0.8785
Epoch 277/500
288/288 [==============================] - 0s 121us/step - loss: 0.3117 - acc: 0.8785
Epoch 278/500
288/288 [==============================] - 0s 128us/step - loss: 0.3080 - acc: 0.8681
Epoch 279/500
288/288 [==============================] - 0s 125us/step - loss: 0.2492 - acc: 0.9132
Epoch 280/500
288/288 [==============================] - 0s 128us/step - loss: 0.3302 - acc: 0.8750
Epoch 281/500
288/288 [==============================] - 0s 135us/step - loss: 0.3125 - acc: 0.8681
Epoch 282/500
288/288 [==============================] - 0s 121us/step - loss: 0.2938 - acc: 0.8785
Epoch 283/500
288/288 [==============================] - 0s 132us/step - loss: 0.3030 - acc: 0.8785
Epoch 284/500
288/288 [==============================] - 0s 114us/step - loss: 0.2707 - acc: 0.8993
Epoch 285/500
288/288 [==============================] - 0s 135us/step - loss: 0.3501 - acc: 0.8542
Epoch 286/500
288/288 [==============================] - 0s 139us/step - loss: 0.3506 - acc: 0.8576
Epoch 287/500
288/288 [==============================] - 0s 121us/step - loss: 0.2517 - acc: 0.9097
Epoch 288/500
288/288 [==============================] - 0s 125us/step - loss: 0.2579 - acc: 0.9132
Epoch 289/500
288/288 [==============================] - 0s 135us/step - loss: 0.2937 - acc: 0.8681
Epoch 290/500
288/288 [==============================] - 0s 138us/step - loss: 0.3613 - acc: 0.8437
Epoch 291/500
288/288 [==============================] - 0s 135us/step - loss: 0.3433 - acc: 0.8819
```

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Epoch 292/500
288/288 [==============================] - 0s 125us/step - loss: 0.2615 - acc: 0.9167
Epoch 293/500
288/288 [==============================] - 0s 128us/step - loss: 0.3362 - acc: 0.8646
Epoch 294/500
288/288 [==============================] - 0s 125us/step - loss: 0.2590 - acc: 0.8889
Epoch 295/500
288/288 [==============================] - 0s 135us/step - loss: 0.3013 - acc: 0.8750
Epoch 296/500
288/288 [==============================] - 0s 125us/step - loss: 0.3499 - acc: 0.8750
Epoch 297/500
288/288 [==============================] - 0s 118us/step - loss: 0.2646 - acc: 0.8819
Epoch 298/500
288/288 [==============================] - 0s 125us/step - loss: 0.3251 - acc: 0.8785
Epoch 299/500
288/288 [==============================] - 0s 121us/step - loss: 0.4004 - acc: 0.8542
Epoch 300/500
288/288 [==============================] - 0s 139us/step - loss: 0.2814 - acc: 0.9028
Epoch 301/500
288/288 [==============================] - 0s 121us/step - loss: 0.3375 - acc: 0.8576
Epoch 302/500
288/288 [==============================] - 0s 128us/step - loss: 0.2928 - acc: 0.8958
Epoch 303/500
288/288 [==============================] - 0s 121us/step - loss: 0.3030 - acc: 0.8681
Epoch 304/500
288/288 [==============================] - 0s 132us/step - loss: 0.2850 - acc: 0.8924
Epoch 305/500
288/288 [==============================] - 0s 125us/step - loss: 0.2783 - acc: 0.8785
Epoch 306/500
288/288 [==============================] - 0s 118us/step - loss: 0.3276 - acc: 0.8437
Epoch 307/500
288/288 [==============================] - 0s 128us/step - loss: 0.3348 - acc: 0.8681
Epoch 308/500
288/288 [==============================] - 0s 132us/step - loss: 0.3121 - acc: 0.8542
Epoch 309/500
288/288 [==============================] - 0s 125us/step - loss: 0.3060 - acc: 0.9062
Epoch 310/500
288/288 [==============================] - 0s 128us/step - loss: 0.2954 - acc: 0.8611
Epoch 311/500
288/288 [==============================] - 0s 125us/step - loss: 0.2885 - acc: 0.8819
Epoch 312/500
288/288 [==============================] - 0s 118us/step - loss: 0.3054 - acc: 0.8889
Epoch 313/500
288/288 [==============================] - 0s 125us/step - loss: 0.3107 - acc: 0.8889
Epoch 314/500
288/288 [==============================] - 0s 121us/step - loss: 0.3298 - acc: 0.8819
Epoch 315/500
288/288 [==============================] - 0s 125us/step - loss: 0.3788 - acc: 0.8507
```

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Epoch 316/500
288/288 [==============================] - 0s 125us/step - loss: 0.2609 - acc: 0.9028
Epoch 317/500
288/288 [==============================] - 0s 121us/step - loss: 0.3394 - acc: 0.8681
Epoch 318/500
288/288 [==============================] - 0s 139us/step - loss: 0.3179 - acc: 0.8785
Epoch 319/500
288/288 [==============================] - 0s 111us/step - loss: 0.3213 - acc: 0.8785
Epoch 320/500
288/288 [==============================] - 0s 135us/step - loss: 0.2632 - acc: 0.8889
Epoch 321/500
288/288 [==============================] - 0s 128us/step - loss: 0.2739 - acc: 0.8924
Epoch 322/500
288/288 [==============================] - 0s 128us/step - loss: 0.3200 - acc: 0.8785
Epoch 323/500
288/288 [==============================] - 0s 128us/step - loss: 0.3074 - acc: 0.8958
Epoch 324/500
288/288 [==============================] - 0s 132us/step - loss: 0.2785 - acc: 0.8785
Epoch 325/500
288/288 [==============================] - 0s 121us/step - loss: 0.2945 - acc: 0.8785
Epoch 326/500
288/288 [==============================] - 0s 125us/step - loss: 0.3292 - acc: 0.8854
Epoch 327/500
288/288 [==============================] - 0s 125us/step - loss: 0.3013 - acc: 0.8854
Epoch 328/500
288/288 [==============================] - 0s 139us/step - loss: 0.2879 - acc: 0.8958
Epoch 329/500
288/288 [==============================] - 0s 132us/step - loss: 0.2840 - acc: 0.9097
Epoch 330/500
288/288 [==============================] - 0s 132us/step - loss: 0.3315 - acc: 0.8646
Epoch 331/500
288/288 [==============================] - 0s 128us/step - loss: 0.2554 - acc: 0.9097
Epoch 332/500
288/288 [==============================] - 0s 128us/step - loss: 0.2659 - acc: 0.8958
Epoch 333/500
288/288 [==============================] - 0s 128us/step - loss: 0.2770 - acc: 0.9062
Epoch 334/500
288/288 [==============================] - 0s 139us/step - loss: 0.3116 - acc: 0.8750
Epoch 335/500
288/288 [==============================] - 0s 125us/step - loss: 0.3036 - acc: 0.8854
Epoch 336/500
288/288 [==============================] - 0s 128us/step - loss: 0.3047 - acc: 0.8819
Epoch 337/500
288/288 [==============================] - 0s 128us/step - loss: 0.2959 - acc: 0.8750
Epoch 338/500
288/288 [==============================] - 0s 128us/step - loss: 0.2627 - acc: 0.9132
Epoch 339/500
288/288 [==============================] - 0s 128us/step - loss: 0.2756 - acc: 0.8715
```

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Epoch 340/500
288/288 [==============================] - 0s 128us/step - loss: 0.3172 - acc: 0.8646
Epoch 341/500
288/288 [==============================] - 0s 125us/step - loss: 0.2935 - acc: 0.8576
Epoch 342/500
288/288 [==============================] - 0s 128us/step - loss: 0.3166 - acc: 0.8646
Epoch 343/500
288/288 [==============================] - 0s 121us/step - loss: 0.2697 - acc: 0.9028
Epoch 344/500
288/288 [==============================] - 0s 121us/step - loss: 0.3277 - acc: 0.8785
Epoch 345/500
288/288 [==============================] - 0s 142us/step - loss: 0.2981 - acc: 0.8715
Epoch 346/500
288/288 [==============================] - 0s 142us/step - loss: 0.3011 - acc: 0.8750
Epoch 347/500
288/288 [==============================] - 0s 128us/step - loss: 0.2716 - acc: 0.9028
Epoch 348/500
288/288 [==============================] - 0s 132us/step - loss: 0.3023 - acc: 0.8750
Epoch 349/500
288/288 [==============================] - 0s 128us/step - loss: 0.3045 - acc: 0.8819
Epoch 350/500
288/288 [==============================] - 0s 128us/step - loss: 0.3085 - acc: 0.8750
Epoch 351/500
288/288 [==============================] - 0s 132us/step - loss: 0.3023 - acc: 0.8819
Epoch 352/500
288/288 [==============================] - 0s 121us/step - loss: 0.3244 - acc: 0.8576
Epoch 353/500
288/288 [==============================] - 0s 132us/step - loss: 0.2397 - acc: 0.9028
Epoch 354/500
288/288 [==============================] - 0s 135us/step - loss: 0.2846 - acc: 0.8889
Epoch 355/500
288/288 [==============================] - 0s 132us/step - loss: 0.3355 - acc: 0.8750
Epoch 356/500
288/288 [==============================] - 0s 128us/step - loss: 0.3008 - acc: 0.8785
Epoch 357/500
288/288 [==============================] - 0s 125us/step - loss: 0.2985 - acc: 0.8889
Epoch 358/500
288/288 [==============================] - 0s 111us/step - loss: 0.3303 - acc: 0.8715
Epoch 359/500
288/288 [==============================] - 0s 139us/step - loss: 0.3293 - acc: 0.8542
Epoch 360/500
288/288 [==============================] - 0s 125us/step - loss: 0.2583 - acc: 0.8958
Epoch 361/500
288/288 [==============================] - 0s 128us/step - loss: 0.2825 - acc: 0.8889
Epoch 362/500
288/288 [==============================] - 0s 139us/step - loss: 0.2985 - acc: 0.8715
Epoch 363/500
288/288 [==============================] - 0s 125us/step - loss: 0.3773 - acc: 0.8785
```

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Epoch 364/500
288/288 [==============================] - 0s 125us/step - loss: 0.2693 - acc: 0.8924
Epoch 365/500
288/288 [==============================] - 0s 121us/step - loss: 0.2836 - acc: 0.9028
Epoch 366/500
288/288 [==============================] - 0s 125us/step - loss: 0.2861 - acc: 0.8889
Epoch 367/500
288/288 [==============================] - 0s 132us/step - loss: 0.3165 - acc: 0.8646
Epoch 368/500
288/288 [==============================] - 0s 128us/step - loss: 0.2420 - acc: 0.8854
Epoch 369/500
288/288 [==============================] - 0s 121us/step - loss: 0.3596 - acc: 0.8542
Epoch 370/500
288/288 [==============================] - 0s 125us/step - loss: 0.2919 - acc: 0.8681
Epoch 371/500
288/288 [==============================] - 0s 139us/step - loss: 0.2755 - acc: 0.8785
Epoch 372/500
288/288 [==============================] - 0s 135us/step - loss: 0.2702 - acc: 0.9028
Epoch 373/500
288/288 [==============================] - 0s 128us/step - loss: 0.3269 - acc: 0.9028
Epoch 374/500
288/288 [==============================] - 0s 132us/step - loss: 0.3106 - acc: 0.8715
Epoch 375/500
288/288 [==============================] - 0s 121us/step - loss: 0.2860 - acc: 0.9097
Epoch 376/500
288/288 [==============================] - 0s 132us/step - loss: 0.2902 - acc: 0.8993
Epoch 377/500
288/288 [==============================] - 0s 121us/step - loss: 0.2967 - acc: 0.8854
Epoch 378/500
288/288 [==============================] - 0s 132us/step - loss: 0.2964 - acc: 0.8819
Epoch 379/500
288/288 [==============================] - 0s 121us/step - loss: 0.2433 - acc: 0.8924
Epoch 380/500
288/288 [==============================] - 0s 125us/step - loss: 0.2834 - acc: 0.8715
Epoch 381/500
288/288 [==============================] - 0s 118us/step - loss: 0.2797 - acc: 0.8681
Epoch 382/500
288/288 [==============================] - 0s 132us/step - loss: 0.2593 - acc: 0.8889
Epoch 383/500
288/288 [==============================] - 0s 125us/step - loss: 0.2833 - acc: 0.8750
Epoch 384/500
288/288 [==============================] - 0s 135us/step - loss: 0.3136 - acc: 0.8681
Epoch 385/500
288/288 [==============================] - 0s 125us/step - loss: 0.2951 - acc: 0.8681
Epoch 386/500
288/288 [==============================] - 0s 135us/step - loss: 0.2985 - acc: 0.8854
Epoch 387/500
288/288 [==============================] - 0s 145us/step - loss: 0.3552 - acc: 0.8472
```

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Epoch 388/500
288/288 [==============================] - 0s 135us/step - loss: 0.3120 - acc: 0.8819
Epoch 389/500
288/288 [==============================] - 0s 159us/step - loss: 0.3638 - acc: 0.8750
Epoch 390/500
288/288 [==============================] - 0s 249us/step - loss: 0.3414 - acc: 0.8715
Epoch 391/500
288/288 [==============================] - 0s 204us/step - loss: 0.2829 - acc: 0.8958
Epoch 392/500
288/288 [==============================] - 0s 239us/step - loss: 0.2437 - acc: 0.9028
Epoch 393/500
288/288 [==============================] - 0s 190us/step - loss: 0.3223 - acc: 0.8611
Epoch 394/500
288/288 [==============================] - 0s 173us/step - loss: 0.3541 - acc: 0.8785
Epoch 395/500
288/288 [==============================] - 0s 152us/step - loss: 0.3143 - acc: 0.8542
Epoch 396/500
288/288 [==============================] - 0s 128us/step - loss: 0.2675 - acc: 0.9028
Epoch 397/500
288/288 [==============================] - 0s 139us/step - loss: 0.3377 - acc: 0.8681
Epoch 398/500
288/288 [==============================] - 0s 121us/step - loss: 0.3516 - acc: 0.8785
Epoch 399/500
288/288 [==============================] - 0s 152us/step - loss: 0.3031 - acc: 0.8542
Epoch 400/500
288/288 [==============================] - 0s 125us/step - loss: 0.2637 - acc: 0.8819
Epoch 401/500
288/288 [==============================] - 0s 149us/step - loss: 0.3056 - acc: 0.8785
Epoch 402/500
288/288 [==============================] - 0s 145us/step - loss: 0.3282 - acc: 0.8819
Epoch 403/500
288/288 [==============================] - 0s 142us/step - loss: 0.2797 - acc: 0.8958
Epoch 404/500
288/288 [==============================] - 0s 159us/step - loss: 0.3141 - acc: 0.8819
Epoch 405/500
288/288 [==============================] - 0s 197us/step - loss: 0.3346 - acc: 0.8715
Epoch 406/500
288/288 [==============================] - 0s 159us/step - loss: 0.2623 - acc: 0.8958
Epoch 407/500
288/288 [==============================] - 0s 163us/step - loss: 0.3173 - acc: 0.8854
Epoch 408/500
288/288 [==============================] - 0s 197us/step - loss: 0.3084 - acc: 0.8611
Epoch 409/500
288/288 [==============================] - 0s 166us/step - loss: 0.3271 - acc: 0.8785
Epoch 410/500
288/288 [==============================] - 0s 170us/step - loss: 0.2784 - acc: 0.8889
Epoch 411/500
288/288 [==============================] - 0s 159us/step - loss: 0.3216 - acc: 0.8681
```

```
Epoch 412/500
288/288 [==============================] - 0s 132us/step - loss: 0.3199 - acc: 0.8889
Epoch 413/500
288/288 [==============================] - 0s 125us/step - loss: 0.3062 - acc: 0.8750
Epoch 414/500
288/288 [==============================] - 0s 128us/step - loss: 0.2965 - acc: 0.9097
Epoch 415/500
288/288 [==============================] - 0s 135us/step - loss: 0.3269 - acc: 0.8750
Epoch 416/500
288/288 [==============================] - 0s 135us/step - loss: 0.3059 - acc: 0.8542
Epoch 417/500
288/288 [==============================] - 0s 128us/step - loss: 0.3594 - acc: 0.8472
Epoch 418/500
288/288 [==============================] - 0s 135us/step - loss: 0.2849 - acc: 0.8854
Epoch 419/500
288/288 [==============================] - 0s 128us/step - loss: 0.2611 - acc: 0.8958
Epoch 420/500
288/288 [==============================] - 0s 125us/step - loss: 0.3037 - acc: 0.8854
Epoch 421/500
288/288 [==============================] - 0s 135us/step - loss: 0.3120 - acc: 0.8819
Epoch 422/500
288/288 [==============================] - 0s 128us/step - loss: 0.2795 - acc: 0.8889
Epoch 423/500
288/288 [==============================] - 0s 135us/step - loss: 0.3149 - acc: 0.8681
Epoch 424/500
288/288 [==============================] - 0s 139us/step - loss: 0.2791 - acc: 0.8819
Epoch 425/500
288/288 [==============================] - 0s 132us/step - loss: 0.3138 - acc: 0.8576
Epoch 426/500
288/288 [==============================] - 0s 132us/step - loss: 0.2556 - acc: 0.9028
Epoch 427/500
288/288 [==============================] - 0s 135us/step - loss: 0.2690 - acc: 0.9028
Epoch 428/500
288/288 [==============================] - 0s 135us/step - loss: 0.2761 - acc: 0.8924
Epoch 429/500
288/288 [==============================] - 0s 132us/step - loss: 0.2803 - acc: 0.8924
Epoch 430/500
288/288 [==============================] - 0s 128us/step - loss: 0.2890 - acc: 0.8889
Epoch 431/500
288/288 [==============================] - 0s 121us/step - loss: 0.2670 - acc: 0.8993
Epoch 432/500
288/288 [==============================] - 0s 128us/step - loss: 0.3015 - acc: 0.8715
Epoch 433/500
288/288 [==============================] - 0s 128us/step - loss: 0.2904 - acc: 0.8819
Epoch 434/500
288/288 [==============================] - 0s 139us/step - loss: 0.2879 - acc: 0.8854
Epoch 435/500
288/288 [==============================] - 0s 135us/step - loss: 0.3414 - acc: 0.8646
```

```
Epoch 436/500
288/288 [==============================] - 0s 125us/step - loss: 0.3203 - acc: 0.8750
Epoch 437/500
288/288 [==============================] - 0s 145us/step - loss: 0.3943 - acc: 0.8889
Epoch 438/500
288/288 [==============================] - 0s 128us/step - loss: 0.2969 - acc: 0.8958
Epoch 439/500
288/288 [==============================] - 0s 132us/step - loss: 0.3016 - acc: 0.8576
Epoch 440/500
288/288 [==============================] - 0s 132us/step - loss: 0.2954 - acc: 0.8819
Epoch 441/500
288/288 [==============================] - 0s 132us/step - loss: 0.3385 - acc: 0.8611
Epoch 442/500
288/288 [==============================] - 0s 121us/step - loss: 0.2850 - acc: 0.8750
Epoch 443/500
288/288 [==============================] - 0s 139us/step - loss: 0.3160 - acc: 0.8611
Epoch 444/500
288/288 [==============================] - 0s 128us/step - loss: 0.2807 - acc: 0.8889
Epoch 445/500
288/288 [==============================] - 0s 121us/step - loss: 0.2976 - acc: 0.8681
Epoch 446/500
288/288 [==============================] - 0s 139us/step - loss: 0.3266 - acc: 0.8750
Epoch 447/500
288/288 [==============================] - 0s 121us/step - loss: 0.3446 - acc: 0.8646
Epoch 448/500
288/288 [==============================] - 0s 132us/step - loss: 0.3149 - acc: 0.8785
Epoch 449/500
288/288 [==============================] - 0s 135us/step - loss: 0.2897 - acc: 0.8958
Epoch 450/500
288/288 [==============================] - 0s 121us/step - loss: 0.2822 - acc: 0.8785
Epoch 451/500
288/288 [==============================] - 0s 132us/step - loss: 0.2416 - acc: 0.9167
Epoch 452/500
288/288 [==============================] - 0s 132us/step - loss: 0.3191 - acc: 0.8437
Epoch 453/500
288/288 [==============================] - 0s 132us/step - loss: 0.2924 - acc: 0.8854
Epoch 454/500
288/288 [==============================] - 0s 135us/step - loss: 0.2517 - acc: 0.8958
Epoch 455/500
288/288 [==============================] - 0s 121us/step - loss: 0.3072 - acc: 0.8819
Epoch 456/500
288/288 [==============================] - 0s 135us/step - loss: 0.2589 - acc: 0.8819
Epoch 457/500
288/288 [==============================] - 0s 128us/step - loss: 0.3252 - acc: 0.8750
Epoch 458/500
288/288 [==============================] - 0s 118us/step - loss: 0.2861 - acc: 0.8819
Epoch 459/500
288/288 [==============================] - 0s 121us/step - loss: 0.2602 - acc: 0.8819
```

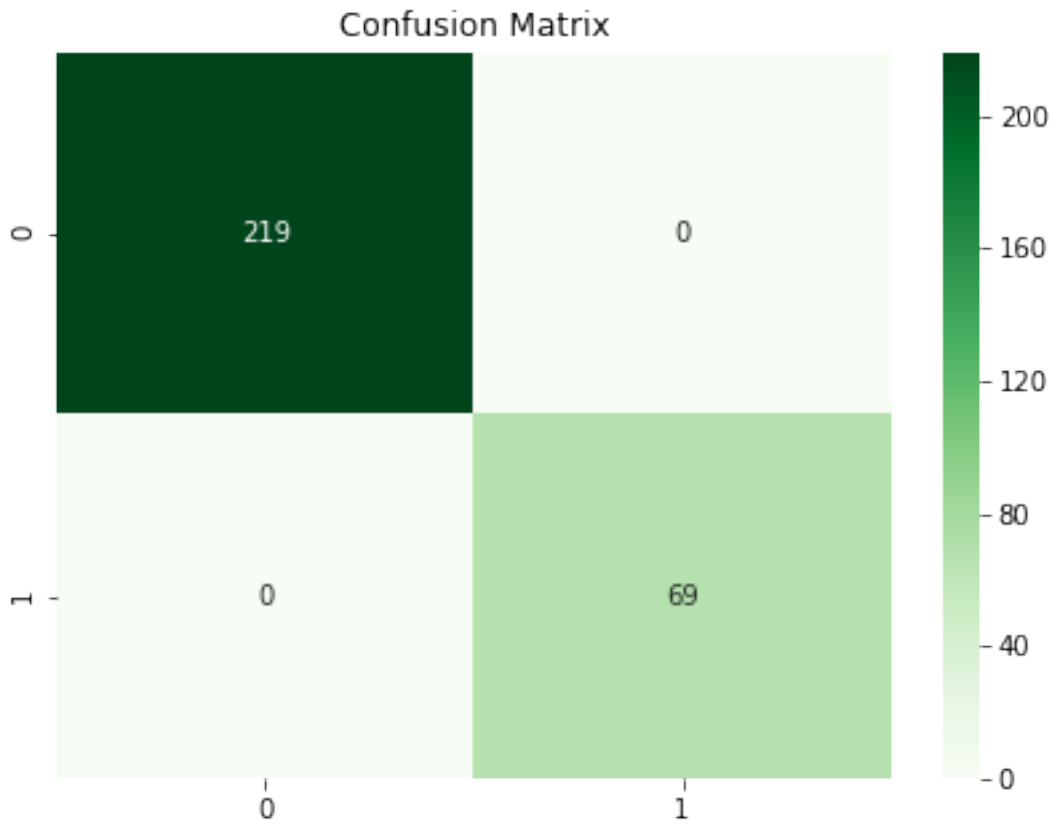
```
Epoch 460/500
288/288 [==============================] - 0s 121us/step - loss: 0.2806 - acc: 0.9132
Epoch 461/500
288/288 [==============================] - 0s 132us/step - loss: 0.3062 - acc: 0.8819
Epoch 462/500
288/288 [==============================] - 0s 128us/step - loss: 0.3223 - acc: 0.8819
Epoch 463/500
288/288 [==============================] - 0s 121us/step - loss: 0.2891 - acc: 0.8785
Epoch 464/500
288/288 [==============================] - 0s 121us/step - loss: 0.2598 - acc: 0.9132
Epoch 465/500
288/288 [==============================] - 0s 139us/step - loss: 0.2908 - acc: 0.8924
Epoch 466/500
288/288 [==============================] - 0s 125us/step - loss: 0.3535 - acc: 0.8646
Epoch 467/500
288/288 [==============================] - 0s 125us/step - loss: 0.2954 - acc: 0.8646
Epoch 468/500
288/288 [==============================] - 0s 121us/step - loss: 0.2729 - acc: 0.8854
Epoch 469/500
288/288 [==============================] - 0s 132us/step - loss: 0.3183 - acc: 0.8750
Epoch 470/500
288/288 [==============================] - 0s 125us/step - loss: 0.2697 - acc: 0.8924
Epoch 471/500
288/288 [==============================] - 0s 111us/step - loss: 0.3006 - acc: 0.8889
Epoch 472/500
288/288 [==============================] - 0s 135us/step - loss: 0.2993 - acc: 0.8611
Epoch 473/500
288/288 [==============================] - 0s 135us/step - loss: 0.2998 - acc: 0.8785
Epoch 474/500
288/288 [==============================] - 0s 132us/step - loss: 0.3272 - acc: 0.8507
Epoch 475/500
288/288 [==============================] - 0s 125us/step - loss: 0.2506 - acc: 0.8993
Epoch 476/500
288/288 [==============================] - 0s 118us/step - loss: 0.2348 - acc: 0.9167
Epoch 477/500
288/288 [==============================] - 0s 132us/step - loss: 0.2816 - acc: 0.8924
Epoch 478/500
288/288 [==============================] - 0s 121us/step - loss: 0.3030 - acc: 0.8854
Epoch 479/500
288/288 [==============================] - 0s 128us/step - loss: 0.3377 - acc: 0.8681
Epoch 480/500
288/288 [==============================] - 0s 114us/step - loss: 0.2789 - acc: 0.8958
Epoch 481/500
288/288 [==============================] - 0s 128us/step - loss: 0.2573 - acc: 0.8924
Epoch 482/500
288/288 [==============================] - 0s 135us/step - loss: 0.3013 - acc: 0.8854
Epoch 483/500
288/288 [==============================] - 0s 128us/step - loss: 0.2743 - acc: 0.8889
```

```
Epoch 484/500
288/288 [==============================] - 0s 125us/step - loss: 0.3151 - acc: 0.8611
Epoch 485/500
288/288 [==============================] - 0s 128us/step - loss: 0.2893 - acc: 0.8993
Epoch 486/500
288/288 [==============================] - 0s 125us/step - loss: 0.2808 - acc: 0.8924
Epoch 487/500
288/288 [==============================] - 0s 128us/step - loss: 0.3015 - acc: 0.8785
Epoch 488/500
288/288 [==============================] - 0s 121us/step - loss: 0.3028 - acc: 0.8681
Epoch 489/500
288/288 [==============================] - 0s 135us/step - loss: 0.3416 - acc: 0.8889
Epoch 490/500
288/288 [==============================] - 0s 128us/step - loss: 0.2974 - acc: 0.8646
Epoch 491/500
288/288 [==============================] - 0s 132us/step - loss: 0.2828 - acc: 0.8854
Epoch 492/500
288/288 [==============================] - 0s 121us/step - loss: 0.2977 - acc: 0.8819
Epoch 493/500
288/288 [==============================] - 0s 135us/step - loss: 0.3014 - acc: 0.8819
Epoch 494/500
288/288 [==============================] - 0s 132us/step - loss: 0.2880 - acc: 0.8993
Epoch 495/500
288/288 [==============================] - 0s 135us/step - loss: 0.3608 - acc: 0.8472
Epoch 496/500
288/288 [==============================] - 0s 152us/step - loss: 0.2747 - acc: 0.8819
Epoch 497/500
288/288 [==============================] - 0s 246us/step - loss: 0.2717 - acc: 0.8819
Epoch 498/500
288/288 [==============================] - 0s 294us/step - loss: 0.3405 - acc: 0.8507
Epoch 499/500
288/288 [==============================] - 0s 253us/step - loss: 0.2760 - acc: 0.9028
Epoch 500/500
288/288 [==============================] - 0s 315us/step - loss: 0.3056 - acc: 0.8819
```

I use 500 epochs with batch size of 10 to train ANN model. Since we are more concerned about identifying sick people rather than misclassifying a healthy person, I slighly reduce the threshold to 0.4 .

```
In [11]: from sklearn.metrics import confusion_matrix, recall_score
         import seaborn as sn
         cm = confusion_matrix(y, y_pred)
         plt.figure(figsize = (7,5))
         plt.title('Confusion Matrix')
         sn.heatmap(cm, annot=True, cmap='Greens', fmt='g')

Out[11]: <matplotlib.axes._subplots.AxesSubplot at 0x2e72ddf65f8>
```



Confusion matrix is a comparison of true lables vs predicted labels. Since we have kept the prediction threshold to be 0.4, we see that there is one false positive while rest of the predictions are correct.

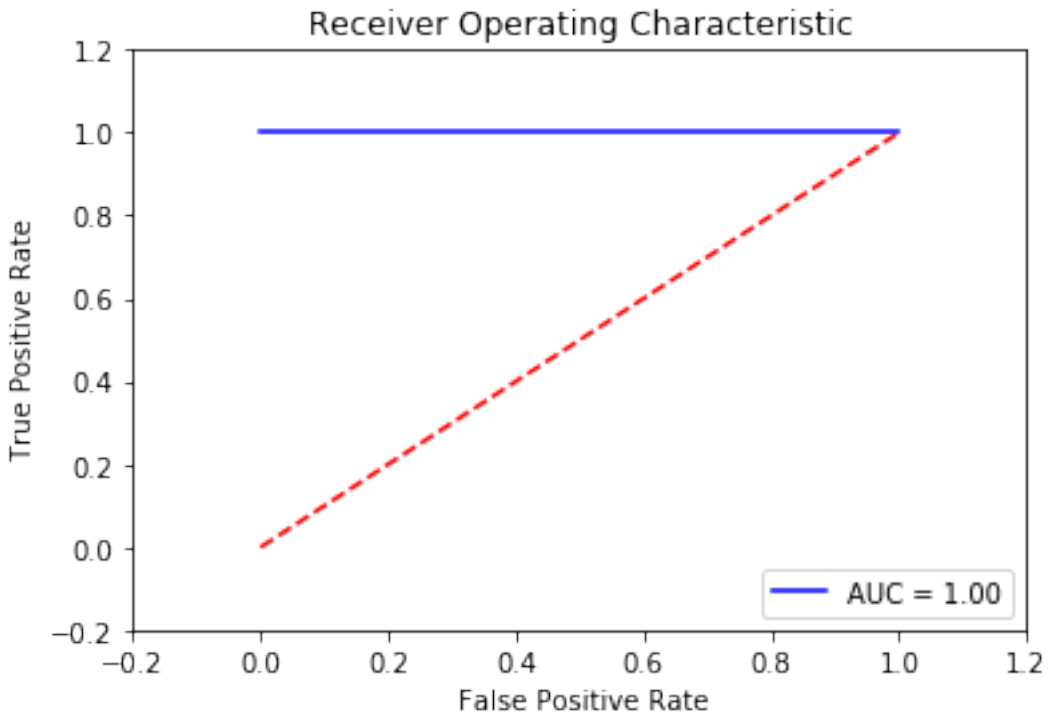
```
In [12]: # recall -
         recall = recall_score(y, y_pred)
         print(recall)
```

```
1.0
```

We are more concerned about false negatives (categorizing sick person as healthy) than false positives (categorizing healthy person as sick), recall is a good indicator of how well we perform in this scenario. Recall score was 1.0 when I ran for the last time. Essentially, there were no false negatives. Since we have taken care of overfitting through regularization, we assume prediction is stable across datasets i.e low variance. A test set could have helped me in this regard.

```
In [13]: # roc curve
         from sklearn.metrics import roc_curve, auc
         false_positive_rate, true_positive_rate, thresholds = roc_curve(y, y_pred)
         roc_auc = auc(false_positive_rate, true_positive_rate)
         plt.figure(2)
```

```
plt.title('Receiver Operating Characteristic')
plt.plot(false_positive_rate, true_positive_rate, 'b',
label='AUC = %0.2f'% roc_auc)
plt.legend(loc='lower right')
plt.plot([0,1],[0,1],'r--')
plt.xlim([-0.2,1.2])
plt.ylim([-0.2,1.2])
plt.ylabel(' True Positive Rate')
plt.xlabel(' False Positive Rate')
plt.show()
```



Receiver operating characteristic (ROC) is used to visualize the performance of a binary classifier. It helps to select model independent of the class distribution (Fig.1). We can see that our model has the best possible performance in ROC curve. Dotted line denotes random classifier.

Finally, We have to take this result with a pinch of salt. There is a high possibility of overfitting since dataset is really small. We could enhance the perrformance of this classifier by increasing dataset, providing a test/validation set or by cross validation etc.