accuracy_eval

May 28, 2020

[305]:
```
import itertools
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import itertools
# for data scaling and splitting
from sklearn.preprocessing import MinMaxScaler
from sklearn.model_selection import train_test_split
from imblearn.over_sampling import SMOTE
# for neural net
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, BatchNormalization
from tensorflow.keras.wrappers.scikit_learn import KerasClassifier
# for evaluation
from sklearn.model_selection import KFold, cross_val_score
from sklearn.metrics import classification_report, confusion_matrix
# data plotting
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
```

[2]:
```
data = pd.read_csv("data/combined_expression.csv")
data['cluster'].replace([1, 2],[0, 1],inplace=True)
data.head()
```

[2]:

	CELL_LINE_NAME	cluster	TSPAN6	TNMD	DPM1	SCYL3	C1orf112	\
0	1240123	1	8.319417	3.111183	9.643558	4.757258	3.919757	
1	1240131	0	7.611268	2.704739	10.276079	3.650299	3.481567	
2	1240132	0	7.678658	2.845781	10.180954	3.573048	3.431235	
3	1240134	0	3.265063	3.063746	10.490285	3.340791	3.676912	
4	1240140	0	7.090138	2.988043	10.264692	4.119555	3.432585	

	FGR	CFH	FUCA2	…	C6orf10	TMEM225	NOTCH4	PBX2	\
0	3.602185	3.329644	9.076950	…	3.085394	3.462811	3.339030	4.614897	
1	3.145538	3.565127	7.861068	…	2.801456	2.985889	3.180068	5.415729	
2	3.090781	4.116643	8.121190	…	2.934962	2.952937	3.164655	5.707506	
3	3.512821	3.873922	8.790851	…	3.041839	3.398847	3.106710	5.773963	

```
4  3.308033  3.318371  6.927761  …  3.028787  3.225982  3.275820  5.334283

       AGER      RNF5    AGPAT1    DFNB59     PRRT1     FKBPL
0  3.395845  3.419193  3.971646  3.729310  3.320022  6.447316
1  3.299858  3.028414  3.877889  3.911516  3.379405  4.729557
2  3.434295  2.961345  4.272194  3.085696  3.002557  5.653588
3  3.412641  3.136110  4.422262  3.522122  3.509437  5.953242
4  3.864678  3.259242  3.840581  5.809553  3.674587  5.577503

[5 rows x 16384 columns]
```

[3]:
```
selected_genes = pd.read_csv('cleaned/boruta.csv')
selected_genes = selected_genes.values.tolist()
selected_genes = list(itertools.chain(*selected_genes))
```

[4]:
```
# retrieving proper columns
X = data.loc[:, selected_genes]
y = data['cluster'].values
# scaling the data
scalar = MinMaxScaler()
x_scaled = scalar.fit_transform(X)
# splitting data (20% test, 80% train)
X_train, X_test, y_train, y_test = train_test_split(x_scaled, y, test_size=0.2)
sm = SMOTE()
X_train, y_train = sm.fit_sample(X_train, y_train)
```

1 Confusion Matrix Plotting Function

[306]:
```
def plot_confusion_matrix(cm, target_names, title='Confusion matrix',␣
↪cmap=None, normalize=True, cbar=True):
    accuracy = np.trace(cm) / np.sum(cm).astype('float')
    misclass = 1 - accuracy

    if cmap is None:
        cmap = plt.get_cmap('Blues')

    plt.figure(figsize=(8, 6))
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    if cbar:
        plt.colorbar()

    if target_names is not None:
        tick_marks = np.arange(len(target_names))
        plt.xticks(tick_marks, target_names)
```

```
        plt.yticks(tick_marks, target_names, rotation=90,␣
↪verticalalignment='center')

    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]

    thresh = cm.max() / 1.5 if normalize else cm.max() / 2
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        if normalize:
            plt.text(j, i, "{:0.4f}".format(cm[i, j]),
                     horizontalalignment="center",
                     color="white" if cm[i, j] > thresh else "black")
        else:
            plt.text(j, i, "{:,}".format(cm[i, j]),
                     horizontalalignment="center",
                     color="white" if cm[i, j] > thresh else "black")

    plt.tight_layout()
    plt.ylabel('True')
    plt.xlabel('Predicted\naccuracy={:0.4f}; misclass={:0.4f}'.format(accuracy,␣
↪misclass))
    plt.show()
```

2 5-Fold Validation for 5 Hidden Layers

[6]:
```
def hidden5(optimizer='adam', init='normal', dropout=0.3):
    model = Sequential()
    # adding layers and adding droplayers to avoid overfitting
    hidden_layers = len(selected_genes)

    model.add(Dense(hidden_layers*2, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*4, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*4, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*2, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))
```

```
    model.add(Dense(hidden_layers, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(1, activation='sigmoid'))
    # compiling
    model.compile(optimizer=optimizer, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
    return model
```

[36]:
```
model5 = KerasClassifier(build_fn=hidden5, epochs=50, batch_size=16,␣
 ↪optimizer='adagrad',init='normal')
kf = KFold(n_splits=5)

cm_results = []
history_results = []
for train_index, test_index in kf.split(X, y):
    X_train, X_test = X.iloc[train_index].values, X.iloc[test_index].values
    y_train, y_test = y[train_index], y[test_index]
    # fitting
    history = model5.fit(X_train, y_train, validation_data=(X_test,y_test))
    # recording
    cm_results.append(confusion_matrix(y_test, model5.predict(X_test)))
    history_results.append(history)
```

```
Train on 432 samples, validate on 109 samples
Epoch 1/50
432/432 [==============================] - 4s 9ms/sample - loss: 0.6198 -
accuracy: 0.7593 - val_loss: 0.4398 - val_accuracy: 0.9266
Epoch 2/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4226 -
accuracy: 0.8241 - val_loss: 0.4251 - val_accuracy: 0.8991
Epoch 3/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4957 -
accuracy: 0.8102 - val_loss: 0.3776 - val_accuracy: 0.9174
Epoch 4/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4827 -
accuracy: 0.7963 - val_loss: 0.4792 - val_accuracy: 0.7798
Epoch 5/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4823 -
accuracy: 0.7940 - val_loss: 0.4075 - val_accuracy: 0.8991
Epoch 6/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4423 -
accuracy: 0.8218 - val_loss: 0.3233 - val_accuracy: 0.9358
Epoch 7/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4255 -
accuracy: 0.8449 - val_loss: 0.3130 - val_accuracy: 0.8991
```

```
Epoch 8/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3749 -
accuracy: 0.8634 - val_loss: 0.2681 - val_accuracy: 0.9174
Epoch 9/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.4202 -
accuracy: 0.8449 - val_loss: 0.2440 - val_accuracy: 0.9358
Epoch 10/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3746 -
accuracy: 0.8356 - val_loss: 0.2375 - val_accuracy: 0.9450
Epoch 11/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3363 -
accuracy: 0.8495 - val_loss: 0.2257 - val_accuracy: 0.9358
Epoch 12/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3706 -
accuracy: 0.8472 - val_loss: 0.2228 - val_accuracy: 0.9358
Epoch 13/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3178 -
accuracy: 0.8634 - val_loss: 0.2242 - val_accuracy: 0.9358
Epoch 14/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3471 -
accuracy: 0.8519 - val_loss: 0.2535 - val_accuracy: 0.9266
Epoch 15/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3336 -
accuracy: 0.8611 - val_loss: 0.2288 - val_accuracy: 0.9266
Epoch 16/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3309 -
accuracy: 0.8681 - val_loss: 0.2255 - val_accuracy: 0.9174
Epoch 17/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3300 -
accuracy: 0.8819 - val_loss: 0.2559 - val_accuracy: 0.9358
Epoch 18/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3021 -
accuracy: 0.8866 - val_loss: 0.2691 - val_accuracy: 0.9174
Epoch 19/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3727 -
accuracy: 0.8356 - val_loss: 0.2613 - val_accuracy: 0.9174
Epoch 20/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3275 -
accuracy: 0.8681 - val_loss: 0.2717 - val_accuracy: 0.8899
Epoch 21/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3446 -
accuracy: 0.8681 - val_loss: 0.2924 - val_accuracy: 0.8624
Epoch 22/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3227 -
accuracy: 0.8773 - val_loss: 0.2864 - val_accuracy: 0.8899
Epoch 23/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2602 -
accuracy: 0.9051 - val_loss: 0.2718 - val_accuracy: 0.9083
```

```
Epoch 24/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3040 -
accuracy: 0.8588 - val_loss: 0.2665 - val_accuracy: 0.9174
Epoch 25/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2982 -
accuracy: 0.8796 - val_loss: 0.2636 - val_accuracy: 0.9174
Epoch 26/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2651 -
accuracy: 0.8981 - val_loss: 0.2652 - val_accuracy: 0.9083
Epoch 27/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2704 -
accuracy: 0.8912 - val_loss: 0.2644 - val_accuracy: 0.9083
Epoch 28/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2442 -
accuracy: 0.8958 - val_loss: 0.2526 - val_accuracy: 0.9174
Epoch 29/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.3006 -
accuracy: 0.8704 - val_loss: 0.2385 - val_accuracy: 0.9266
Epoch 30/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2444 -
accuracy: 0.9190 - val_loss: 0.2540 - val_accuracy: 0.9083
Epoch 31/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2867 -
accuracy: 0.8796 - val_loss: 0.2619 - val_accuracy: 0.8991
Epoch 32/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2630 -
accuracy: 0.9074 - val_loss: 0.2617 - val_accuracy: 0.8991
Epoch 33/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2330 -
accuracy: 0.9167 - val_loss: 0.2601 - val_accuracy: 0.8991
Epoch 34/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2463 -
accuracy: 0.8889 - val_loss: 0.2612 - val_accuracy: 0.9174
Epoch 35/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2324 -
accuracy: 0.8981 - val_loss: 0.2567 - val_accuracy: 0.9083
Epoch 36/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2865 -
accuracy: 0.8935 - val_loss: 0.2667 - val_accuracy: 0.9083
Epoch 37/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2590 -
accuracy: 0.8981 - val_loss: 0.2854 - val_accuracy: 0.9083
Epoch 38/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2915 -
accuracy: 0.8912 - val_loss: 0.2799 - val_accuracy: 0.9083
Epoch 39/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2493 -
accuracy: 0.8819 - val_loss: 0.2590 - val_accuracy: 0.8991
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Epoch 40/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2908 -
accuracy: 0.8843 - val_loss: 0.2644 - val_accuracy: 0.8899
Epoch 41/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2536 -
accuracy: 0.8912 - val_loss: 0.2731 - val_accuracy: 0.8991
Epoch 42/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2959 -
accuracy: 0.8866 - val_loss: 0.2908 - val_accuracy: 0.8991
Epoch 43/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2471 -
accuracy: 0.8866 - val_loss: 0.2593 - val_accuracy: 0.9174
Epoch 44/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2467 -
accuracy: 0.9051 - val_loss: 0.2599 - val_accuracy: 0.9174
Epoch 45/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2594 -
accuracy: 0.8981 - val_loss: 0.2665 - val_accuracy: 0.8991
Epoch 46/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2491 -
accuracy: 0.9051 - val_loss: 0.2610 - val_accuracy: 0.9083
Epoch 47/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2691 -
accuracy: 0.9097 - val_loss: 0.2921 - val_accuracy: 0.8991
Epoch 48/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2351 -
accuracy: 0.9005 - val_loss: 0.2962 - val_accuracy: 0.8991
Epoch 49/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2071 -
accuracy: 0.9282 - val_loss: 0.2927 - val_accuracy: 0.8899
Epoch 50/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1956 -
accuracy: 0.9352 - val_loss: 0.2883 - val_accuracy: 0.8807
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 5s 11ms/sample - loss: 0.5589 -
accuracy: 0.7691 - val_loss: 0.4258 - val_accuracy: 0.8148
Epoch 2/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4834 -
accuracy: 0.8245 - val_loss: 0.4292 - val_accuracy: 0.8241
Epoch 3/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4082 -
accuracy: 0.8430 - val_loss: 0.4342 - val_accuracy: 0.8426
Epoch 4/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4526 -
accuracy: 0.8383 - val_loss: 0.4302 - val_accuracy: 0.8519
Epoch 5/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4279 -
```

```
accuracy: 0.8453 - val_loss: 0.4418 - val_accuracy: 0.8333
Epoch 6/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3752 -
accuracy: 0.8661 - val_loss: 0.4314 - val_accuracy: 0.8519
Epoch 7/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3944 -
accuracy: 0.8499 - val_loss: 0.4420 - val_accuracy: 0.8704
Epoch 8/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3598 -
accuracy: 0.8614 - val_loss: 0.4383 - val_accuracy: 0.8704
Epoch 9/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2950 -
accuracy: 0.8915 - val_loss: 0.4416 - val_accuracy: 0.8704
Epoch 10/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3253 -
accuracy: 0.8868 - val_loss: 0.4686 - val_accuracy: 0.8704
Epoch 11/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3208 -
accuracy: 0.8845 - val_loss: 0.4673 - val_accuracy: 0.8796
Epoch 12/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3010 -
accuracy: 0.8891 - val_loss: 0.4562 - val_accuracy: 0.8796
Epoch 13/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3199 -
accuracy: 0.8845 - val_loss: 0.4529 - val_accuracy: 0.8889
Epoch 14/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3194 -
accuracy: 0.8868 - val_loss: 0.4522 - val_accuracy: 0.8796
Epoch 15/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3217 -
accuracy: 0.8591 - val_loss: 0.4515 - val_accuracy: 0.8796
Epoch 16/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3060 -
accuracy: 0.8730 - val_loss: 0.4662 - val_accuracy: 0.8796
Epoch 17/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2565 -
accuracy: 0.8984 - val_loss: 0.4484 - val_accuracy: 0.8796
Epoch 18/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2915 -
accuracy: 0.8822 - val_loss: 0.4776 - val_accuracy: 0.8704
Epoch 19/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2924 -
accuracy: 0.8915 - val_loss: 0.4694 - val_accuracy: 0.8796
Epoch 20/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3158 -
accuracy: 0.8730 - val_loss: 0.4536 - val_accuracy: 0.8796
Epoch 21/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2509 -
```

```
accuracy: 0.9122 - val_loss: 0.4530 - val_accuracy: 0.8796
Epoch 22/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2841 -
accuracy: 0.9030 - val_loss: 0.4635 - val_accuracy: 0.8796
Epoch 23/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2823 -
accuracy: 0.9076 - val_loss: 0.4513 - val_accuracy: 0.8796
Epoch 24/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2821 -
accuracy: 0.8868 - val_loss: 0.4733 - val_accuracy: 0.8889
Epoch 25/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2646 -
accuracy: 0.9076 - val_loss: 0.4843 - val_accuracy: 0.8611
Epoch 26/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2834 -
accuracy: 0.8938 - val_loss: 0.4752 - val_accuracy: 0.8519
Epoch 27/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2634 -
accuracy: 0.8961 - val_loss: 0.4861 - val_accuracy: 0.8704
Epoch 28/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2031 -
accuracy: 0.9192 - val_loss: 0.4890 - val_accuracy: 0.8704
Epoch 29/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2477 -
accuracy: 0.9122 - val_loss: 0.4860 - val_accuracy: 0.8704
Epoch 30/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2642 -
accuracy: 0.8915 - val_loss: 0.4877 - val_accuracy: 0.8796
Epoch 31/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1912 -
accuracy: 0.9307 - val_loss: 0.4852 - val_accuracy: 0.8796
Epoch 32/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2559 -
accuracy: 0.9053 - val_loss: 0.4780 - val_accuracy: 0.8796
Epoch 33/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2000 -
accuracy: 0.9261 - val_loss: 0.4928 - val_accuracy: 0.8611
Epoch 34/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2460 -
accuracy: 0.9099 - val_loss: 0.5096 - val_accuracy: 0.8704
Epoch 35/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2489 -
accuracy: 0.8845 - val_loss: 0.4992 - val_accuracy: 0.8611
Epoch 36/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2588 -
accuracy: 0.9030 - val_loss: 0.4866 - val_accuracy: 0.8611
Epoch 37/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2467 -
```

```
accuracy: 0.8891 - val_loss: 0.4938 - val_accuracy: 0.8611
Epoch 38/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2067 -
accuracy: 0.9122 - val_loss: 0.4954 - val_accuracy: 0.8519
Epoch 39/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2537 -
accuracy: 0.9122 - val_loss: 0.5142 - val_accuracy: 0.8611
Epoch 40/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1881 -
accuracy: 0.9261 - val_loss: 0.4963 - val_accuracy: 0.8704
Epoch 41/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1845 -
accuracy: 0.9400 - val_loss: 0.5024 - val_accuracy: 0.8704
Epoch 42/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2087 -
accuracy: 0.9330 - val_loss: 0.4847 - val_accuracy: 0.8704
Epoch 43/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1965 -
accuracy: 0.9261 - val_loss: 0.4963 - val_accuracy: 0.8611
Epoch 44/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2245 -
accuracy: 0.9169 - val_loss: 0.4802 - val_accuracy: 0.8519
Epoch 45/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2559 -
accuracy: 0.8984 - val_loss: 0.4658 - val_accuracy: 0.8519
Epoch 46/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2302 -
accuracy: 0.9169 - val_loss: 0.4733 - val_accuracy: 0.8611
Epoch 47/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1968 -
accuracy: 0.9169 - val_loss: 0.4953 - val_accuracy: 0.8796
Epoch 48/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2300 -
accuracy: 0.9007 - val_loss: 0.4970 - val_accuracy: 0.8519
Epoch 49/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1944 -
accuracy: 0.9400 - val_loss: 0.5018 - val_accuracy: 0.8611
Epoch 50/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1763 -
accuracy: 0.9353 - val_loss: 0.5142 - val_accuracy: 0.8611
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 5s 11ms/sample - loss: 0.5560 -
accuracy: 0.7806 - val_loss: 0.4613 - val_accuracy: 0.8148
Epoch 2/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.4106 -
accuracy: 0.8337 - val_loss: 0.5309 - val_accuracy: 0.7963
Epoch 3/50
```

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433/433 [==============================] - 1s 3ms/sample - loss: 0.3783 -
accuracy: 0.8568 - val_loss: 0.4606 - val_accuracy: 0.8148
Epoch 4/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3723 -
accuracy: 0.8637 - val_loss: 0.4650 - val_accuracy: 0.8148
Epoch 5/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3920 -
accuracy: 0.8522 - val_loss: 0.4639 - val_accuracy: 0.8148
Epoch 6/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3280 -
accuracy: 0.8822 - val_loss: 0.4737 - val_accuracy: 0.7963
Epoch 7/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3261 -
accuracy: 0.8707 - val_loss: 0.4926 - val_accuracy: 0.7963
Epoch 8/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2855 -
accuracy: 0.9007 - val_loss: 0.4991 - val_accuracy: 0.8056
Epoch 9/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3563 -
accuracy: 0.8476 - val_loss: 0.5133 - val_accuracy: 0.8241
Epoch 10/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3333 -
accuracy: 0.8614 - val_loss: 0.4918 - val_accuracy: 0.8333
Epoch 11/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3337 -
accuracy: 0.8522 - val_loss: 0.4940 - val_accuracy: 0.8056
Epoch 12/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3816 -
accuracy: 0.8453 - val_loss: 0.5037 - val_accuracy: 0.8241
Epoch 13/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3471 -
accuracy: 0.8637 - val_loss: 0.4934 - val_accuracy: 0.8426
Epoch 14/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2988 -
accuracy: 0.8961 - val_loss: 0.5108 - val_accuracy: 0.8333
Epoch 15/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2897 -
accuracy: 0.8776 - val_loss: 0.5360 - val_accuracy: 0.8426
Epoch 16/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2667 -
accuracy: 0.8661 - val_loss: 0.5351 - val_accuracy: 0.8519
Epoch 17/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2812 -
accuracy: 0.9030 - val_loss: 0.5342 - val_accuracy: 0.8519
Epoch 18/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3099 -
accuracy: 0.8799 - val_loss: 0.5613 - val_accuracy: 0.8426
Epoch 19/50
```

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433/433 [==============================] - 1s 3ms/sample - loss: 0.2514 -
accuracy: 0.9122 - val_loss: 0.5826 - val_accuracy: 0.8333
Epoch 20/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2535 -
accuracy: 0.8799 - val_loss: 0.5660 - val_accuracy: 0.8333
Epoch 21/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2705 -
accuracy: 0.8845 - val_loss: 0.5501 - val_accuracy: 0.8333
Epoch 22/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2743 -
accuracy: 0.8868 - val_loss: 0.5414 - val_accuracy: 0.8426
Epoch 23/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2230 -
accuracy: 0.9215 - val_loss: 0.5587 - val_accuracy: 0.8333
Epoch 24/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2701 -
accuracy: 0.8891 - val_loss: 0.5959 - val_accuracy: 0.8426
Epoch 25/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2421 -
accuracy: 0.8938 - val_loss: 0.5984 - val_accuracy: 0.8333
Epoch 26/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2145 -
accuracy: 0.9122 - val_loss: 0.5864 - val_accuracy: 0.8241
Epoch 27/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1923 -
accuracy: 0.9238 - val_loss: 0.6170 - val_accuracy: 0.8241
Epoch 28/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2691 -
accuracy: 0.8868 - val_loss: 0.5728 - val_accuracy: 0.8333
Epoch 29/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2047 -
accuracy: 0.9192 - val_loss: 0.5627 - val_accuracy: 0.8426
Epoch 30/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2345 -
accuracy: 0.9053 - val_loss: 0.5742 - val_accuracy: 0.8426
Epoch 31/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2932 -
accuracy: 0.8915 - val_loss: 0.5829 - val_accuracy: 0.8241
Epoch 32/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2615 -
accuracy: 0.8938 - val_loss: 0.5856 - val_accuracy: 0.8426
Epoch 33/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2479 -
accuracy: 0.9053 - val_loss: 0.5956 - val_accuracy: 0.8426
Epoch 34/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2324 -
accuracy: 0.9007 - val_loss: 0.5997 - val_accuracy: 0.8333
Epoch 35/50
```

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433/433 [==============================] - 1s 3ms/sample - loss: 0.1795 -
accuracy: 0.9307 - val_loss: 0.5890 - val_accuracy: 0.8426
Epoch 36/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2300 -
accuracy: 0.9076 - val_loss: 0.5956 - val_accuracy: 0.8241
Epoch 37/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2328 -
accuracy: 0.9007 - val_loss: 0.5990 - val_accuracy: 0.8333
Epoch 38/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2254 -
accuracy: 0.9030 - val_loss: 0.5986 - val_accuracy: 0.8333
Epoch 39/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2169 -
accuracy: 0.9261 - val_loss: 0.6024 - val_accuracy: 0.8148
Epoch 40/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1916 -
accuracy: 0.9353 - val_loss: 0.5833 - val_accuracy: 0.8333
Epoch 41/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2130 -
accuracy: 0.9145 - val_loss: 0.5925 - val_accuracy: 0.8519
Epoch 42/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1916 -
accuracy: 0.9192 - val_loss: 0.6010 - val_accuracy: 0.8333
Epoch 43/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1904 -
accuracy: 0.9238 - val_loss: 0.6272 - val_accuracy: 0.8333
Epoch 44/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1987 -
accuracy: 0.9099 - val_loss: 0.6194 - val_accuracy: 0.8426
Epoch 45/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2334 -
accuracy: 0.9099 - val_loss: 0.6258 - val_accuracy: 0.8426
Epoch 46/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1940 -
accuracy: 0.9307 - val_loss: 0.6213 - val_accuracy: 0.8519
Epoch 47/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1793 -
accuracy: 0.9330 - val_loss: 0.6458 - val_accuracy: 0.8241
Epoch 48/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1412 -
accuracy: 0.9400 - val_loss: 0.6400 - val_accuracy: 0.8241
Epoch 49/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1853 -
accuracy: 0.9330 - val_loss: 0.6549 - val_accuracy: 0.8333
Epoch 50/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1743 -
accuracy: 0.9307 - val_loss: 0.6425 - val_accuracy: 0.8426
Train on 433 samples, validate on 108 samples
```

```
Epoch 1/50
433/433 [==============================] - 5s 11ms/sample - loss: 0.5987 -
accuracy: 0.7460 - val_loss: 0.5171 - val_accuracy: 0.6944
Epoch 2/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4874 -
accuracy: 0.8037 - val_loss: 0.4885 - val_accuracy: 0.7685
Epoch 3/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4382 -
accuracy: 0.8268 - val_loss: 0.6459 - val_accuracy: 0.5648
Epoch 4/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4489 -
accuracy: 0.8222 - val_loss: 0.4864 - val_accuracy: 0.7963
Epoch 5/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4251 -
accuracy: 0.8268 - val_loss: 0.4548 - val_accuracy: 0.8241
Epoch 6/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4404 -
accuracy: 0.8360 - val_loss: 0.5482 - val_accuracy: 0.8056
Epoch 7/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3484 -
accuracy: 0.8614 - val_loss: 0.5526 - val_accuracy: 0.8056
Epoch 8/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3992 -
accuracy: 0.8453 - val_loss: 0.5418 - val_accuracy: 0.8056
Epoch 9/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3793 -
accuracy: 0.8406 - val_loss: 0.5455 - val_accuracy: 0.8148
Epoch 10/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3247 -
accuracy: 0.8707 - val_loss: 0.5632 - val_accuracy: 0.8241
Epoch 11/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3743 -
accuracy: 0.8360 - val_loss: 0.5303 - val_accuracy: 0.8426
Epoch 12/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3561 -
accuracy: 0.8637 - val_loss: 0.5437 - val_accuracy: 0.8426
Epoch 13/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3233 -
accuracy: 0.8707 - val_loss: 0.5375 - val_accuracy: 0.8704
Epoch 14/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3828 -
accuracy: 0.8453 - val_loss: 0.5494 - val_accuracy: 0.8241
Epoch 15/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3447 -
accuracy: 0.8522 - val_loss: 0.5964 - val_accuracy: 0.8333
Epoch 16/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3145 -
accuracy: 0.8799 - val_loss: 0.5883 - val_accuracy: 0.8241
```

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Epoch 17/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2706 -
accuracy: 0.8915 - val_loss: 0.5981 - val_accuracy: 0.8426
Epoch 18/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3261 -
accuracy: 0.8776 - val_loss: 0.6060 - val_accuracy: 0.8148
Epoch 19/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3122 -
accuracy: 0.8753 - val_loss: 0.5800 - val_accuracy: 0.8241
Epoch 20/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3141 -
accuracy: 0.8637 - val_loss: 0.5905 - val_accuracy: 0.8148
Epoch 21/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2941 -
accuracy: 0.8753 - val_loss: 0.6202 - val_accuracy: 0.8056
Epoch 22/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2997 -
accuracy: 0.8730 - val_loss: 0.6125 - val_accuracy: 0.8148
Epoch 23/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3016 -
accuracy: 0.8868 - val_loss: 0.6236 - val_accuracy: 0.8241
Epoch 24/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3424 -
accuracy: 0.8661 - val_loss: 0.6494 - val_accuracy: 0.8241
Epoch 25/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2903 -
accuracy: 0.8799 - val_loss: 0.6635 - val_accuracy: 0.8148
Epoch 26/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2447 -
accuracy: 0.9122 - val_loss: 0.6320 - val_accuracy: 0.8519
Epoch 27/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2879 -
accuracy: 0.9076 - val_loss: 0.6598 - val_accuracy: 0.8241
Epoch 28/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2749 -
accuracy: 0.8822 - val_loss: 0.6803 - val_accuracy: 0.8241
Epoch 29/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2550 -
accuracy: 0.8961 - val_loss: 0.6908 - val_accuracy: 0.8056
Epoch 30/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2744 -
accuracy: 0.8822 - val_loss: 0.6957 - val_accuracy: 0.7963
Epoch 31/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2757 -
accuracy: 0.8915 - val_loss: 0.7054 - val_accuracy: 0.8056
Epoch 32/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3003 -
accuracy: 0.8730 - val_loss: 0.6906 - val_accuracy: 0.8056
```

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Epoch 33/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2487 -
accuracy: 0.9099 - val_loss: 0.6690 - val_accuracy: 0.8148
Epoch 34/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2892 -
accuracy: 0.8915 - val_loss: 0.6713 - val_accuracy: 0.8241
Epoch 35/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2641 -
accuracy: 0.8915 - val_loss: 0.6933 - val_accuracy: 0.8148
Epoch 36/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2994 -
accuracy: 0.8868 - val_loss: 0.6947 - val_accuracy: 0.8148
Epoch 37/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3192 -
accuracy: 0.8730 - val_loss: 0.6979 - val_accuracy: 0.8056
Epoch 38/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2164 -
accuracy: 0.9099 - val_loss: 0.7058 - val_accuracy: 0.8056
Epoch 39/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2359 -
accuracy: 0.9238 - val_loss: 0.6838 - val_accuracy: 0.8056
Epoch 40/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2414 -
accuracy: 0.9099 - val_loss: 0.6775 - val_accuracy: 0.7963
Epoch 41/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2198 -
accuracy: 0.9007 - val_loss: 0.6901 - val_accuracy: 0.8148
Epoch 42/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2617 -
accuracy: 0.8799 - val_loss: 0.6838 - val_accuracy: 0.8241
Epoch 43/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2111 -
accuracy: 0.9192 - val_loss: 0.6867 - val_accuracy: 0.8426
Epoch 44/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2206 -
accuracy: 0.9122 - val_loss: 0.6907 - val_accuracy: 0.8426
Epoch 45/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1894 -
accuracy: 0.9238 - val_loss: 0.6962 - val_accuracy: 0.8333
Epoch 46/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1824 -
accuracy: 0.9261 - val_loss: 0.7199 - val_accuracy: 0.8241
Epoch 47/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2026 -
accuracy: 0.9307 - val_loss: 0.7553 - val_accuracy: 0.8056
Epoch 48/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1945 -
accuracy: 0.9192 - val_loss: 0.7393 - val_accuracy: 0.8148
```

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Epoch 49/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1924 -
accuracy: 0.9192 - val_loss: 0.7260 - val_accuracy: 0.8148
Epoch 50/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2775 -
accuracy: 0.8915 - val_loss: 0.7442 - val_accuracy: 0.8148
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 5s 11ms/sample - loss: 0.6765 -
accuracy: 0.7575 - val_loss: 0.6095 - val_accuracy: 0.6481
Epoch 2/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.4435 -
accuracy: 0.8337 - val_loss: 0.4994 - val_accuracy: 0.7593
Epoch 3/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4529 -
accuracy: 0.8406 - val_loss: 0.5057 - val_accuracy: 0.7778
Epoch 4/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4142 -
accuracy: 0.8314 - val_loss: 0.4149 - val_accuracy: 0.8333
Epoch 5/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3628 -
accuracy: 0.8707 - val_loss: 0.3733 - val_accuracy: 0.8426
Epoch 6/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3781 -
accuracy: 0.8314 - val_loss: 0.3577 - val_accuracy: 0.8519
Epoch 7/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3864 -
accuracy: 0.8453 - val_loss: 0.3593 - val_accuracy: 0.8333
Epoch 8/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3677 -
accuracy: 0.8453 - val_loss: 0.3661 - val_accuracy: 0.8426
Epoch 9/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.4132 -
accuracy: 0.8522 - val_loss: 0.3841 - val_accuracy: 0.8426
Epoch 10/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3420 -
accuracy: 0.8730 - val_loss: 0.4003 - val_accuracy: 0.8519
Epoch 11/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3863 -
accuracy: 0.8614 - val_loss: 0.4091 - val_accuracy: 0.8333
Epoch 12/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2932 -
accuracy: 0.8891 - val_loss: 0.4120 - val_accuracy: 0.8148
Epoch 13/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3657 -
accuracy: 0.8522 - val_loss: 0.4387 - val_accuracy: 0.8056
Epoch 14/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3825 -
```

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accuracy: 0.8637 - val_loss: 0.4008 - val_accuracy: 0.8148
Epoch 15/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3027 -
accuracy: 0.8799 - val_loss: 0.4068 - val_accuracy: 0.8241
Epoch 16/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3049 -
accuracy: 0.8776 - val_loss: 0.4348 - val_accuracy: 0.8426
Epoch 17/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2801 -
accuracy: 0.8915 - val_loss: 0.4455 - val_accuracy: 0.8333
Epoch 18/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3278 -
accuracy: 0.8845 - val_loss: 0.4453 - val_accuracy: 0.8241
Epoch 19/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3313 -
accuracy: 0.8868 - val_loss: 0.4282 - val_accuracy: 0.8148
Epoch 20/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3345 -
accuracy: 0.8707 - val_loss: 0.4072 - val_accuracy: 0.8241
Epoch 21/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3261 -
accuracy: 0.8730 - val_loss: 0.3894 - val_accuracy: 0.8333
Epoch 22/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2809 -
accuracy: 0.8822 - val_loss: 0.4048 - val_accuracy: 0.8241
Epoch 23/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2741 -
accuracy: 0.8961 - val_loss: 0.4238 - val_accuracy: 0.8241
Epoch 24/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3108 -
accuracy: 0.8822 - val_loss: 0.4673 - val_accuracy: 0.8241
Epoch 25/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.3232 -
accuracy: 0.8730 - val_loss: 0.4161 - val_accuracy: 0.8148
Epoch 26/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2690 -
accuracy: 0.9053 - val_loss: 0.4070 - val_accuracy: 0.8148
Epoch 27/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2869 -
accuracy: 0.9030 - val_loss: 0.4094 - val_accuracy: 0.8241
Epoch 28/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2945 -
accuracy: 0.8753 - val_loss: 0.4101 - val_accuracy: 0.8148
Epoch 29/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2988 -
accuracy: 0.8730 - val_loss: 0.4149 - val_accuracy: 0.8056
Epoch 30/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2805 -
```

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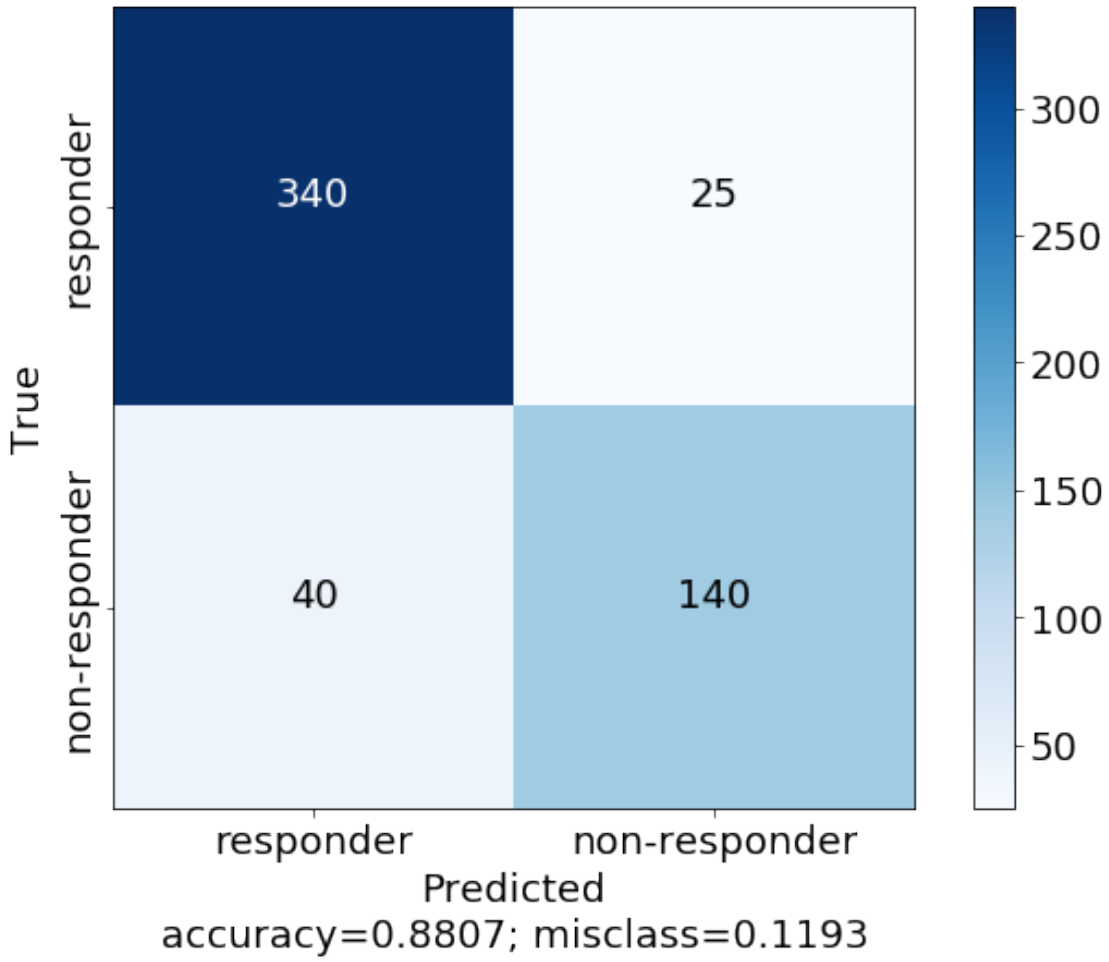
accuracy: 0.8891 - val_loss: 0.4059 - val_accuracy: 0.8056
Epoch 31/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2589 -
accuracy: 0.8891 - val_loss: 0.4187 - val_accuracy: 0.8056
Epoch 32/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2524 -
accuracy: 0.9030 - val_loss: 0.4166 - val_accuracy: 0.8148
Epoch 33/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2633 -
accuracy: 0.8868 - val_loss: 0.4063 - val_accuracy: 0.8148
Epoch 34/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2520 -
accuracy: 0.8845 - val_loss: 0.4277 - val_accuracy: 0.8148
Epoch 35/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2534 -
accuracy: 0.9284 - val_loss: 0.4482 - val_accuracy: 0.8056
Epoch 36/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2531 -
accuracy: 0.9030 - val_loss: 0.4654 - val_accuracy: 0.8056
Epoch 37/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2558 -
accuracy: 0.8961 - val_loss: 0.4439 - val_accuracy: 0.7870
Epoch 38/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2426 -
accuracy: 0.9030 - val_loss: 0.4447 - val_accuracy: 0.7870
Epoch 39/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2472 -
accuracy: 0.9215 - val_loss: 0.4542 - val_accuracy: 0.7963
Epoch 40/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2309 -
accuracy: 0.9030 - val_loss: 0.4583 - val_accuracy: 0.7870
Epoch 41/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2853 -
accuracy: 0.8891 - val_loss: 0.4564 - val_accuracy: 0.7870
Epoch 42/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1988 -
accuracy: 0.9284 - val_loss: 0.4524 - val_accuracy: 0.7963
Epoch 43/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2857 -
accuracy: 0.9099 - val_loss: 0.4475 - val_accuracy: 0.7963
Epoch 44/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2621 -
accuracy: 0.9145 - val_loss: 0.4569 - val_accuracy: 0.7963
Epoch 45/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2015 -
accuracy: 0.9307 - val_loss: 0.4556 - val_accuracy: 0.7870
Epoch 46/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2204 -
```

```
accuracy: 0.9053 - val_loss: 0.4531 - val_accuracy: 0.7870
Epoch 47/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2053 -
accuracy: 0.9192 - val_loss: 0.4657 - val_accuracy: 0.7870
Epoch 48/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2124 -
accuracy: 0.9215 - val_loss: 0.4818 - val_accuracy: 0.7963
Epoch 49/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.1968 -
accuracy: 0.9284 - val_loss: 0.4899 - val_accuracy: 0.7870
Epoch 50/50
433/433 [==============================] - 1s 3ms/sample - loss: 0.2443 -
accuracy: 0.9099 - val_loss: 0.5169 - val_accuracy: 0.8056
```

[79]:
```
cm5 = [[0, 0]]
k, l = 0, 0
for i in cm_results:
    for j in cm_results[0]:
        cm5[k][l] += j
        l = (l+1) % 2
    j = (j+1) % 2
cm5 = np.array(cm5[0])
```

[219]:
```
plt.rcParams.update({'font.size': 18})
plot_confusion_matrix(cm5, ['responder', 'non-responder'], title='',␣
↪normalize=False)
```



3 4 Hidden Layers

[222]:
```
def hidden4(optimizer='adam', init='normal', dropout=0.3):
    model = Sequential()
    # adding layers and adding droplayers to avoid overfitting
    hidden_layers = len(selected_genes)

    model.add(Dense(hidden_layers*2, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*4, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*4, activation='relu'))
```

```
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*2, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(1, activation='sigmoid'))
    # compiling
    model.compile(optimizer=optimizer, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
    return model
```

[225]:
```
model4 = KerasClassifier(build_fn=hidden4, epochs=50, batch_size=32,␣
 ↪optimizer='adagrad',init='normal')
kf = KFold(n_splits=5)

cm_results4 = []
history_results4 = []
for train_index, test_index in kf.split(X, y):
    X_train, X_test = X.iloc[train_index].values, X.iloc[test_index].values
    y_train, y_test = y[train_index], y[test_index]
    # fitting
    history4 = model4.fit(X_train, y_train, validation_data=(X_test,y_test))
    # recording
    cm_results4.append(confusion_matrix(y_test, model4.predict(X_test)))
    history_results4.append(history)
```

```
Train on 432 samples, validate on 109 samples
Epoch 1/50
432/432 [==============================] - 3s 8ms/sample - loss: 0.5999 -
accuracy: 0.7569 - val_loss: 1.0864 - val_accuracy: 0.3303
Epoch 2/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.3917 -
accuracy: 0.8565 - val_loss: 1.1699 - val_accuracy: 0.3303
Epoch 3/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.4168 -
accuracy: 0.8495 - val_loss: 0.6589 - val_accuracy: 0.5688
Epoch 4/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.3601 -
accuracy: 0.8472 - val_loss: 0.4154 - val_accuracy: 0.8257
Epoch 5/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.3565 -
accuracy: 0.8681 - val_loss: 0.5732 - val_accuracy: 0.6881
Epoch 6/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.3139 -
accuracy: 0.8843 - val_loss: 0.4268 - val_accuracy: 0.7890
```

```
Epoch 7/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.2624 -
accuracy: 0.8889 - val_loss: 0.5884 - val_accuracy: 0.6789
Epoch 8/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.3327 -
accuracy: 0.8773 - val_loss: 0.4510 - val_accuracy: 0.7798
Epoch 9/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.2571 -
accuracy: 0.9144 - val_loss: 0.4131 - val_accuracy: 0.8257
Epoch 10/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.2871 -
accuracy: 0.8889 - val_loss: 0.5833 - val_accuracy: 0.7431
Epoch 11/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.2206 -
accuracy: 0.9167 - val_loss: 0.5962 - val_accuracy: 0.7156
Epoch 12/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.2084 -
accuracy: 0.9259 - val_loss: 0.5733 - val_accuracy: 0.7248
Epoch 13/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1953 -
accuracy: 0.9282 - val_loss: 0.6834 - val_accuracy: 0.6789
Epoch 14/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.2380 -
accuracy: 0.9190 - val_loss: 0.6090 - val_accuracy: 0.7156
Epoch 15/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1912 -
accuracy: 0.9329 - val_loss: 0.4024 - val_accuracy: 0.8073
Epoch 16/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1477 -
accuracy: 0.9468 - val_loss: 0.4785 - val_accuracy: 0.7890
Epoch 17/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1766 -
accuracy: 0.9190 - val_loss: 0.3936 - val_accuracy: 0.8349
Epoch 18/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1998 -
accuracy: 0.9259 - val_loss: 0.4678 - val_accuracy: 0.7798
Epoch 19/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1694 -
accuracy: 0.9398 - val_loss: 0.5935 - val_accuracy: 0.7156
Epoch 20/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1923 -
accuracy: 0.9213 - val_loss: 0.5156 - val_accuracy: 0.7706
Epoch 21/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1671 -
accuracy: 0.9491 - val_loss: 0.4454 - val_accuracy: 0.8165
Epoch 22/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1616 -
accuracy: 0.9398 - val_loss: 0.3680 - val_accuracy: 0.8440
```

```
Epoch 23/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1759 -
accuracy: 0.9259 - val_loss: 0.3208 - val_accuracy: 0.8532
Epoch 24/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1516 -
accuracy: 0.9444 - val_loss: 0.3341 - val_accuracy: 0.8440
Epoch 25/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1391 -
accuracy: 0.9514 - val_loss: 0.4023 - val_accuracy: 0.8165
Epoch 26/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1579 -
accuracy: 0.9352 - val_loss: 0.2736 - val_accuracy: 0.8807
Epoch 27/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1904 -
accuracy: 0.9398 - val_loss: 0.3312 - val_accuracy: 0.8349
Epoch 28/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1549 -
accuracy: 0.9329 - val_loss: 0.4709 - val_accuracy: 0.7982
Epoch 29/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1846 -
accuracy: 0.9282 - val_loss: 0.3641 - val_accuracy: 0.8440
Epoch 30/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1172 -
accuracy: 0.9560 - val_loss: 0.3723 - val_accuracy: 0.8440
Epoch 31/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1416 -
accuracy: 0.9468 - val_loss: 0.4007 - val_accuracy: 0.8257
Epoch 32/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1198 -
accuracy: 0.9537 - val_loss: 0.3278 - val_accuracy: 0.8807
Epoch 33/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.1407 -
accuracy: 0.9468 - val_loss: 0.3127 - val_accuracy: 0.8716
Epoch 34/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1343 -
accuracy: 0.9560 - val_loss: 0.3140 - val_accuracy: 0.8807
Epoch 35/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1107 -
accuracy: 0.9676 - val_loss: 0.2823 - val_accuracy: 0.8899
Epoch 36/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.0885 -
accuracy: 0.9699 - val_loss: 0.2751 - val_accuracy: 0.8899
Epoch 37/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1258 -
accuracy: 0.9676 - val_loss: 0.2930 - val_accuracy: 0.8807
Epoch 38/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1286 -
accuracy: 0.9444 - val_loss: 0.3939 - val_accuracy: 0.8440
```

```
Epoch 39/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1056 -
accuracy: 0.9653 - val_loss: 0.3250 - val_accuracy: 0.8807
Epoch 40/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.0876 -
accuracy: 0.9722 - val_loss: 0.3480 - val_accuracy: 0.8624
Epoch 41/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1040 -
accuracy: 0.9606 - val_loss: 0.3228 - val_accuracy: 0.8807
Epoch 42/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.0782 -
accuracy: 0.9676 - val_loss: 0.3466 - val_accuracy: 0.8532
Epoch 43/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1140 -
accuracy: 0.9630 - val_loss: 0.3448 - val_accuracy: 0.8532
Epoch 44/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.1039 -
accuracy: 0.9583 - val_loss: 0.3199 - val_accuracy: 0.8716
Epoch 45/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1033 -
accuracy: 0.9537 - val_loss: 0.2866 - val_accuracy: 0.8991
Epoch 46/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.1253 -
accuracy: 0.9583 - val_loss: 0.2856 - val_accuracy: 0.8991
Epoch 47/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.0996 -
accuracy: 0.9630 - val_loss: 0.3004 - val_accuracy: 0.8899
Epoch 48/50
432/432 [==============================] - 1s 1ms/sample - loss: 0.1398 -
accuracy: 0.9491 - val_loss: 0.3400 - val_accuracy: 0.8624
Epoch 49/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.0788 -
accuracy: 0.9722 - val_loss: 0.3153 - val_accuracy: 0.8624
Epoch 50/50
432/432 [==============================] - 1s 2ms/sample - loss: 0.0953 -
accuracy: 0.9630 - val_loss: 0.2748 - val_accuracy: 0.8899
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 4s 8ms/sample - loss: 0.6125 -
accuracy: 0.7829 - val_loss: 0.7091 - val_accuracy: 0.6944
Epoch 2/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3477 -
accuracy: 0.8730 - val_loss: 0.5103 - val_accuracy: 0.7870
Epoch 3/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3684 -
accuracy: 0.8799 - val_loss: 0.4949 - val_accuracy: 0.8241
Epoch 4/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3435 -
```

```
accuracy: 0.8845 - val_loss: 0.4535 - val_accuracy: 0.8333
Epoch 5/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2980 -
accuracy: 0.8799 - val_loss: 0.4236 - val_accuracy: 0.8426
Epoch 6/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2317 -
accuracy: 0.8961 - val_loss: 0.4401 - val_accuracy: 0.8333
Epoch 7/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2388 -
accuracy: 0.9238 - val_loss: 0.4353 - val_accuracy: 0.8519
Epoch 8/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2295 -
accuracy: 0.9192 - val_loss: 0.4396 - val_accuracy: 0.8519
Epoch 9/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1803 -
accuracy: 0.9192 - val_loss: 0.4756 - val_accuracy: 0.8148
Epoch 10/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1708 -
accuracy: 0.9376 - val_loss: 0.4535 - val_accuracy: 0.8519
Epoch 11/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2115 -
accuracy: 0.9099 - val_loss: 0.5360 - val_accuracy: 0.7315
Epoch 12/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2458 -
accuracy: 0.9053 - val_loss: 0.5422 - val_accuracy: 0.7593
Epoch 13/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1845 -
accuracy: 0.9330 - val_loss: 0.4988 - val_accuracy: 0.7593
Epoch 14/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2058 -
accuracy: 0.9284 - val_loss: 0.5529 - val_accuracy: 0.7407
Epoch 15/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1963 -
accuracy: 0.9261 - val_loss: 0.5362 - val_accuracy: 0.7685
Epoch 16/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1484 -
accuracy: 0.9584 - val_loss: 0.4765 - val_accuracy: 0.8333
Epoch 17/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1661 -
accuracy: 0.9400 - val_loss: 0.4852 - val_accuracy: 0.8056
Epoch 18/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1773 -
accuracy: 0.9353 - val_loss: 0.5534 - val_accuracy: 0.7593
Epoch 19/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1705 -
accuracy: 0.9492 - val_loss: 0.5502 - val_accuracy: 0.7593
Epoch 20/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1201 -
```

```
accuracy: 0.9700 - val_loss: 0.5071 - val_accuracy: 0.7963
Epoch 21/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1543 -
accuracy: 0.9538 - val_loss: 0.6651 - val_accuracy: 0.7222
Epoch 22/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1575 -
accuracy: 0.9330 - val_loss: 0.6493 - val_accuracy: 0.7593
Epoch 23/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0972 -
accuracy: 0.9607 - val_loss: 0.5797 - val_accuracy: 0.7685
Epoch 24/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1170 -
accuracy: 0.9607 - val_loss: 0.5385 - val_accuracy: 0.7963
Epoch 25/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1372 -
accuracy: 0.9400 - val_loss: 0.5505 - val_accuracy: 0.7778
Epoch 26/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1002 -
accuracy: 0.9700 - val_loss: 0.5731 - val_accuracy: 0.7593
Epoch 27/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1186 -
accuracy: 0.9584 - val_loss: 0.5699 - val_accuracy: 0.7870
Epoch 28/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1519 -
accuracy: 0.9307 - val_loss: 0.5367 - val_accuracy: 0.7778
Epoch 29/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1261 -
accuracy: 0.9446 - val_loss: 0.5481 - val_accuracy: 0.7963
Epoch 30/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1287 -
accuracy: 0.9607 - val_loss: 0.6082 - val_accuracy: 0.7593
Epoch 31/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1032 -
accuracy: 0.9607 - val_loss: 0.5320 - val_accuracy: 0.8056
Epoch 32/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0800 -
accuracy: 0.9723 - val_loss: 0.5379 - val_accuracy: 0.8056
Epoch 33/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1284 -
accuracy: 0.9469 - val_loss: 0.5666 - val_accuracy: 0.8148
Epoch 34/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0889 -
accuracy: 0.9769 - val_loss: 0.5206 - val_accuracy: 0.8241
Epoch 35/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0792 -
accuracy: 0.9792 - val_loss: 0.5472 - val_accuracy: 0.8241
Epoch 36/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0746 -
```

```
accuracy: 0.9723 - val_loss: 0.5302 - val_accuracy: 0.8241
Epoch 37/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1073 -
accuracy: 0.9584 - val_loss: 0.5548 - val_accuracy: 0.8333
Epoch 38/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0889 -
accuracy: 0.9700 - val_loss: 0.5911 - val_accuracy: 0.8056
Epoch 39/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1022 -
accuracy: 0.9677 - val_loss: 0.5827 - val_accuracy: 0.7963
Epoch 40/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0771 -
accuracy: 0.9723 - val_loss: 0.6113 - val_accuracy: 0.7870
Epoch 41/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0969 -
accuracy: 0.9654 - val_loss: 0.6237 - val_accuracy: 0.7593
Epoch 42/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0716 -
accuracy: 0.9700 - val_loss: 0.6136 - val_accuracy: 0.7593
Epoch 43/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0934 -
accuracy: 0.9700 - val_loss: 0.6033 - val_accuracy: 0.7870
Epoch 44/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0840 -
accuracy: 0.9746 - val_loss: 0.5957 - val_accuracy: 0.8056
Epoch 45/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1097 -
accuracy: 0.9630 - val_loss: 0.5606 - val_accuracy: 0.8241
Epoch 46/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0704 -
accuracy: 0.9838 - val_loss: 0.5578 - val_accuracy: 0.8426
Epoch 47/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0904 -
accuracy: 0.9677 - val_loss: 0.5549 - val_accuracy: 0.8426
Epoch 48/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0720 -
accuracy: 0.9723 - val_loss: 0.5745 - val_accuracy: 0.8426
Epoch 49/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1027 -
accuracy: 0.9561 - val_loss: 0.5785 - val_accuracy: 0.8333
Epoch 50/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0781 -
accuracy: 0.9654 - val_loss: 0.6023 - val_accuracy: 0.8241
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 4s 10ms/sample - loss: 0.5525 -
accuracy: 0.7898 - val_loss: 0.6897 - val_accuracy: 0.7315
Epoch 2/50
```

```
433/433 [==============================] - 1s 1ms/sample - loss: 0.3401 -
accuracy: 0.8707 - val_loss: 0.4523 - val_accuracy: 0.8056
Epoch 3/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3169 -
accuracy: 0.8637 - val_loss: 0.4490 - val_accuracy: 0.8148
Epoch 4/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2893 -
accuracy: 0.8822 - val_loss: 0.4499 - val_accuracy: 0.8056
Epoch 5/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2599 -
accuracy: 0.8938 - val_loss: 0.4628 - val_accuracy: 0.8241
Epoch 6/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2578 -
accuracy: 0.9030 - val_loss: 0.4997 - val_accuracy: 0.8241
Epoch 7/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2394 -
accuracy: 0.9238 - val_loss: 0.5110 - val_accuracy: 0.8241
Epoch 8/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1778 -
accuracy: 0.9261 - val_loss: 0.5364 - val_accuracy: 0.8056
Epoch 9/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1929 -
accuracy: 0.9423 - val_loss: 0.6130 - val_accuracy: 0.7963
Epoch 10/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1762 -
accuracy: 0.9423 - val_loss: 0.6403 - val_accuracy: 0.7963
Epoch 11/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2001 -
accuracy: 0.9192 - val_loss: 0.5866 - val_accuracy: 0.8148
Epoch 12/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2113 -
accuracy: 0.9215 - val_loss: 0.6464 - val_accuracy: 0.7685
Epoch 13/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1227 -
accuracy: 0.9584 - val_loss: 0.5844 - val_accuracy: 0.8426
Epoch 14/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1998 -
accuracy: 0.9307 - val_loss: 0.6405 - val_accuracy: 0.7500
Epoch 15/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1672 -
accuracy: 0.9492 - val_loss: 0.6550 - val_accuracy: 0.7870
Epoch 16/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1664 -
accuracy: 0.9423 - val_loss: 0.6878 - val_accuracy: 0.7315
Epoch 17/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1541 -
accuracy: 0.9400 - val_loss: 0.6445 - val_accuracy: 0.7500
Epoch 18/50
```

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433/433 [==============================] - 1s 2ms/sample - loss: 0.1199 -
accuracy: 0.9654 - val_loss: 0.6219 - val_accuracy: 0.7778
Epoch 19/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1455 -
accuracy: 0.9446 - val_loss: 0.6084 - val_accuracy: 0.7870
Epoch 20/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1346 -
accuracy: 0.9515 - val_loss: 0.6334 - val_accuracy: 0.7778
Epoch 21/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0900 -
accuracy: 0.9746 - val_loss: 0.6345 - val_accuracy: 0.7778
Epoch 22/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1232 -
accuracy: 0.9400 - val_loss: 0.6407 - val_accuracy: 0.7778
Epoch 23/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1058 -
accuracy: 0.9607 - val_loss: 0.6524 - val_accuracy: 0.7778
Epoch 24/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1307 -
accuracy: 0.9515 - val_loss: 0.6776 - val_accuracy: 0.7500
Epoch 25/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1026 -
accuracy: 0.9630 - val_loss: 0.7004 - val_accuracy: 0.7870
Epoch 26/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1375 -
accuracy: 0.9492 - val_loss: 0.6834 - val_accuracy: 0.7963
Epoch 27/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1476 -
accuracy: 0.9538 - val_loss: 0.6799 - val_accuracy: 0.8056
Epoch 28/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1163 -
accuracy: 0.9538 - val_loss: 0.6905 - val_accuracy: 0.7500
Epoch 29/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1619 -
accuracy: 0.9353 - val_loss: 0.6601 - val_accuracy: 0.8056
Epoch 30/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1046 -
accuracy: 0.9561 - val_loss: 0.6780 - val_accuracy: 0.7870
Epoch 31/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0984 -
accuracy: 0.9654 - val_loss: 0.6855 - val_accuracy: 0.7963
Epoch 32/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0766 -
accuracy: 0.9677 - val_loss: 0.6882 - val_accuracy: 0.7963
Epoch 33/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0807 -
accuracy: 0.9723 - val_loss: 0.6980 - val_accuracy: 0.8056
Epoch 34/50
```

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433/433 [==============================] - 1s 2ms/sample - loss: 0.0929 -
accuracy: 0.9700 - val_loss: 0.6970 - val_accuracy: 0.7963
Epoch 35/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0950 -
accuracy: 0.9630 - val_loss: 0.7092 - val_accuracy: 0.7963
Epoch 36/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0780 -
accuracy: 0.9677 - val_loss: 0.6939 - val_accuracy: 0.7963
Epoch 37/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0971 -
accuracy: 0.9677 - val_loss: 0.7019 - val_accuracy: 0.7963
Epoch 38/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0802 -
accuracy: 0.9746 - val_loss: 0.6930 - val_accuracy: 0.7685
Epoch 39/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0701 -
accuracy: 0.9769 - val_loss: 0.7173 - val_accuracy: 0.8056
Epoch 40/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0806 -
accuracy: 0.9654 - val_loss: 0.7192 - val_accuracy: 0.8056
Epoch 41/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1131 -
accuracy: 0.9607 - val_loss: 0.7010 - val_accuracy: 0.7963
Epoch 42/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0735 -
accuracy: 0.9746 - val_loss: 0.6837 - val_accuracy: 0.8056
Epoch 43/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0659 -
accuracy: 0.9723 - val_loss: 0.7079 - val_accuracy: 0.8148
Epoch 44/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0621 -
accuracy: 0.9838 - val_loss: 0.7144 - val_accuracy: 0.8056
Epoch 45/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0741 -
accuracy: 0.9654 - val_loss: 0.7184 - val_accuracy: 0.7963
Epoch 46/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0565 -
accuracy: 0.9838 - val_loss: 0.7214 - val_accuracy: 0.8056
Epoch 47/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0618 -
accuracy: 0.9746 - val_loss: 0.7230 - val_accuracy: 0.7870
Epoch 48/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0672 -
accuracy: 0.9815 - val_loss: 0.7175 - val_accuracy: 0.7963
Epoch 49/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0836 -
accuracy: 0.9630 - val_loss: 0.7191 - val_accuracy: 0.8148
Epoch 50/50
```

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433/433 [==============================] - 1s 2ms/sample - loss: 0.0830 -
accuracy: 0.9630 - val_loss: 0.7530 - val_accuracy: 0.8056
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 4s 8ms/sample - loss: 0.5890 -
accuracy: 0.7760 - val_loss: 0.4316 - val_accuracy: 0.8148
Epoch 2/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.4051 -
accuracy: 0.8430 - val_loss: 0.3872 - val_accuracy: 0.8611
Epoch 3/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3198 -
accuracy: 0.8799 - val_loss: 0.4730 - val_accuracy: 0.8241
Epoch 4/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3047 -
accuracy: 0.8961 - val_loss: 0.3310 - val_accuracy: 0.8519
Epoch 5/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2930 -
accuracy: 0.8891 - val_loss: 0.3355 - val_accuracy: 0.8889
Epoch 6/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2991 -
accuracy: 0.8868 - val_loss: 0.3402 - val_accuracy: 0.8704
Epoch 7/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3184 -
accuracy: 0.8868 - val_loss: 0.3607 - val_accuracy: 0.8796
Epoch 8/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2603 -
accuracy: 0.8984 - val_loss: 0.4126 - val_accuracy: 0.8333
Epoch 9/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2528 -
accuracy: 0.9007 - val_loss: 0.3920 - val_accuracy: 0.8611
Epoch 10/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2199 -
accuracy: 0.9169 - val_loss: 0.4150 - val_accuracy: 0.8426
Epoch 11/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2348 -
accuracy: 0.9169 - val_loss: 0.4131 - val_accuracy: 0.8519
Epoch 12/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2410 -
accuracy: 0.9076 - val_loss: 0.4140 - val_accuracy: 0.8519
Epoch 13/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1964 -
accuracy: 0.9284 - val_loss: 0.4086 - val_accuracy: 0.8796
Epoch 14/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2687 -
accuracy: 0.9053 - val_loss: 0.4308 - val_accuracy: 0.8611
Epoch 15/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1776 -
accuracy: 0.9238 - val_loss: 0.4350 - val_accuracy: 0.8426
```

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Epoch 16/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1595 -
accuracy: 0.9376 - val_loss: 0.4889 - val_accuracy: 0.8519
Epoch 17/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1640 -
accuracy: 0.9492 - val_loss: 0.4879 - val_accuracy: 0.8426
Epoch 18/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2156 -
accuracy: 0.9169 - val_loss: 0.5370 - val_accuracy: 0.8333
Epoch 19/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1473 -
accuracy: 0.9515 - val_loss: 0.5069 - val_accuracy: 0.8333
Epoch 20/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1665 -
accuracy: 0.9492 - val_loss: 0.5345 - val_accuracy: 0.8426
Epoch 21/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1921 -
accuracy: 0.9353 - val_loss: 0.5546 - val_accuracy: 0.8426
Epoch 22/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1652 -
accuracy: 0.9423 - val_loss: 0.5091 - val_accuracy: 0.8426
Epoch 23/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1094 -
accuracy: 0.9677 - val_loss: 0.5231 - val_accuracy: 0.8611
Epoch 24/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1538 -
accuracy: 0.9400 - val_loss: 0.5313 - val_accuracy: 0.8241
Epoch 25/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1538 -
accuracy: 0.9469 - val_loss: 0.5868 - val_accuracy: 0.8333
Epoch 26/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1424 -
accuracy: 0.9423 - val_loss: 0.5824 - val_accuracy: 0.8241
Epoch 27/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1365 -
accuracy: 0.9538 - val_loss: 0.5822 - val_accuracy: 0.8241
Epoch 28/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1184 -
accuracy: 0.9700 - val_loss: 0.5879 - val_accuracy: 0.8241
Epoch 29/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1191 -
accuracy: 0.9538 - val_loss: 0.6025 - val_accuracy: 0.8148
Epoch 30/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1601 -
accuracy: 0.9515 - val_loss: 0.5887 - val_accuracy: 0.8241
Epoch 31/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1446 -
accuracy: 0.9584 - val_loss: 0.5902 - val_accuracy: 0.8148
```

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Epoch 32/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1341 -
accuracy: 0.9469 - val_loss: 0.6166 - val_accuracy: 0.8333
Epoch 33/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1461 -
accuracy: 0.9630 - val_loss: 0.5958 - val_accuracy: 0.8519
Epoch 34/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1269 -
accuracy: 0.9607 - val_loss: 0.5903 - val_accuracy: 0.8611
Epoch 35/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1742 -
accuracy: 0.9423 - val_loss: 0.5884 - val_accuracy: 0.8611
Epoch 36/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1083 -
accuracy: 0.9654 - val_loss: 0.6331 - val_accuracy: 0.8519
Epoch 37/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1548 -
accuracy: 0.9330 - val_loss: 0.6056 - val_accuracy: 0.8333
Epoch 38/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1185 -
accuracy: 0.9492 - val_loss: 0.6120 - val_accuracy: 0.8333
Epoch 39/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0901 -
accuracy: 0.9815 - val_loss: 0.6186 - val_accuracy: 0.8333
Epoch 40/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0960 -
accuracy: 0.9654 - val_loss: 0.6262 - val_accuracy: 0.8426
Epoch 41/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1106 -
accuracy: 0.9561 - val_loss: 0.6405 - val_accuracy: 0.8333
Epoch 42/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1079 -
accuracy: 0.9561 - val_loss: 0.6590 - val_accuracy: 0.8333
Epoch 43/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1127 -
accuracy: 0.9515 - val_loss: 0.6768 - val_accuracy: 0.8426
Epoch 44/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1134 -
accuracy: 0.9630 - val_loss: 0.6700 - val_accuracy: 0.8611
Epoch 45/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0808 -
accuracy: 0.9746 - val_loss: 0.6646 - val_accuracy: 0.8611
Epoch 46/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0820 -
accuracy: 0.9700 - val_loss: 0.7188 - val_accuracy: 0.8704
Epoch 47/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0903 -
accuracy: 0.9723 - val_loss: 0.6960 - val_accuracy: 0.8611
```

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Epoch 48/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0708 -
accuracy: 0.9792 - val_loss: 0.6797 - val_accuracy: 0.8519
Epoch 49/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0931 -
accuracy: 0.9584 - val_loss: 0.7301 - val_accuracy: 0.7963
Epoch 50/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0789 -
accuracy: 0.9815 - val_loss: 0.7023 - val_accuracy: 0.8056
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 4s 10ms/sample - loss: 0.5621 -
accuracy: 0.7829 - val_loss: 1.1423 - val_accuracy: 0.3611
Epoch 2/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.4833 -
accuracy: 0.8199 - val_loss: 1.0276 - val_accuracy: 0.3796
Epoch 3/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.3709 -
accuracy: 0.8707 - val_loss: 1.4671 - val_accuracy: 0.3611
Epoch 4/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.3280 -
accuracy: 0.8684 - val_loss: 0.8932 - val_accuracy: 0.4630
Epoch 5/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.3169 -
accuracy: 0.8822 - val_loss: 1.5488 - val_accuracy: 0.3611
Epoch 6/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2838 -
accuracy: 0.9030 - val_loss: 1.3386 - val_accuracy: 0.3704
Epoch 7/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.3041 -
accuracy: 0.8868 - val_loss: 0.9691 - val_accuracy: 0.5000
Epoch 8/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2432 -
accuracy: 0.9053 - val_loss: 0.9885 - val_accuracy: 0.4259
Epoch 9/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2600 -
accuracy: 0.9076 - val_loss: 0.8033 - val_accuracy: 0.5278
Epoch 10/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2251 -
accuracy: 0.9169 - val_loss: 0.5783 - val_accuracy: 0.7222
Epoch 11/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2293 -
accuracy: 0.9284 - val_loss: 0.6844 - val_accuracy: 0.6667
Epoch 12/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.2176 -
accuracy: 0.9192 - val_loss: 0.6799 - val_accuracy: 0.6852
Epoch 13/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.2051 -
```

```
accuracy: 0.9145 - val_loss: 0.7439 - val_accuracy: 0.6019
Epoch 14/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1979 -
accuracy: 0.9376 - val_loss: 0.5911 - val_accuracy: 0.7222
Epoch 15/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1952 -
accuracy: 0.9330 - val_loss: 0.4971 - val_accuracy: 0.7778
Epoch 16/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1875 -
accuracy: 0.9330 - val_loss: 0.4623 - val_accuracy: 0.7870
Epoch 17/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1848 -
accuracy: 0.9284 - val_loss: 0.4546 - val_accuracy: 0.8056
Epoch 18/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1562 -
accuracy: 0.9538 - val_loss: 0.4673 - val_accuracy: 0.8056
Epoch 19/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1118 -
accuracy: 0.9677 - val_loss: 0.4601 - val_accuracy: 0.8148
Epoch 20/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1499 -
accuracy: 0.9492 - val_loss: 0.4755 - val_accuracy: 0.8056
Epoch 21/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1464 -
accuracy: 0.9469 - val_loss: 0.4702 - val_accuracy: 0.8148
Epoch 22/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1352 -
accuracy: 0.9330 - val_loss: 0.4745 - val_accuracy: 0.8148
Epoch 23/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1346 -
accuracy: 0.9584 - val_loss: 0.4831 - val_accuracy: 0.8148
Epoch 24/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1424 -
accuracy: 0.9538 - val_loss: 0.4539 - val_accuracy: 0.8056
Epoch 25/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1235 -
accuracy: 0.9561 - val_loss: 0.4599 - val_accuracy: 0.8241
Epoch 26/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1608 -
accuracy: 0.9469 - val_loss: 0.4463 - val_accuracy: 0.8241
Epoch 27/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1652 -
accuracy: 0.9353 - val_loss: 0.4627 - val_accuracy: 0.8148
Epoch 28/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1200 -
accuracy: 0.9515 - val_loss: 0.4603 - val_accuracy: 0.8148
Epoch 29/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1332 -
```

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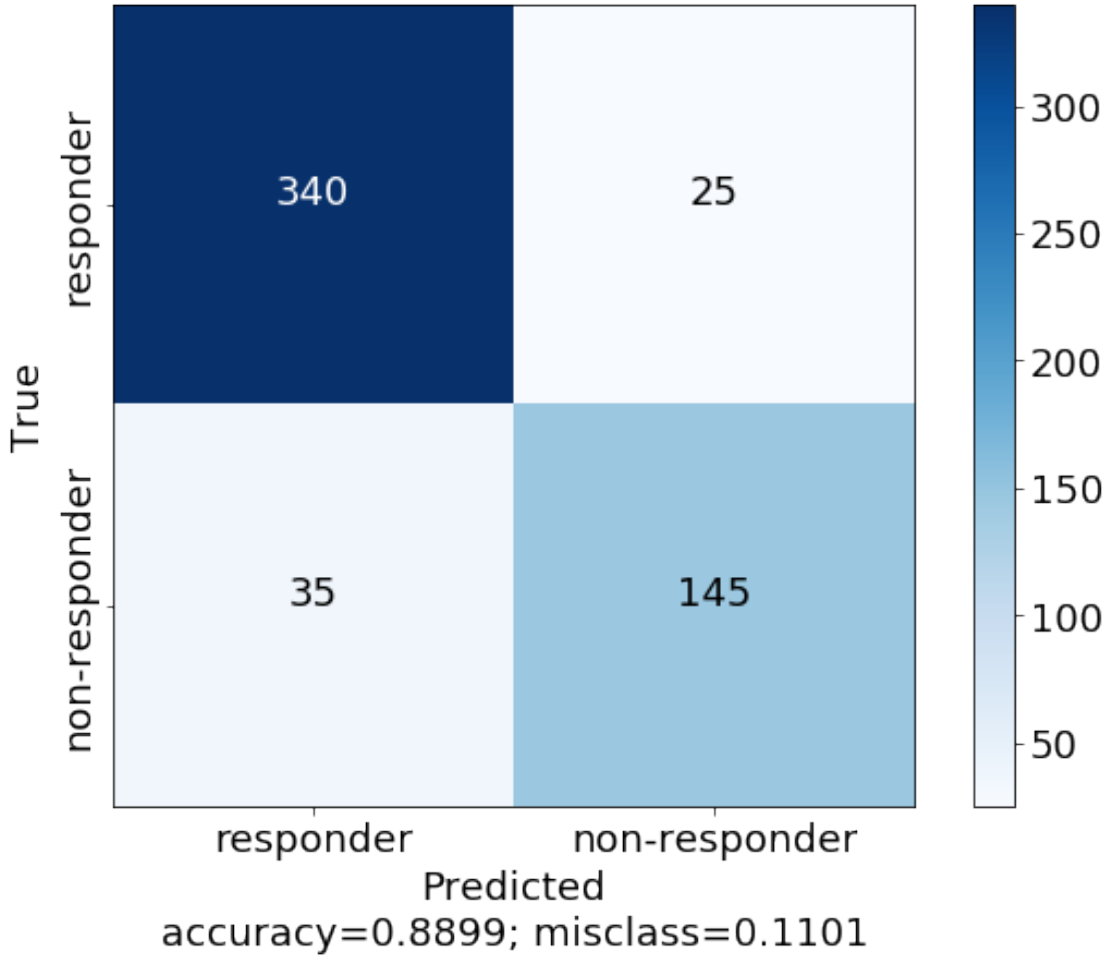
accuracy: 0.9423 - val_loss: 0.4679 - val_accuracy: 0.8056
Epoch 30/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1487 -
accuracy: 0.9538 - val_loss: 0.4476 - val_accuracy: 0.8241
Epoch 31/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1017 -
accuracy: 0.9538 - val_loss: 0.4459 - val_accuracy: 0.8426
Epoch 32/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1357 -
accuracy: 0.9469 - val_loss: 0.4432 - val_accuracy: 0.8241
Epoch 33/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0915 -
accuracy: 0.9677 - val_loss: 0.4545 - val_accuracy: 0.8148
Epoch 34/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1015 -
accuracy: 0.9677 - val_loss: 0.4798 - val_accuracy: 0.8426
Epoch 35/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1230 -
accuracy: 0.9584 - val_loss: 0.5196 - val_accuracy: 0.7963
Epoch 36/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1120 -
accuracy: 0.9700 - val_loss: 0.5024 - val_accuracy: 0.8148
Epoch 37/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1148 -
accuracy: 0.9584 - val_loss: 0.5110 - val_accuracy: 0.8056
Epoch 38/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0803 -
accuracy: 0.9700 - val_loss: 0.5131 - val_accuracy: 0.8056
Epoch 39/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1054 -
accuracy: 0.9607 - val_loss: 0.5083 - val_accuracy: 0.8241
Epoch 40/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1226 -
accuracy: 0.9700 - val_loss: 0.4922 - val_accuracy: 0.8241
Epoch 41/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0921 -
accuracy: 0.9677 - val_loss: 0.5021 - val_accuracy: 0.8241
Epoch 42/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0733 -
accuracy: 0.9700 - val_loss: 0.5203 - val_accuracy: 0.8056
Epoch 43/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1074 -
accuracy: 0.9584 - val_loss: 0.5248 - val_accuracy: 0.7963
Epoch 44/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1063 -
accuracy: 0.9607 - val_loss: 0.5207 - val_accuracy: 0.8241
Epoch 45/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0743 -
```

```
accuracy: 0.9746 - val_loss: 0.5095 - val_accuracy: 0.8148
Epoch 46/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1194 -
accuracy: 0.9607 - val_loss: 0.5219 - val_accuracy: 0.7870
Epoch 47/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.1628 -
accuracy: 0.9400 - val_loss: 0.5345 - val_accuracy: 0.7870
Epoch 48/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0767 -
accuracy: 0.9700 - val_loss: 0.5426 - val_accuracy: 0.8056
Epoch 49/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0926 -
accuracy: 0.9677 - val_loss: 0.5466 - val_accuracy: 0.7870
Epoch 50/50
433/433 [==============================] - 1s 2ms/sample - loss: 0.0989 -
accuracy: 0.9584 - val_loss: 0.5318 - val_accuracy: 0.8056
```

[293]:
```
cm4 = [[0, 0]]
k, l = 0, 0
for i in cm_results4:
    for j in cm_results4[0]:
        cm4[k][l] += j
        l = (l+1) % 2
    j = (j+1) % 2
cm4 = np.array(cm4[0])
```

[227]:
```
plt.rcParams.update({'font.size': 18})
plot_confusion_matrix(cm4, ['responder', 'non-responder'], title='',␣
↪normalize=False)
```



4 3 Hidden Layers

[251]:
```
def hidden3(optimizer='rmsprop',init='glorot_uniform', dropout=0.3):
    model = Sequential()
    # adding layers and adding droplayers to avoid overfitting
    hidden_layers = len(selected_genes)
    model.add(Dense(hidden_layers*2, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*4, activation='relu'))
    model.add(BatchNormalization())
    model.add(Dropout(dropout))

    model.add(Dense(hidden_layers*2, activation='relu'))
    model.add(BatchNormalization())
```

```
    model.add(Dropout(dropout))

    model.add(Dense(1, activation='sigmoid'))
    # compiling
    model.compile(optimizer=optimizer, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
    return model
```

[296]:
```
model3 = KerasClassifier(build_fn=hidden3, epochs=50, batch_size=32,␣
 ↪optimizer='adagrad',init='normal')
kf = KFold(n_splits=5)

cm_results3 = []
history_results3 = []
for train_index, test_index in kf.split(X, y):
    X_train, X_test = X.iloc[train_index].values, X.iloc[test_index].values
    y_train, y_test = y[train_index], y[test_index]
    # fitting
    history3 = model3.fit(X_train, y_train, validation_data=(X_test,y_test))
    # recording
    cm_results3.append(confusion_matrix(y_test, model3.predict(X_test)))
    history_results3.append(history)
```

```
Train on 432 samples, validate on 109 samples
Epoch 1/50
432/432 [==============================] - 3s 6ms/sample - loss: 0.5903 -
accuracy: 0.8102 - val_loss: 1.3038 - val_accuracy: 0.3303
Epoch 2/50
432/432 [==============================] - 0s 826us/sample - loss: 0.4130 -
accuracy: 0.8634 - val_loss: 1.3841 - val_accuracy: 0.3303
Epoch 3/50
432/432 [==============================] - 0s 842us/sample - loss: 0.3564 -
accuracy: 0.8634 - val_loss: 0.8878 - val_accuracy: 0.4404
Epoch 4/50
432/432 [==============================] - 0s 839us/sample - loss: 0.3475 -
accuracy: 0.8704 - val_loss: 0.5882 - val_accuracy: 0.6147
Epoch 5/50
432/432 [==============================] - 0s 844us/sample - loss: 0.2833 -
accuracy: 0.8843 - val_loss: 0.8651 - val_accuracy: 0.4128
Epoch 6/50
432/432 [==============================] - 0s 869us/sample - loss: 0.2699 -
accuracy: 0.8912 - val_loss: 0.6625 - val_accuracy: 0.5596
Epoch 7/50
432/432 [==============================] - 0s 848us/sample - loss: 0.2563 -
accuracy: 0.8958 - val_loss: 0.8099 - val_accuracy: 0.4954
Epoch 8/50
432/432 [==============================] - 0s 840us/sample - loss: 0.2507 -
```

```
accuracy: 0.8912 - val_loss: 0.5083 - val_accuracy: 0.7339
Epoch 9/50
432/432 [==============================] - 0s 868us/sample - loss: 0.2492 -
accuracy: 0.8958 - val_loss: 1.1615 - val_accuracy: 0.3945
Epoch 10/50
432/432 [==============================] - 0s 889us/sample - loss: 0.2364 -
accuracy: 0.9028 - val_loss: 0.6215 - val_accuracy: 0.6514
Epoch 11/50
432/432 [==============================] - 0s 906us/sample - loss: 0.2240 -
accuracy: 0.9144 - val_loss: 0.7831 - val_accuracy: 0.5413
Epoch 12/50
432/432 [==============================] - 0s 890us/sample - loss: 0.2007 -
accuracy: 0.9306 - val_loss: 0.4794 - val_accuracy: 0.7615
Epoch 13/50
432/432 [==============================] - 0s 891us/sample - loss: 0.1684 -
accuracy: 0.9352 - val_loss: 0.4423 - val_accuracy: 0.8257
Epoch 14/50
432/432 [==============================] - 0s 893us/sample - loss: 0.1695 -
accuracy: 0.9352 - val_loss: 0.3507 - val_accuracy: 0.8624
Epoch 15/50
432/432 [==============================] - 0s 896us/sample - loss: 0.1812 -
accuracy: 0.9398 - val_loss: 0.5865 - val_accuracy: 0.6606
Epoch 16/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1723 -
accuracy: 0.9375 - val_loss: 0.4541 - val_accuracy: 0.7982
Epoch 17/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1649 -
accuracy: 0.9306 - val_loss: 0.3716 - val_accuracy: 0.8624
Epoch 18/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1753 -
accuracy: 0.9282 - val_loss: 0.3476 - val_accuracy: 0.8624
Epoch 19/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1827 -
accuracy: 0.9259 - val_loss: 0.3090 - val_accuracy: 0.8716
Epoch 20/50
432/432 [==============================] - 0s 973us/sample - loss: 0.1895 -
accuracy: 0.9236 - val_loss: 0.3873 - val_accuracy: 0.8624
Epoch 21/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1503 -
accuracy: 0.9375 - val_loss: 0.2470 - val_accuracy: 0.9083
Epoch 22/50
432/432 [==============================] - 0s 993us/sample - loss: 0.1646 -
accuracy: 0.9329 - val_loss: 0.2640 - val_accuracy: 0.9174
Epoch 23/50
432/432 [==============================] - 0s 969us/sample - loss: 0.1682 -
accuracy: 0.9444 - val_loss: 0.2469 - val_accuracy: 0.9174
Epoch 24/50
432/432 [==============================] - 0s 978us/sample - loss: 0.1329 -
```

```
accuracy: 0.9444 - val_loss: 0.2396 - val_accuracy: 0.9174
Epoch 25/50
432/432 [==============================] - 0s 997us/sample - loss: 0.1361 -
accuracy: 0.9514 - val_loss: 0.2473 - val_accuracy: 0.9083
Epoch 26/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1221 -
accuracy: 0.9560 - val_loss: 0.2481 - val_accuracy: 0.9083
Epoch 27/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1306 -
accuracy: 0.9583 - val_loss: 0.2903 - val_accuracy: 0.9083
Epoch 28/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1455 -
accuracy: 0.9444 - val_loss: 0.3375 - val_accuracy: 0.8991
Epoch 29/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1154 -
accuracy: 0.9630 - val_loss: 0.3079 - val_accuracy: 0.8991
Epoch 30/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1135 -
accuracy: 0.9583 - val_loss: 0.2796 - val_accuracy: 0.9174
Epoch 31/50
432/432 [==============================] - 0s 999us/sample - loss: 0.1154 -
accuracy: 0.9583 - val_loss: 0.2763 - val_accuracy: 0.9083
Epoch 32/50
432/432 [==============================] - 0s 992us/sample - loss: 0.1474 -
accuracy: 0.9444 - val_loss: 0.2738 - val_accuracy: 0.8899
Epoch 33/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1000 -
accuracy: 0.9606 - val_loss: 0.2943 - val_accuracy: 0.8807
Epoch 34/50
432/432 [==============================] - 0s 981us/sample - loss: 0.1339 -
accuracy: 0.9676 - val_loss: 0.2730 - val_accuracy: 0.8991
Epoch 35/50
432/432 [==============================] - 0s 991us/sample - loss: 0.1207 -
accuracy: 0.9560 - val_loss: 0.2527 - val_accuracy: 0.9174
Epoch 36/50
432/432 [==============================] - 0s 967us/sample - loss: 0.1186 -
accuracy: 0.9537 - val_loss: 0.2479 - val_accuracy: 0.9083
Epoch 37/50
432/432 [==============================] - 0s 983us/sample - loss: 0.1084 -
accuracy: 0.9630 - val_loss: 0.2798 - val_accuracy: 0.8991
Epoch 38/50
432/432 [==============================] - 0s 967us/sample - loss: 0.0796 -
accuracy: 0.9676 - val_loss: 0.3035 - val_accuracy: 0.8899
Epoch 39/50
432/432 [==============================] - 0s 956us/sample - loss: 0.1003 -
accuracy: 0.9745 - val_loss: 0.2682 - val_accuracy: 0.9174
Epoch 40/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1250 -
```

```
accuracy: 0.9630 - val_loss: 0.3103 - val_accuracy: 0.8899
Epoch 41/50
432/432 [==============================] - 0s 995us/sample - loss: 0.1203 -
accuracy: 0.9375 - val_loss: 0.3290 - val_accuracy: 0.8807
Epoch 42/50
432/432 [==============================] - 0s 983us/sample - loss: 0.0982 -
accuracy: 0.9699 - val_loss: 0.3233 - val_accuracy: 0.8807
Epoch 43/50
432/432 [==============================] - 0s 967us/sample - loss: 0.1208 -
accuracy: 0.9514 - val_loss: 0.2914 - val_accuracy: 0.9083
Epoch 44/50
432/432 [==============================] - 0s 992us/sample - loss: 0.0771 -
accuracy: 0.9815 - val_loss: 0.2787 - val_accuracy: 0.9174
Epoch 45/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.0757 -
accuracy: 0.9792 - val_loss: 0.2849 - val_accuracy: 0.9174
Epoch 46/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1060 -
accuracy: 0.9606 - val_loss: 0.3066 - val_accuracy: 0.9083
Epoch 47/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1020 -
accuracy: 0.9606 - val_loss: 0.2968 - val_accuracy: 0.9083
Epoch 48/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.0810 -
accuracy: 0.9676 - val_loss: 0.3052 - val_accuracy: 0.8991
Epoch 49/50
432/432 [==============================] - 0s 991us/sample - loss: 0.0939 -
accuracy: 0.9676 - val_loss: 0.3205 - val_accuracy: 0.8899
Epoch 50/50
432/432 [==============================] - 0s 1ms/sample - loss: 0.1100 -
accuracy: 0.9676 - val_loss: 0.3360 - val_accuracy: 0.8991
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 3s 7ms/sample - loss: 0.6011 -
accuracy: 0.7852 - val_loss: 0.6154 - val_accuracy: 0.6759
Epoch 2/50
433/433 [==============================] - 0s 987us/sample - loss: 0.3739 -
accuracy: 0.8360 - val_loss: 0.4556 - val_accuracy: 0.7963
Epoch 3/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.3376 -
accuracy: 0.8753 - val_loss: 0.8540 - val_accuracy: 0.4630
Epoch 4/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2765 -
accuracy: 0.9007 - val_loss: 0.7105 - val_accuracy: 0.6296
Epoch 5/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2258 -
accuracy: 0.9145 - val_loss: 0.6786 - val_accuracy: 0.6574
Epoch 6/50
```

```
433/433 [==============================] - 0s 976us/sample - loss: 0.2592 -
accuracy: 0.9030 - val_loss: 0.5439 - val_accuracy: 0.7685
Epoch 7/50
433/433 [==============================] - 0s 977us/sample - loss: 0.2044 -
accuracy: 0.9307 - val_loss: 0.7482 - val_accuracy: 0.6481
Epoch 8/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1877 -
accuracy: 0.9192 - val_loss: 0.6663 - val_accuracy: 0.6852
Epoch 9/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2285 -
accuracy: 0.9099 - val_loss: 0.8826 - val_accuracy: 0.5556
Epoch 10/50
433/433 [==============================] - 0s 990us/sample - loss: 0.1780 -
accuracy: 0.9376 - val_loss: 0.7643 - val_accuracy: 0.6481
Epoch 11/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2018 -
accuracy: 0.9307 - val_loss: 0.7386 - val_accuracy: 0.6296
Epoch 12/50
433/433 [==============================] - 0s 966us/sample - loss: 0.1629 -
accuracy: 0.9376 - val_loss: 0.6298 - val_accuracy: 0.7315
Epoch 13/50
433/433 [==============================] - 0s 1000us/sample - loss: 0.1672 -
accuracy: 0.9492 - val_loss: 0.7573 - val_accuracy: 0.6574
Epoch 14/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1766 -
accuracy: 0.9353 - val_loss: 0.7644 - val_accuracy: 0.6481
Epoch 15/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1271 -
accuracy: 0.9538 - val_loss: 0.6916 - val_accuracy: 0.6852
Epoch 16/50
433/433 [==============================] - 0s 984us/sample - loss: 0.1710 -
accuracy: 0.9376 - val_loss: 0.8147 - val_accuracy: 0.6111
Epoch 17/50
433/433 [==============================] - 0s 989us/sample - loss: 0.1355 -
accuracy: 0.9515 - val_loss: 0.6003 - val_accuracy: 0.7315
Epoch 18/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1371 -
accuracy: 0.9423 - val_loss: 0.5973 - val_accuracy: 0.7315
Epoch 19/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1232 -
accuracy: 0.9677 - val_loss: 0.5564 - val_accuracy: 0.7963
Epoch 20/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1644 -
accuracy: 0.9400 - val_loss: 0.6541 - val_accuracy: 0.7037
Epoch 21/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1382 -
accuracy: 0.9538 - val_loss: 0.7082 - val_accuracy: 0.6852
Epoch 22/50
```

```
433/433 [==============================] - 0s 1ms/sample - loss: 0.1508 -
accuracy: 0.9400 - val_loss: 0.6295 - val_accuracy: 0.7315
Epoch 23/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1139 -
accuracy: 0.9584 - val_loss: 0.5597 - val_accuracy: 0.7685
Epoch 24/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1156 -
accuracy: 0.9654 - val_loss: 0.6166 - val_accuracy: 0.7593
Epoch 25/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1332 -
accuracy: 0.9584 - val_loss: 0.6081 - val_accuracy: 0.7870
Epoch 26/50
433/433 [==============================] - 0s 992us/sample - loss: 0.1295 -
accuracy: 0.9492 - val_loss: 0.6631 - val_accuracy: 0.7593
Epoch 27/50
433/433 [==============================] - 0s 989us/sample - loss: 0.1136 -
accuracy: 0.9630 - val_loss: 0.6436 - val_accuracy: 0.7778
Epoch 28/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0881 -
accuracy: 0.9792 - val_loss: 0.5883 - val_accuracy: 0.8148
Epoch 29/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1169 -
accuracy: 0.9400 - val_loss: 0.6119 - val_accuracy: 0.7963
Epoch 30/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0812 -
accuracy: 0.9746 - val_loss: 0.6083 - val_accuracy: 0.8056
Epoch 31/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0647 -
accuracy: 0.9792 - val_loss: 0.5698 - val_accuracy: 0.8333
Epoch 32/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1137 -
accuracy: 0.9584 - val_loss: 0.5590 - val_accuracy: 0.8333
Epoch 33/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0865 -
accuracy: 0.9746 - val_loss: 0.5721 - val_accuracy: 0.8148
Epoch 34/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.1395 -
accuracy: 0.9515 - val_loss: 0.5671 - val_accuracy: 0.8241
Epoch 35/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0914 -
accuracy: 0.9677 - val_loss: 0.5683 - val_accuracy: 0.8148
Epoch 36/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1100 -
accuracy: 0.9630 - val_loss: 0.5866 - val_accuracy: 0.8241
Epoch 37/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0829 -
accuracy: 0.9723 - val_loss: 0.5934 - val_accuracy: 0.8148
Epoch 38/50
```

```
433/433 [==============================] - 0s 1ms/sample - loss: 0.0855 -
accuracy: 0.9700 - val_loss: 0.5701 - val_accuracy: 0.8241
Epoch 39/50
433/433 [==============================] - 1s 1ms/sample - loss: 0.0696 -
accuracy: 0.9838 - val_loss: 0.5940 - val_accuracy: 0.8148
Epoch 40/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0821 -
accuracy: 0.9700 - val_loss: 0.6029 - val_accuracy: 0.8241
Epoch 41/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0644 -
accuracy: 0.9815 - val_loss: 0.6117 - val_accuracy: 0.8426
Epoch 42/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1146 -
accuracy: 0.9677 - val_loss: 0.5964 - val_accuracy: 0.8241
Epoch 43/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0763 -
accuracy: 0.9861 - val_loss: 0.5974 - val_accuracy: 0.8148
Epoch 44/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0775 -
accuracy: 0.9723 - val_loss: 0.6226 - val_accuracy: 0.8241
Epoch 45/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1078 -
accuracy: 0.9677 - val_loss: 0.6017 - val_accuracy: 0.8333
Epoch 46/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0695 -
accuracy: 0.9723 - val_loss: 0.6123 - val_accuracy: 0.8519
Epoch 47/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0838 -
accuracy: 0.9792 - val_loss: 0.6136 - val_accuracy: 0.8148
Epoch 48/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0608 -
accuracy: 0.9792 - val_loss: 0.6275 - val_accuracy: 0.8056
Epoch 49/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1097 -
accuracy: 0.9538 - val_loss: 0.6535 - val_accuracy: 0.7963
Epoch 50/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0583 -
accuracy: 0.9838 - val_loss: 0.6446 - val_accuracy: 0.7963
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 3s 6ms/sample - loss: 0.5012 -
accuracy: 0.8129 - val_loss: 0.8115 - val_accuracy: 0.7222
Epoch 2/50
433/433 [==============================] - 0s 940us/sample - loss: 0.3324 -
accuracy: 0.8661 - val_loss: 0.6044 - val_accuracy: 0.7870
Epoch 3/50
433/433 [==============================] - 0s 962us/sample - loss: 0.3025 -
accuracy: 0.8845 - val_loss: 0.4403 - val_accuracy: 0.8241
```

```
Epoch 4/50
433/433 [==============================] - 0s 958us/sample - loss: 0.2685 -
accuracy: 0.8961 - val_loss: 0.4489 - val_accuracy: 0.8241
Epoch 5/50
433/433 [==============================] - 0s 960us/sample - loss: 0.2082 -
accuracy: 0.9261 - val_loss: 0.4648 - val_accuracy: 0.7963
Epoch 6/50
433/433 [==============================] - 0s 965us/sample - loss: 0.2038 -
accuracy: 0.9215 - val_loss: 0.4746 - val_accuracy: 0.8241
Epoch 7/50
433/433 [==============================] - 0s 960us/sample - loss: 0.2030 -
accuracy: 0.9099 - val_loss: 0.4893 - val_accuracy: 0.8241
Epoch 8/50
433/433 [==============================] - 0s 968us/sample - loss: 0.2082 -
accuracy: 0.9215 - val_loss: 0.6376 - val_accuracy: 0.6667
Epoch 9/50
433/433 [==============================] - 0s 969us/sample - loss: 0.1760 -
accuracy: 0.9238 - val_loss: 0.5327 - val_accuracy: 0.7685
Epoch 10/50
433/433 [==============================] - 0s 973us/sample - loss: 0.1547 -
accuracy: 0.9353 - val_loss: 0.5161 - val_accuracy: 0.8056
Epoch 11/50
433/433 [==============================] - 0s 975us/sample - loss: 0.1529 -
accuracy: 0.9469 - val_loss: 0.5894 - val_accuracy: 0.7407
Epoch 12/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1756 -
accuracy: 0.9307 - val_loss: 0.6069 - val_accuracy: 0.7130
Epoch 13/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1595 -
accuracy: 0.9330 - val_loss: 0.5709 - val_accuracy: 0.7222
Epoch 14/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1742 -
accuracy: 0.9446 - val_loss: 0.7920 - val_accuracy: 0.6574
Epoch 15/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2075 -
accuracy: 0.9169 - val_loss: 0.6475 - val_accuracy: 0.7130
Epoch 16/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1435 -
accuracy: 0.9423 - val_loss: 0.7096 - val_accuracy: 0.6944
Epoch 17/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1269 -
accuracy: 0.9584 - val_loss: 0.8607 - val_accuracy: 0.6481
Epoch 18/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1456 -
accuracy: 0.9515 - val_loss: 0.8125 - val_accuracy: 0.6389
Epoch 19/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1552 -
accuracy: 0.9492 - val_loss: 0.6447 - val_accuracy: 0.7130
```

```
Epoch 20/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1114 -
accuracy: 0.9677 - val_loss: 0.6493 - val_accuracy: 0.7222
Epoch 21/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1155 -
accuracy: 0.9492 - val_loss: 0.6605 - val_accuracy: 0.6944
Epoch 22/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1168 -
accuracy: 0.9607 - val_loss: 0.7136 - val_accuracy: 0.6667
Epoch 23/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0908 -
accuracy: 0.9677 - val_loss: 0.6744 - val_accuracy: 0.7037
Epoch 24/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0946 -
accuracy: 0.9700 - val_loss: 0.6359 - val_accuracy: 0.7315
Epoch 25/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1228 -
accuracy: 0.9538 - val_loss: 0.6478 - val_accuracy: 0.7037
Epoch 26/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1280 -
accuracy: 0.9492 - val_loss: 0.5942 - val_accuracy: 0.7963
Epoch 27/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0909 -
accuracy: 0.9561 - val_loss: 0.5833 - val_accuracy: 0.8333
Epoch 28/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0660 -
accuracy: 0.9815 - val_loss: 0.5914 - val_accuracy: 0.7870
Epoch 29/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0859 -
accuracy: 0.9723 - val_loss: 0.6034 - val_accuracy: 0.8148
Epoch 30/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1019 -
accuracy: 0.9584 - val_loss: 0.6122 - val_accuracy: 0.7870
Epoch 31/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1267 -
accuracy: 0.9561 - val_loss: 0.6810 - val_accuracy: 0.7130
Epoch 32/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0955 -
accuracy: 0.9746 - val_loss: 0.6301 - val_accuracy: 0.7685
Epoch 33/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1000 -
accuracy: 0.9700 - val_loss: 0.6910 - val_accuracy: 0.7222
Epoch 34/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0554 -
accuracy: 0.9861 - val_loss: 0.6569 - val_accuracy: 0.7870
Epoch 35/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0952 -
accuracy: 0.9677 - val_loss: 0.6480 - val_accuracy: 0.7963
```

```
Epoch 36/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0558 -
accuracy: 0.9861 - val_loss: 0.6432 - val_accuracy: 0.8056
Epoch 37/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0998 -
accuracy: 0.9607 - val_loss: 0.6314 - val_accuracy: 0.7870
Epoch 38/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0644 -
accuracy: 0.9885 - val_loss: 0.6361 - val_accuracy: 0.7870
Epoch 39/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0509 -
accuracy: 0.9815 - val_loss: 0.6436 - val_accuracy: 0.7778
Epoch 40/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0452 -
accuracy: 0.9838 - val_loss: 0.6591 - val_accuracy: 0.8148
Epoch 41/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1079 -
accuracy: 0.9654 - val_loss: 0.6509 - val_accuracy: 0.7870
Epoch 42/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0670 -
accuracy: 0.9838 - val_loss: 0.6658 - val_accuracy: 0.7870
Epoch 43/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0737 -
accuracy: 0.9792 - val_loss: 0.6615 - val_accuracy: 0.8056
Epoch 44/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0561 -
accuracy: 0.9815 - val_loss: 0.6768 - val_accuracy: 0.7963
Epoch 45/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0699 -
accuracy: 0.9769 - val_loss: 0.6854 - val_accuracy: 0.8056
Epoch 46/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0912 -
accuracy: 0.9584 - val_loss: 0.6744 - val_accuracy: 0.8148
Epoch 47/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0657 -
accuracy: 0.9815 - val_loss: 0.6534 - val_accuracy: 0.8148
Epoch 48/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0703 -
accuracy: 0.9769 - val_loss: 0.6783 - val_accuracy: 0.8148
Epoch 49/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0391 -
accuracy: 0.9931 - val_loss: 0.7167 - val_accuracy: 0.8148
Epoch 50/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0665 -
accuracy: 0.9769 - val_loss: 0.6890 - val_accuracy: 0.8148
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 3s 6ms/sample - loss: 0.5661 -
```

```
accuracy: 0.7898 - val_loss: 0.4457 - val_accuracy: 0.7963
Epoch 2/50
433/433 [==============================] - 0s 938us/sample - loss: 0.3251 -
accuracy: 0.8915 - val_loss: 0.3919 - val_accuracy: 0.8704
Epoch 3/50
433/433 [==============================] - 0s 921us/sample - loss: 0.3247 -
accuracy: 0.8891 - val_loss: 1.2205 - val_accuracy: 0.4537
Epoch 4/50
433/433 [==============================] - 0s 950us/sample - loss: 0.2739 -
accuracy: 0.8938 - val_loss: 0.9935 - val_accuracy: 0.4815
Epoch 5/50
433/433 [==============================] - 0s 934us/sample - loss: 0.2502 -
accuracy: 0.9099 - val_loss: 1.0114 - val_accuracy: 0.4907
Epoch 6/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2531 -
accuracy: 0.9076 - val_loss: 0.5973 - val_accuracy: 0.7407
Epoch 7/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2380 -
accuracy: 0.9169 - val_loss: 0.7081 - val_accuracy: 0.6852
Epoch 8/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2384 -
accuracy: 0.9192 - val_loss: 0.8866 - val_accuracy: 0.5648
Epoch 9/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2128 -
accuracy: 0.9261 - val_loss: 0.6766 - val_accuracy: 0.7222
Epoch 10/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1748 -
accuracy: 0.9307 - val_loss: 0.7449 - val_accuracy: 0.7037
Epoch 11/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1910 -
accuracy: 0.9261 - val_loss: 0.7456 - val_accuracy: 0.7222
Epoch 12/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1675 -
accuracy: 0.9400 - val_loss: 0.5850 - val_accuracy: 0.8333
Epoch 13/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1476 -
accuracy: 0.9607 - val_loss: 0.6343 - val_accuracy: 0.8056
Epoch 14/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1482 -
accuracy: 0.9515 - val_loss: 0.5399 - val_accuracy: 0.8519
Epoch 15/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1891 -
accuracy: 0.9284 - val_loss: 0.6317 - val_accuracy: 0.8148
Epoch 16/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2014 -
accuracy: 0.9423 - val_loss: 0.6819 - val_accuracy: 0.8056
Epoch 17/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1465 -
```

```
accuracy: 0.9584 - val_loss: 0.6569 - val_accuracy: 0.8148
Epoch 18/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1395 -
accuracy: 0.9515 - val_loss: 0.6903 - val_accuracy: 0.8148
Epoch 19/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1736 -
accuracy: 0.9353 - val_loss: 0.7576 - val_accuracy: 0.7778
Epoch 20/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1906 -
accuracy: 0.9261 - val_loss: 0.6336 - val_accuracy: 0.8333
Epoch 21/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1445 -
accuracy: 0.9561 - val_loss: 0.6718 - val_accuracy: 0.8241
Epoch 22/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1575 -
accuracy: 0.9446 - val_loss: 0.7984 - val_accuracy: 0.7778
Epoch 23/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1488 -
accuracy: 0.9515 - val_loss: 0.7278 - val_accuracy: 0.7963
Epoch 24/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1181 -
accuracy: 0.9607 - val_loss: 0.6770 - val_accuracy: 0.8148
Epoch 25/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1173 -
accuracy: 0.9654 - val_loss: 0.6610 - val_accuracy: 0.8333
Epoch 26/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1015 -
accuracy: 0.9723 - val_loss: 0.6287 - val_accuracy: 0.8333
Epoch 27/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1273 -
accuracy: 0.9515 - val_loss: 0.7055 - val_accuracy: 0.8148
Epoch 28/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1553 -
accuracy: 0.9515 - val_loss: 0.7182 - val_accuracy: 0.8056
Epoch 29/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1224 -
accuracy: 0.9607 - val_loss: 0.7122 - val_accuracy: 0.8056
Epoch 30/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0840 -
accuracy: 0.9723 - val_loss: 0.6948 - val_accuracy: 0.8148
Epoch 31/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1003 -
accuracy: 0.9700 - val_loss: 0.7084 - val_accuracy: 0.8148
Epoch 32/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1247 -
accuracy: 0.9561 - val_loss: 0.7332 - val_accuracy: 0.8056
Epoch 33/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1335 -
```

```
accuracy: 0.9515 - val_loss: 0.7038 - val_accuracy: 0.8333
Epoch 34/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0890 -
accuracy: 0.9769 - val_loss: 0.8084 - val_accuracy: 0.7778
Epoch 35/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1027 -
accuracy: 0.9677 - val_loss: 0.7432 - val_accuracy: 0.8148
Epoch 36/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1250 -
accuracy: 0.9607 - val_loss: 0.7524 - val_accuracy: 0.7963
Epoch 37/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0988 -
accuracy: 0.9654 - val_loss: 0.6918 - val_accuracy: 0.8333
Epoch 38/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1131 -
accuracy: 0.9654 - val_loss: 0.7216 - val_accuracy: 0.8056
Epoch 39/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1223 -
accuracy: 0.9607 - val_loss: 0.7457 - val_accuracy: 0.7870
Epoch 40/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0732 -
accuracy: 0.9769 - val_loss: 0.7184 - val_accuracy: 0.8241
Epoch 41/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0974 -
accuracy: 0.9677 - val_loss: 0.7146 - val_accuracy: 0.8241
Epoch 42/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1338 -
accuracy: 0.9515 - val_loss: 0.8075 - val_accuracy: 0.7870
Epoch 43/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0881 -
accuracy: 0.9677 - val_loss: 0.7658 - val_accuracy: 0.7963
Epoch 44/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0730 -
accuracy: 0.9861 - val_loss: 0.7428 - val_accuracy: 0.8148
Epoch 45/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0627 -
accuracy: 0.9838 - val_loss: 0.7487 - val_accuracy: 0.8056
Epoch 46/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1058 -
accuracy: 0.9677 - val_loss: 0.7561 - val_accuracy: 0.7963
Epoch 47/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0618 -
accuracy: 0.9908 - val_loss: 0.7472 - val_accuracy: 0.8056
Epoch 48/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0555 -
accuracy: 0.9861 - val_loss: 0.7397 - val_accuracy: 0.8148
Epoch 49/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0860 -
```

```
accuracy: 0.9792 - val_loss: 0.7401 - val_accuracy: 0.8148
Epoch 50/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0627 -
accuracy: 0.9815 - val_loss: 0.7406 - val_accuracy: 0.8333
Train on 433 samples, validate on 108 samples
Epoch 1/50
433/433 [==============================] - 4s 8ms/sample - loss: 0.6384 -
accuracy: 0.7644 - val_loss: 0.4413 - val_accuracy: 0.8056
Epoch 2/50
433/433 [==============================] - 0s 912us/sample - loss: 0.3455 -
accuracy: 0.8753 - val_loss: 0.6765 - val_accuracy: 0.7500
Epoch 3/50
433/433 [==============================] - 0s 921us/sample - loss: 0.3745 -
accuracy: 0.8661 - val_loss: 0.5014 - val_accuracy: 0.8056
Epoch 4/50
433/433 [==============================] - 0s 920us/sample - loss: 0.2895 -
accuracy: 0.8961 - val_loss: 0.4710 - val_accuracy: 0.8333
Epoch 5/50
433/433 [==============================] - 0s 914us/sample - loss: 0.2672 -
accuracy: 0.8938 - val_loss: 0.3964 - val_accuracy: 0.8241
Epoch 6/50
433/433 [==============================] - 0s 936us/sample - loss: 0.2242 -
accuracy: 0.9284 - val_loss: 0.4018 - val_accuracy: 0.8241
Epoch 7/50
433/433 [==============================] - 0s 942us/sample - loss: 0.2212 -
accuracy: 0.9353 - val_loss: 0.4022 - val_accuracy: 0.8241
Epoch 8/50
433/433 [==============================] - 0s 996us/sample - loss: 0.2084 -
accuracy: 0.9122 - val_loss: 0.4291 - val_accuracy: 0.8426
Epoch 9/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2041 -
accuracy: 0.9353 - val_loss: 0.4807 - val_accuracy: 0.8148
Epoch 10/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.2502 -
accuracy: 0.9145 - val_loss: 0.5104 - val_accuracy: 0.8056
Epoch 11/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1875 -
accuracy: 0.9307 - val_loss: 0.5858 - val_accuracy: 0.7593
Epoch 12/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1636 -
accuracy: 0.9400 - val_loss: 0.5873 - val_accuracy: 0.7500
Epoch 13/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1959 -
accuracy: 0.9284 - val_loss: 0.4477 - val_accuracy: 0.8056
Epoch 14/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1700 -
accuracy: 0.9515 - val_loss: 0.5770 - val_accuracy: 0.7315
Epoch 15/50
```

```
433/433 [==============================] - 0s 1ms/sample - loss: 0.1717 -
accuracy: 0.9307 - val_loss: 0.5661 - val_accuracy: 0.7407
Epoch 16/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1715 -
accuracy: 0.9330 - val_loss: 0.5252 - val_accuracy: 0.7685
Epoch 17/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1604 -
accuracy: 0.9469 - val_loss: 0.6545 - val_accuracy: 0.7130
Epoch 18/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1396 -
accuracy: 0.9538 - val_loss: 0.5839 - val_accuracy: 0.7222
Epoch 19/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1413 -
accuracy: 0.9492 - val_loss: 0.5187 - val_accuracy: 0.7963
Epoch 20/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1597 -
accuracy: 0.9400 - val_loss: 0.5909 - val_accuracy: 0.7222
Epoch 21/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1292 -
accuracy: 0.9607 - val_loss: 0.6104 - val_accuracy: 0.7130
Epoch 22/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1654 -
accuracy: 0.9423 - val_loss: 0.5644 - val_accuracy: 0.7500
Epoch 23/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1220 -
accuracy: 0.9607 - val_loss: 0.5023 - val_accuracy: 0.8241
Epoch 24/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1194 -
accuracy: 0.9607 - val_loss: 0.5274 - val_accuracy: 0.7685
Epoch 25/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1243 -
accuracy: 0.9607 - val_loss: 0.5098 - val_accuracy: 0.7778
Epoch 26/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0884 -
accuracy: 0.9723 - val_loss: 0.5465 - val_accuracy: 0.7500
Epoch 27/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1123 -
accuracy: 0.9654 - val_loss: 0.4898 - val_accuracy: 0.8148
Epoch 28/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1352 -
accuracy: 0.9423 - val_loss: 0.5978 - val_accuracy: 0.7500
Epoch 29/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0979 -
accuracy: 0.9700 - val_loss: 0.4980 - val_accuracy: 0.7870
Epoch 30/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1210 -
accuracy: 0.9515 - val_loss: 0.5739 - val_accuracy: 0.7778
Epoch 31/50
```

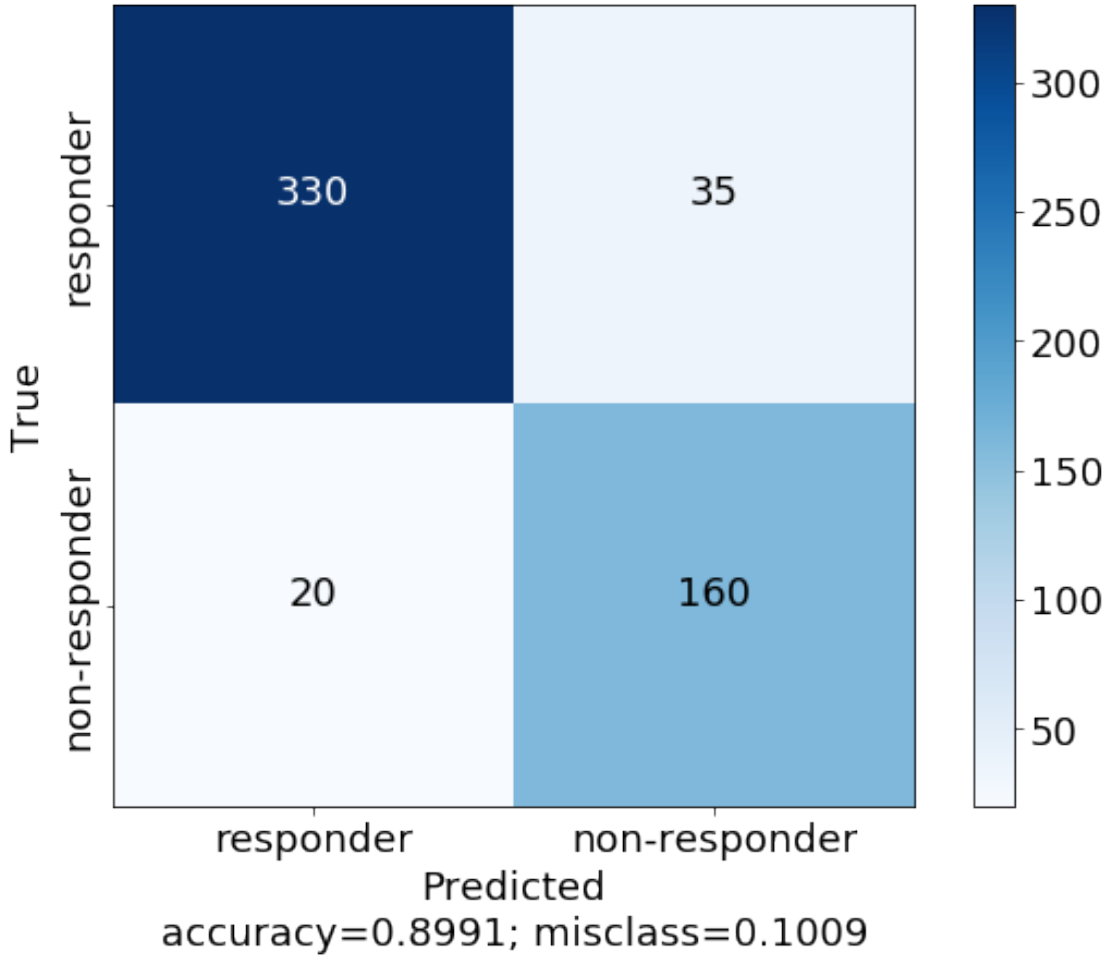
```
433/433 [==============================] - 0s 1ms/sample - loss: 0.1421 -
accuracy: 0.9400 - val_loss: 0.5943 - val_accuracy: 0.7778
Epoch 32/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1196 -
accuracy: 0.9538 - val_loss: 0.5762 - val_accuracy: 0.7593
Epoch 33/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0889 -
accuracy: 0.9700 - val_loss: 0.5425 - val_accuracy: 0.7870
Epoch 34/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0951 -
accuracy: 0.9584 - val_loss: 0.4849 - val_accuracy: 0.8056
Epoch 35/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0954 -
accuracy: 0.9792 - val_loss: 0.5189 - val_accuracy: 0.7963
Epoch 36/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0996 -
accuracy: 0.9630 - val_loss: 0.5091 - val_accuracy: 0.7963
Epoch 37/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0888 -
accuracy: 0.9677 - val_loss: 0.4859 - val_accuracy: 0.8056
Epoch 38/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0958 -
accuracy: 0.9746 - val_loss: 0.4940 - val_accuracy: 0.7870
Epoch 39/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.1126 -
accuracy: 0.9607 - val_loss: 0.5441 - val_accuracy: 0.7963
Epoch 40/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0896 -
accuracy: 0.9746 - val_loss: 0.5668 - val_accuracy: 0.7963
Epoch 41/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0938 -
accuracy: 0.9677 - val_loss: 0.5746 - val_accuracy: 0.7685
Epoch 42/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0805 -
accuracy: 0.9769 - val_loss: 0.5343 - val_accuracy: 0.8148
Epoch 43/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0762 -
accuracy: 0.9700 - val_loss: 0.5328 - val_accuracy: 0.8056
Epoch 44/50
433/433 [==============================] - 0s 983us/sample - loss: 0.0877 -
accuracy: 0.9630 - val_loss: 0.5338 - val_accuracy: 0.8148
Epoch 45/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0824 -
accuracy: 0.9700 - val_loss: 0.5587 - val_accuracy: 0.7963
Epoch 46/50
433/433 [==============================] - 0s 994us/sample - loss: 0.0685 -
accuracy: 0.9815 - val_loss: 0.5219 - val_accuracy: 0.7963
Epoch 47/50
```

```
433/433 [==============================] - 0s 977us/sample - loss: 0.0723 -
accuracy: 0.9792 - val_loss: 0.5226 - val_accuracy: 0.7870
Epoch 48/50
433/433 [==============================] - 0s 998us/sample - loss: 0.0844 -
accuracy: 0.9838 - val_loss: 0.5326 - val_accuracy: 0.7963
Epoch 49/50
433/433 [==============================] - 0s 987us/sample - loss: 0.0689 -
accuracy: 0.9792 - val_loss: 0.5508 - val_accuracy: 0.7963
Epoch 50/50
433/433 [==============================] - 0s 1ms/sample - loss: 0.0827 -
accuracy: 0.9838 - val_loss: 0.5279 - val_accuracy: 0.7870
```

[299]:
```
cm3 = [[0, 0]]
k, l = 0, 0
for i in cm_results3:
    for j in cm_results3[0]:
        cm3[k][l] += j
        l = (l+1) % 2
    j = (j+1) % 2
cm3 = np.array(cm3[0])
cm3
```

[299]:
```
array([[330,  35],
       [ 20, 160]])
```

[300]:
```
plt.rcParams.update({'font.size': 18})
plot_confusion_matrix(cm3, ['responder', 'non-responder'], title='',␣
↪normalize=False)
```



5 Comparison Plots

[ ]:
```
loss, accuracy, val_loss, val_accuracy
```

[ ]:
```

```