In [1]:
```
import numpy as np
import pandas as pd
```

Obtain the train and test data

In [2]:
```
train = pd.read_csv('UCI_HAR_dataset/csv_files/train.csv')
test = pd.read_csv('UCI_HAR_dataset/csv_files/test.csv')
print(train.shape, test.shape)
```

```
(7352, 564) (2947, 564)
```

In [3]:
```
train.head(3)
```

Out[3]:

	tBodyAccmeanX	tBodyAccmeanY	tBodyAccmeanZ	tBodyAccstdX	tBodyAccstdY	tBodyAccst
0	0.288585	-0.020294	-0.132905	-0.995279	-0.983111	-0.9135
1	0.278419	-0.016411	-0.123520	-0.998245	-0.975300	-0.9603
2	0.279653	-0.019467	-0.113462	-0.995380	-0.967187	-0.9789

3 rows × 564 columns

In [4]:
```
# get X_train and y_train from csv files
X_train = train.drop(['subject', 'Activity', 'ActivityName'], axis=1)
y_train = train.ActivityName
```

In [5]:
```
# get X_test and y_test from test csv file
X_test = test.drop(['subject', 'Activity', 'ActivityName'], axis=1)
y_test = test.ActivityName
```

In [6]:
```
print('X_train and y_train : ({},{})'.format(X_train.shape, y_train.shape))
print('X_test  and y_test  : ({},{})'.format(X_test.shape, y_test.shape))
```

```
X_train and y_train : ((7352, 561),(7352,))
X_test  and y_test  : ((2947, 561),(2947,))
```

Let's model with our data

Labels that are useful in plotting confusion matrix

In [7]:
```
labels=['LAYING', 'SITTING','STANDING','WALKING','WALKING_DOWNSTAIRS','WALKING
_UPSTAIRS']
```

Function to plot the confusion matrix

In [8]:
```
import itertools
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
plt.rcParams["font.family"] = 'DejaVu Sans'

def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=90)
    plt.yticks(tick_marks, classes)

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

    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

Generic function to run any model specified

In [9]:
```
from datetime import datetime
def perform_model(model, X_train, y_train, X_test, y_test, class_labels, cm_no
rmalize=True, \
                  print_cm=True, cm_cmap=plt.cm.Greens):


    # to store results at various phases
    results = dict()

    # time at which model starts training
    train_start_time = datetime.now()
    print('training the model..')
    model.fit(X_train, y_train)
    print('Done \n \n')
    train_end_time = datetime.now()
    results['training_time'] =  train_end_time - train_start_time
    print('training_time(HH:MM:SS.ms) - {}\n\n'.format(results['training_time'
]))


    # predict test data
    print('Predicting test data')
    test_start_time = datetime.now()
    y_pred = model.predict(X_test)
    test_end_time = datetime.now()
    print('Done \n \n')
    results['testing_time'] = test_end_time - test_start_time
    print('testing time(HH:MM:SS:ms) - {}\n\n'.format(results['testing_time'
]))
    results['predicted'] = y_pred


    # calculate overall accuracty of the model
    accuracy = metrics.accuracy_score(y_true=y_test, y_pred=y_pred)
    # store accuracy in results
    results['accuracy'] = accuracy
    print('---------------------')
    print('|      Accuracy      |')
    print('---------------------')
    print('\n    {}\n\n'.format(accuracy))


    # confusion matrix
    cm = metrics.confusion_matrix(y_test, y_pred)
    results['confusion_matrix'] = cm
    if print_cm:
        print('--------------------')
        print('| Confusion Matrix |')
        print('--------------------')
        print('\n {}'.format(cm))

    # plot confusin matrix
    plt.figure(figsize=(8,8))
    plt.grid(b=False)
    plot_confusion_matrix(cm, classes=class_labels, normalize=True, title='Nor
malized confusion matrix', cmap = cm_cmap)
```

```
    plt.show()

    # get classification report
    print('-------------------------')
    print('| Classifiction Report |')
    print('-------------------------')
    classification_report = metrics.classification_report(y_test, y_pred)
    # store report in results
    results['classification_report'] = classification_report
    print(classification_report)

    # add the trained  model to the results
    results['model'] = model

    return results
```

Method to print the gridsearch Attributes

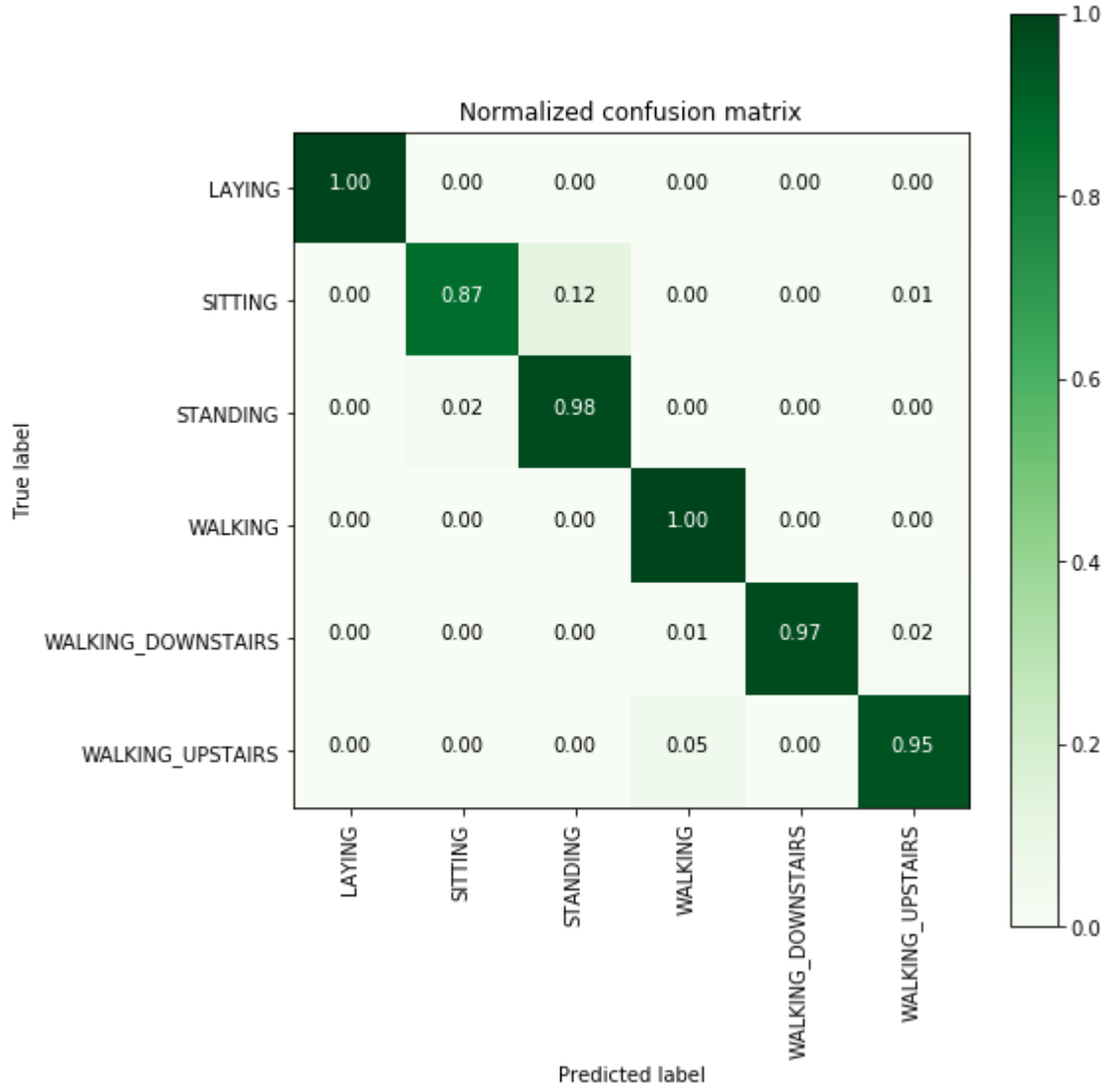
In [10]:
```
def print_grid_search_attributes(model):
    # Estimator that gave highest score among all the estimators formed in GridSearch
    print('--------------------------')
    print('|      Best Estimator     |')
    print('--------------------------')
    print('\n\t{}\n'.format(model.best_estimator_))


    # parameters that gave best results while performing grid search
    print('--------------------------')
    print('|     Best parameters     |')
    print('--------------------------')
    print('\tParameters of best estimator : \n\n\t{}\n'.format(model.best_params_))


    #  number of cross validation splits
    print('---------------------------------')
    print('|   No of CrossValidation sets   |')
    print('---------------------------------')
    print('\n\tTotal numbre of cross validation sets: {}\n'.format(model.n_splits_))


    # Average cross validated score of the best estimator, from the Grid Search
    print('--------------------------')
    print('|        Best Score       |')
    print('--------------------------')
    print('\n\tAverage Cross Validate scores of best estimator : \n\n\t{}\n'.format(model.best_score_))
```

1. Logistic Regression with Grid Search

In [11]:
```
from sklearn import linear_model
from sklearn import metrics

from sklearn.model_selection import GridSearchCV
```

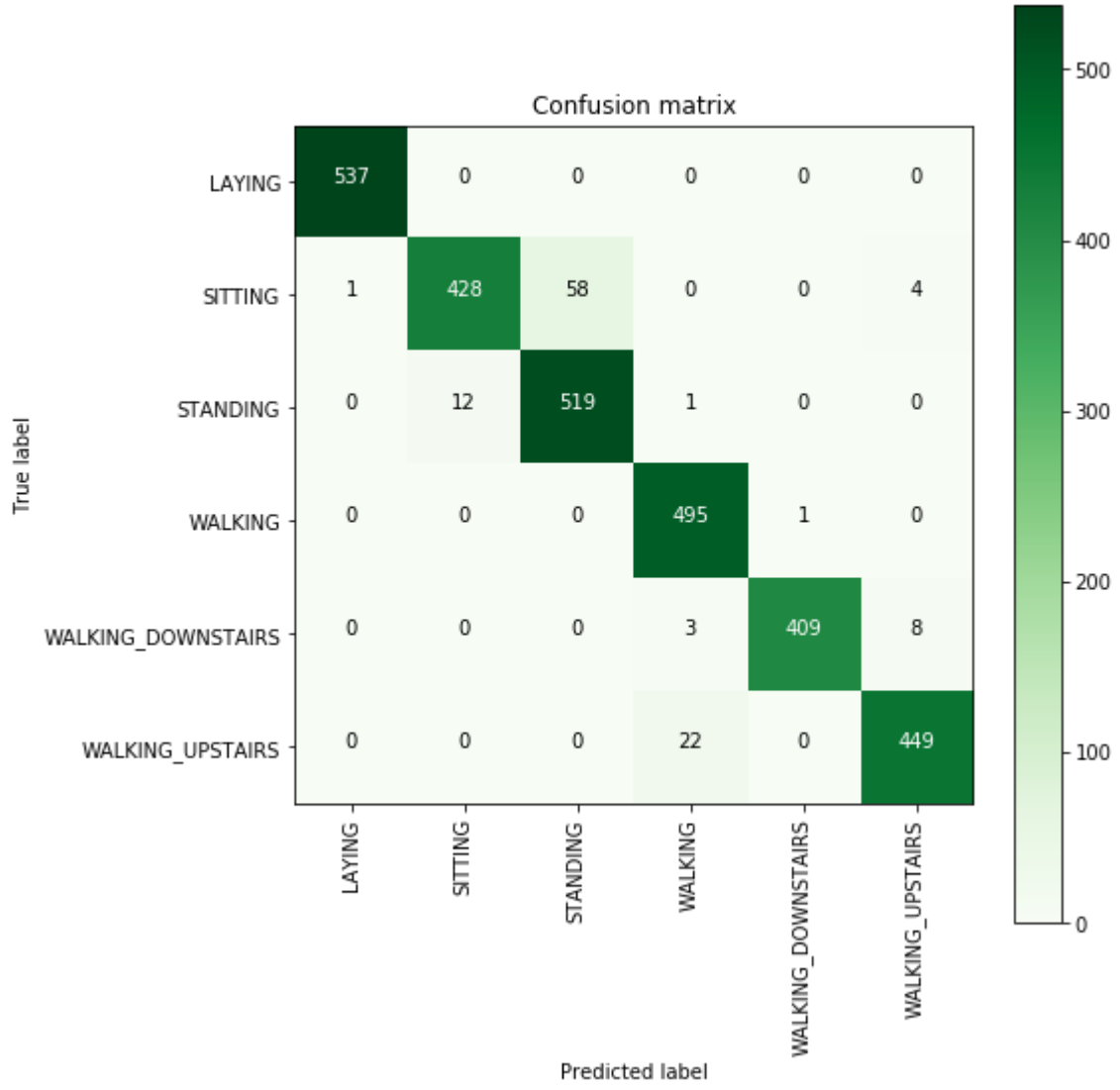
In [12]:
```
# start Grid search
parameters = {'C':[0.01, 0.1, 1, 10, 20, 30], 'penalty':['l2','l1']}
log_reg = linear_model.LogisticRegression()
log_reg_grid = GridSearchCV(log_reg, param_grid=parameters, cv=3, verbose=1, n
_jobs=-1)
log_reg_grid_results =  perform_model(log_reg_grid, X_train, y_train, X_test,
y_test, class_labels=labels)
```

```
training the model..
Fitting 3 folds for each of 12 candidates, totalling 36 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  36 out of  36 | elapsed:  1.7min finished
C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\linear_model\logis
tic.py:433: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22.
Specify a solver to silence this warning.
  FutureWarning)
C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\linear_model\logis
tic.py:460: FutureWarning: Default multi_class will be changed to 'auto' in
0.22. Specify the multi_class option to silence this warning.
  "this warning.", FutureWarning)

Done


training_time(HH:MM:SS.ms) - 0:01:55.292116


Predicting test data
Done


testing time(HH:MM:SS:ms) - 0:00:00.113713


---------------------
|      Accuracy      |
---------------------

    0.9626739056667798


--------------------
| Confusion Matrix |
--------------------

 [[537   0   0   0   0   0]
 [  1 428  58   0   0   4]
 [  0  12 519   1   0   0]
 [  0   0   0 495   1   0]
 [  0   0   0   3 409   8]
 [  0   0   0  22   0 449]]
```




```
-------------------------
| Classifiction Report |
-------------------------
                    precision    recall  f1-score   support

           LAYING       1.00      1.00      1.00       537
          SITTING       0.97      0.87      0.92       491
         STANDING       0.90      0.98      0.94       532
          WALKING       0.95      1.00      0.97       496
WALKING_DOWNSTAIRS       1.00      0.97      0.99       420
  WALKING_UPSTAIRS       0.97      0.95      0.96       471

        micro avg       0.96      0.96      0.96      2947
        macro avg       0.97      0.96      0.96      2947
     weighted avg       0.96      0.96      0.96      2947
```

In [13]:
```
plt.figure(figsize=(8,8))
plt.grid(b=False)
plot_confusion_matrix(log_reg_grid_results['confusion_matrix'], classes=labels
, cmap=plt.cm.Greens, )
plt.show()
```



In [14]:
```
# observe the attributes of the model
print_grid_search_attributes(log_reg_grid_results['model'])
```

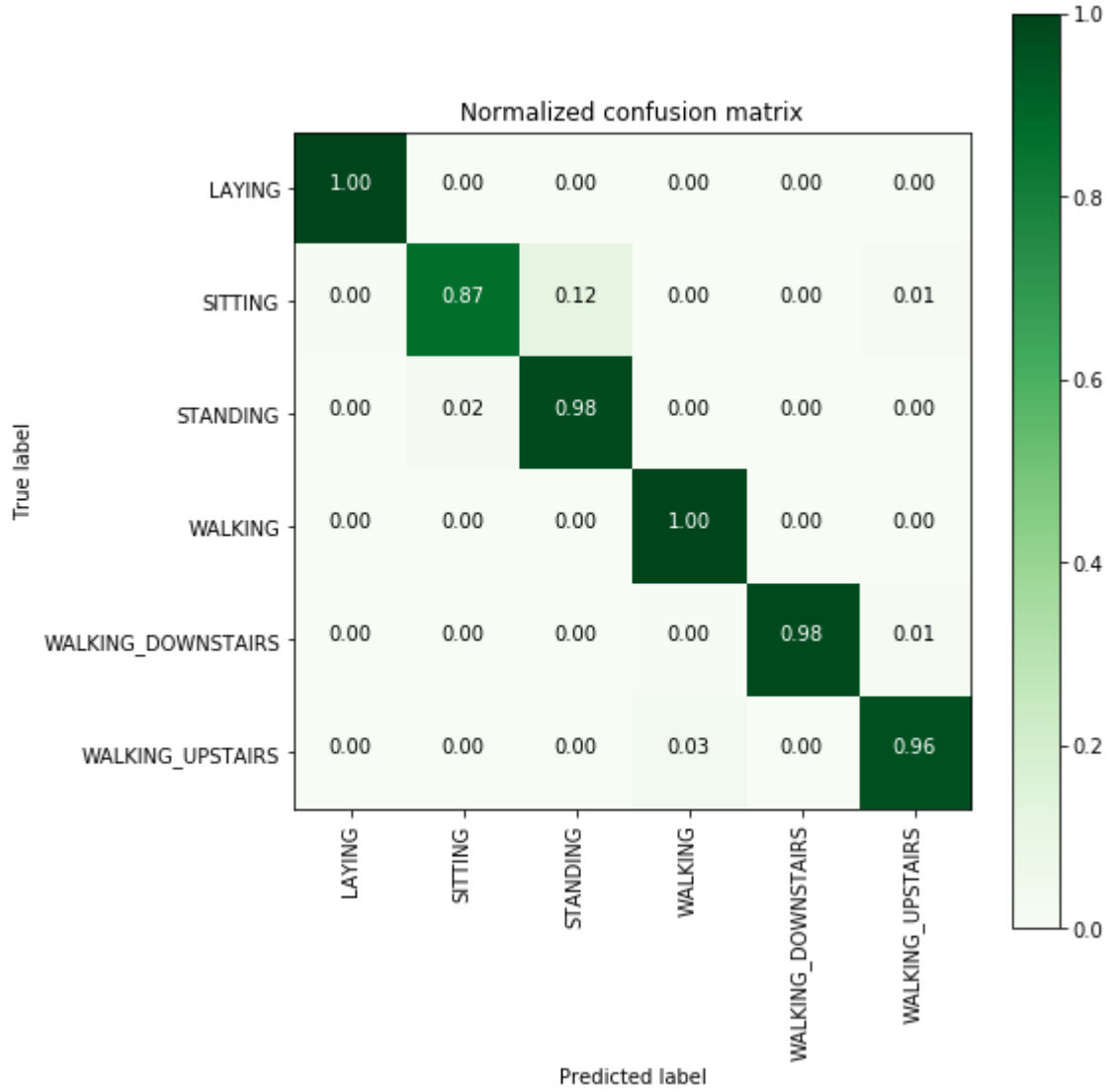
```
-------------------------
|      Best Estimator     |
-------------------------

        LogisticRegression(C=30, class_weight=None, dual=False, fit_intercept
=True,
          intercept_scaling=1, max_iter=100, multi_class='warn',
          n_jobs=None, penalty='l2', random_state=None, solver='warn',
          tol=0.0001, verbose=0, warm_start=False)

-------------------------
|     Best parameters     |
-------------------------
        Parameters of best estimator :

        {'C': 30, 'penalty': 'l2'}

---------------------------------
|   No of CrossValidation sets   |
---------------------------------

        Total numbre of cross validation sets: 3

-------------------------
|       Best Score       |
-------------------------

        Average Cross Validate scores of best estimator :

        0.9461371055495104
```

2. Linear SVC with GridSearch

In [15]:
```
from sklearn.svm import LinearSVC
```

In [16]:
```
parameters = {'C':[0.125, 0.5, 1, 2, 8, 16]}
lr_svc = LinearSVC(tol=0.00005)
lr_svc_grid = GridSearchCV(lr_svc, param_grid=parameters, n_jobs=-1, verbose=1
)
lr_svc_grid_results = perform_model(lr_svc_grid, X_train, y_train, X_test, y_t
est, class_labels=labels)
```

```
training the model..

C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\model_selection\_s
plit.py:2053: FutureWarning: You should specify a value for 'cv' instead of r
elying on the default value. The default value will change from 3 to 5 in ver
sion 0.22.
  warnings.warn(CV_WARNING, FutureWarning)
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.

Fitting 3 folds for each of 6 candidates, totalling 18 fits

[Parallel(n_jobs=-1)]: Done  18 out of  18 | elapsed:   33.7s finished
C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\svm\base.py:931: C
onvergenceWarning: Liblinear failed to converge, increase the number of itera
tions.
  "the number of iterations.", ConvergenceWarning)

Done


training_time(HH:MM:SS.ms) - 0:00:41.770372


Predicting test data
Done


testing time(HH:MM:SS:ms) - 0:00:00.010972


---------------------
|      Accuracy      |
---------------------

    0.9657278588394977


--------------------
| Confusion Matrix |
--------------------

 [[537   0   0   0   0   0]
 [  2 426  58   0   0   5]
 [  0  11 520   1   0   0]
 [  0   0   0 496   0   0]
 [  0   0   0   2 413   5]
 [  0   0   0  16   1 454]]
```




```
-------------------------
| Classifiction Report |
-------------------------
```

	precision	recall	f1-score	support
LAYING	1.00	1.00	1.00	537
SITTING	0.97	0.87	0.92	491
STANDING	0.90	0.98	0.94	532
WALKING	0.96	1.00	0.98	496
WALKING_DOWNSTAIRS	1.00	0.98	0.99	420
WALKING_UPSTAIRS	0.98	0.96	0.97	471
micro avg	0.97	0.97	0.97	2947
macro avg	0.97	0.97	0.97	2947
weighted avg	0.97	0.97	0.97	2947

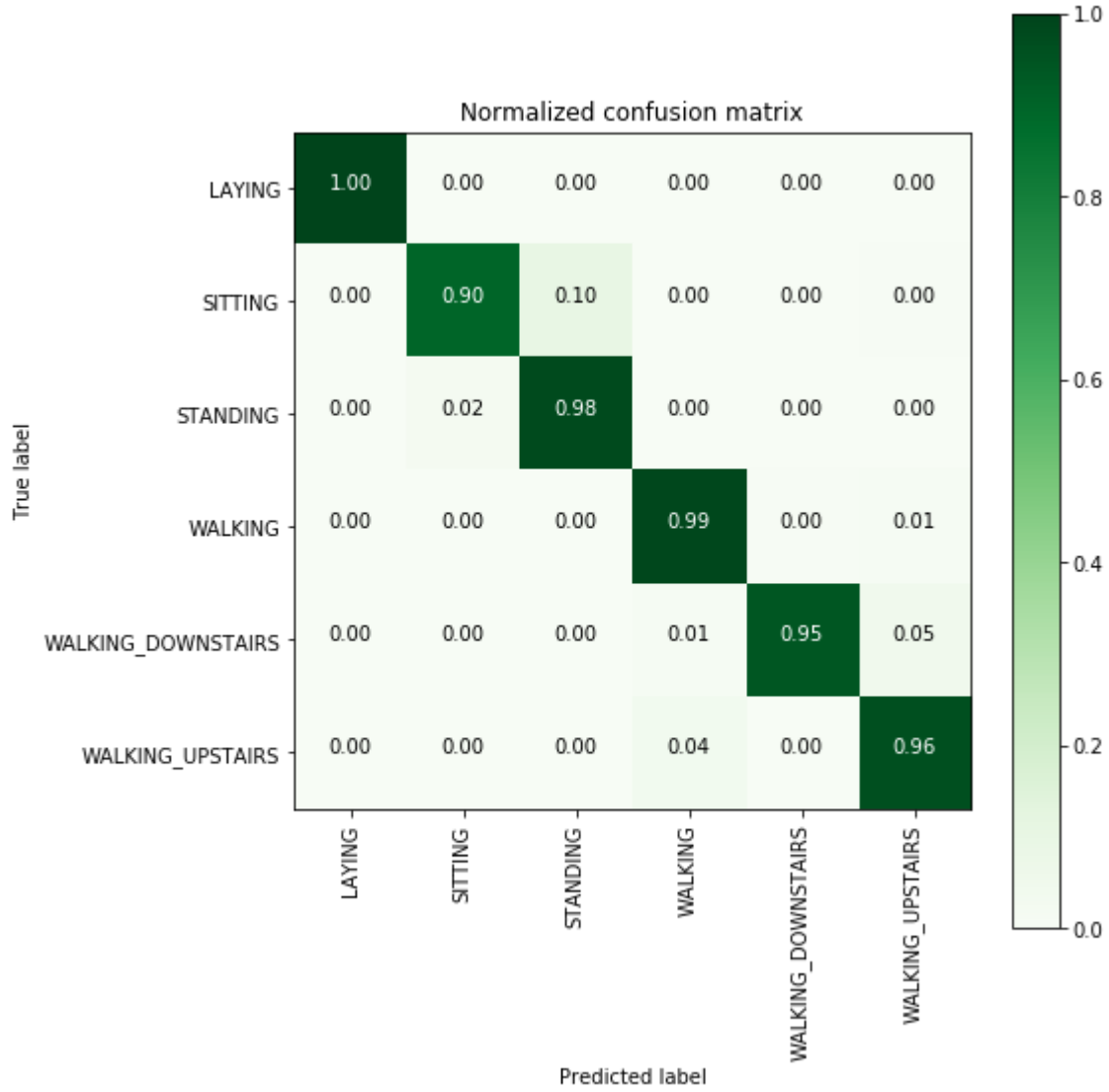
In [17]:
```
print_grid_search_attributes(lr_svc_grid_results['model'])
```

```
-------------------------
|      Best Estimator     |
-------------------------

        LinearSVC(C=2, class_weight=None, dual=True, fit_intercept=True,
     intercept_scaling=1, loss='squared_hinge', max_iter=1000,
     multi_class='ovr', penalty='l2', random_state=None, tol=5e-05,
     verbose=0)

-------------------------
|     Best parameters     |
-------------------------
        Parameters of best estimator :

        {'C': 2}

---------------------------------
|   No of CrossValidation sets   |
---------------------------------

        Total numbre of cross validation sets: 3

-------------------------
|       Best Score       |
-------------------------

        Average Cross Validate scores of best estimator :

        0.9469532100108814
```

3. Kernel SVM with GridSearch

In [18]:
```
from sklearn.svm import SVC
parameters = {'C':[2,8,16],\
              'gamma': [ 0.0078125, 0.125, 2]}
rbf_svm = SVC(kernel='rbf')
rbf_svm_grid = GridSearchCV(rbf_svm,param_grid=parameters, n_jobs=-1)
rbf_svm_grid_results = perform_model(rbf_svm_grid, X_train, y_train, X_test, y
_test, class_labels=labels)
```

```
training the model..

C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\model_selection\_s
plit.py:2053: FutureWarning: You should specify a value for 'cv' instead of r
elying on the default value. The default value will change from 3 to 5 in ver
sion 0.22.
  warnings.warn(CV_WARNING, FutureWarning)

Done


training_time(HH:MM:SS.ms) - 0:07:41.717459


Predicting test data
Done


testing time(HH:MM:SS:ms) - 0:00:04.439175


----------------------
|      Accuracy      |
----------------------

    0.9626739056667798


--------------------
| Confusion Matrix |
--------------------

 [[537   0   0   0   0   0]
 [  0 441  48   0   0   2]
 [  0  12 520   0   0   0]
 [  0   0   0 489   2   5]
 [  0   0   0   4 397  19]
 [  0   0   0  17   1 453]]
```




```
-------------------------
| Classifiction Report |
-------------------------
                    precision    recall  f1-score   support

           LAYING       1.00      1.00      1.00       537
          SITTING       0.97      0.90      0.93       491
         STANDING       0.92      0.98      0.95       532
          WALKING       0.96      0.99      0.97       496
WALKING_DOWNSTAIRS       0.99      0.95      0.97       420
  WALKING_UPSTAIRS       0.95      0.96      0.95       471

        micro avg       0.96      0.96      0.96      2947
        macro avg       0.96      0.96      0.96      2947
     weighted avg       0.96      0.96      0.96      2947
```

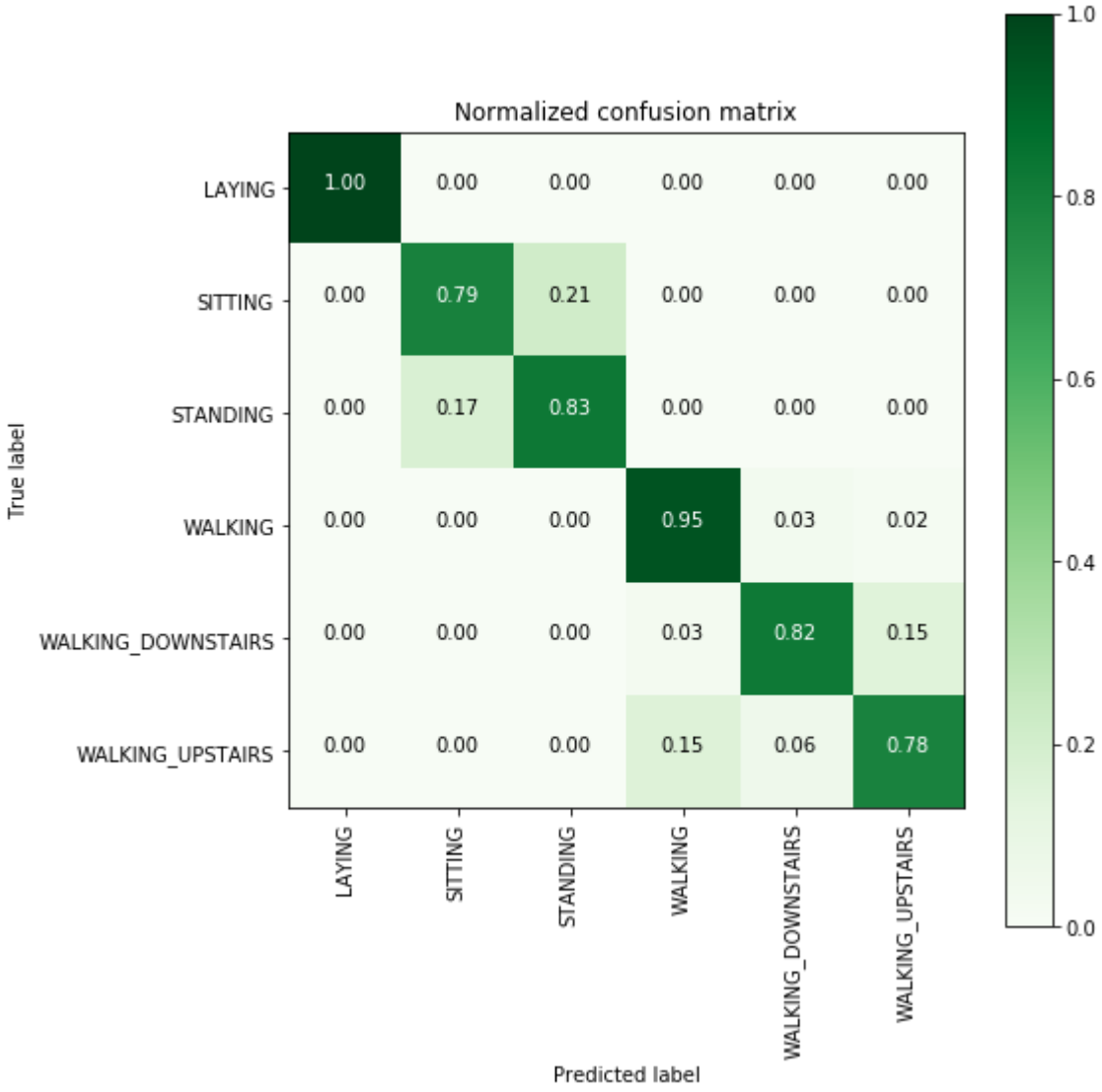
In [19]:
```
print_grid_search_attributes(rbf_svm_grid_results['model'])
```

```
-------------------------
|      Best Estimator     |
-------------------------

        SVC(C=16, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma=0.0078125, kernel='rbf',
  max_iter=-1, probability=False, random_state=None, shrinking=True,
  tol=0.001, verbose=False)

-------------------------
|     Best parameters     |
-------------------------
        Parameters of best estimator :

        {'C': 16, 'gamma': 0.0078125}

---------------------------------
|   No of CrossValidation sets   |
---------------------------------

        Total numbre of cross validation sets: 3

-------------------------
|        Best Score       |
-------------------------

        Average Cross Validate scores of best estimator :

        0.9440968443960827
```

4. Decision Trees with GridSearchCV

In [20]:
```
from sklearn.tree import DecisionTreeClassifier
parameters = {'max_depth':np.arange(3,10,2)}
dt = DecisionTreeClassifier()
dt_grid = GridSearchCV(dt,param_grid=parameters, n_jobs=-1)
dt_grid_results = perform_model(dt_grid, X_train, y_train, X_test, y_test, cla
ss_labels=labels)
print_grid_search_attributes(dt_grid_results['model'])
```

```
training the model..

C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\model_selection\_s
plit.py:2053: FutureWarning: You should specify a value for 'cv' instead of r
elying on the default value. The default value will change from 3 to 5 in ver
sion 0.22.
  warnings.warn(CV_WARNING, FutureWarning)

Done


training_time(HH:MM:SS.ms) - 0:00:17.129530


Predicting test data
Done


testing time(HH:MM:SS:ms) - 0:00:00.009973


---------------------
|      Accuracy      |
---------------------

    0.8646080760095012


--------------------
| Confusion Matrix |
--------------------

 [[537   0   0   0   0   0]
 [  0 386 105   0   0   0]
 [  0  93 439   0   0   0]
 [  0   0   0 471  17   8]
 [  0   0   0  13 346  61]
 [  0   0   0  73  29 369]]
```

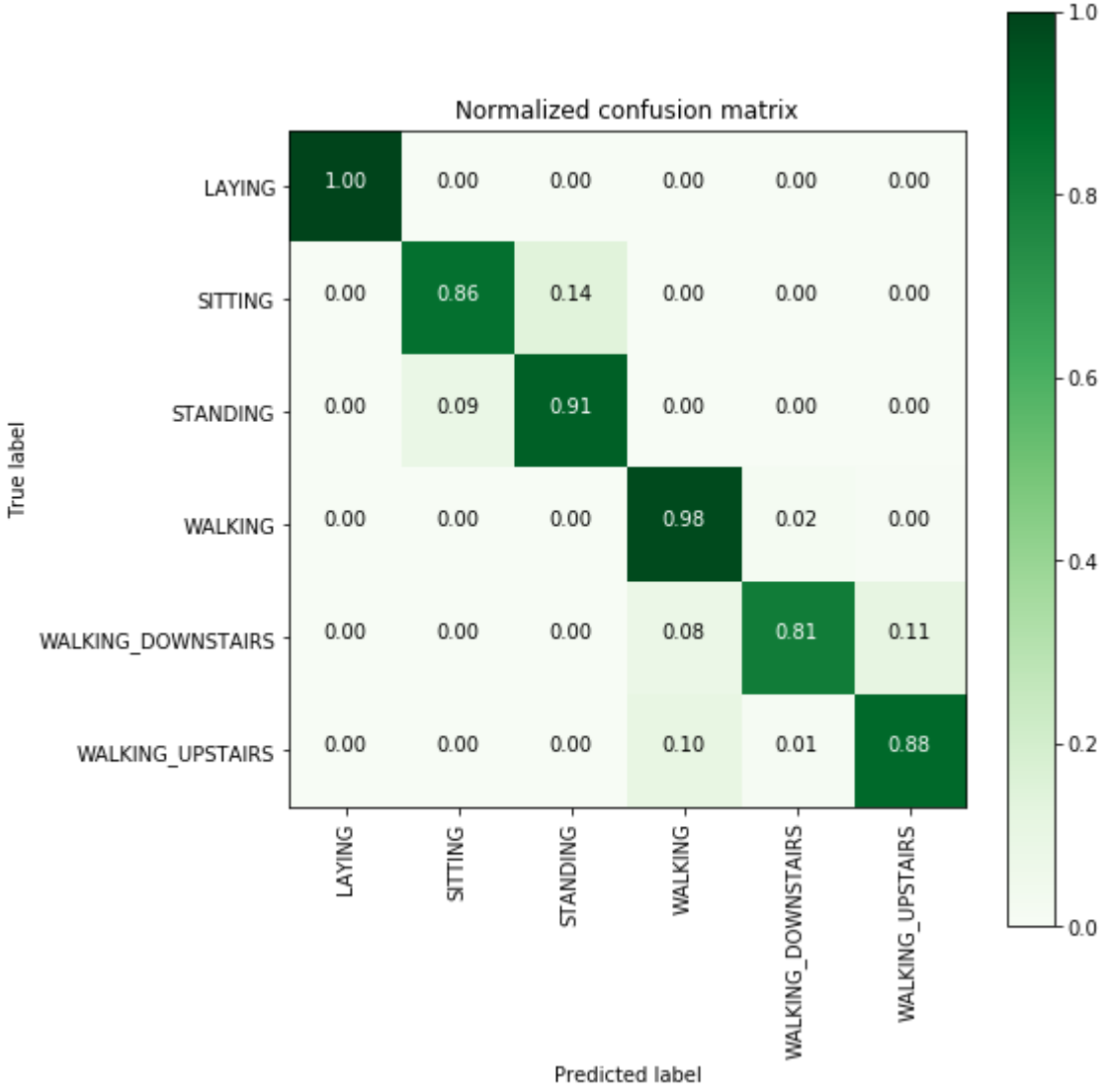

Normalized confusion matrix
True label
Predicted label
LAYING
SITTING
STANDING
WALKING
WALKING_DOWNSTAIRS
WALKING_UPSTAIRS
1.00 0.00 0.00 0.00 0.00 0.00
0.00 0.79 0.21 0.00 0.00 0.00
0.00 0.17 0.83 0.00 0.00 0.00
0.00 0.00 0.00 0.95 0.03 0.02
0.00 0.00 0.00 0.03 0.82 0.15
0.00 0.00 0.00 0.15 0.06 0.78
1.0
0.8
0.6
0.4
0.2
0.0

```
-------------------------
| Classifiction Report |
-------------------------
                    precision    recall  f1-score   support

           LAYING       1.00      1.00      1.00       537
          SITTING       0.81      0.79      0.80       491
         STANDING       0.81      0.83      0.82       532
          WALKING       0.85      0.95      0.89       496
WALKING_DOWNSTAIRS       0.88      0.82      0.85       420
  WALKING_UPSTAIRS       0.84      0.78      0.81       471

         micro avg       0.86      0.86      0.86      2947
         macro avg       0.86      0.86      0.86      2947
      weighted avg       0.86      0.86      0.86      2947

-------------------------
|      Best Estimator     |
-------------------------

        DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth
=7,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')

-------------------------
|     Best parameters     |
-------------------------
        Parameters of best estimator :

        {'max_depth': 7}

---------------------------------
|   No of CrossValidation sets   |
---------------------------------

        Total numbre of cross validation sets: 3

-------------------------
|        Best Score       |
-------------------------

        Average Cross Validate scores of best estimator :

        0.8375952121871599
```

5. Random Forest Classifier with GridSearch

In [21]:
```
from sklearn.ensemble import RandomForestClassifier
params = {'n_estimators': np.arange(10,201,20), 'max_depth':np.arange(3,15,2)}
rfc = RandomForestClassifier()
rfc_grid = GridSearchCV(rfc, param_grid=params, n_jobs=-1)
rfc_grid_results = perform_model(rfc_grid, X_train, y_train, X_test, y_test, c
lass_labels=labels)
print_grid_search_attributes(rfc_grid_results['model'])
```

```
training the model..

C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\model_selection\_s
plit.py:2053: FutureWarning: You should specify a value for 'cv' instead of r
elying on the default value. The default value will change from 3 to 5 in ver
sion 0.22.
  warnings.warn(CV_WARNING, FutureWarning)

Done


training_time(HH:MM:SS.ms) - 0:09:22.684772


Predicting test data
Done


testing time(HH:MM:SS:ms) - 0:00:00.053856


---------------------
|      Accuracy      |
---------------------

    0.9110960298608755


--------------------
| Confusion Matrix |
--------------------

 [[537   0   0   0   0   0]
 [  0 421  70   0   0   0]
 [  0  47 485   0   0   0]
 [  0   0   0 485   9   2]
 [  0   0   0  33 341  46]
 [  0   0   0  49   6 416]]
```

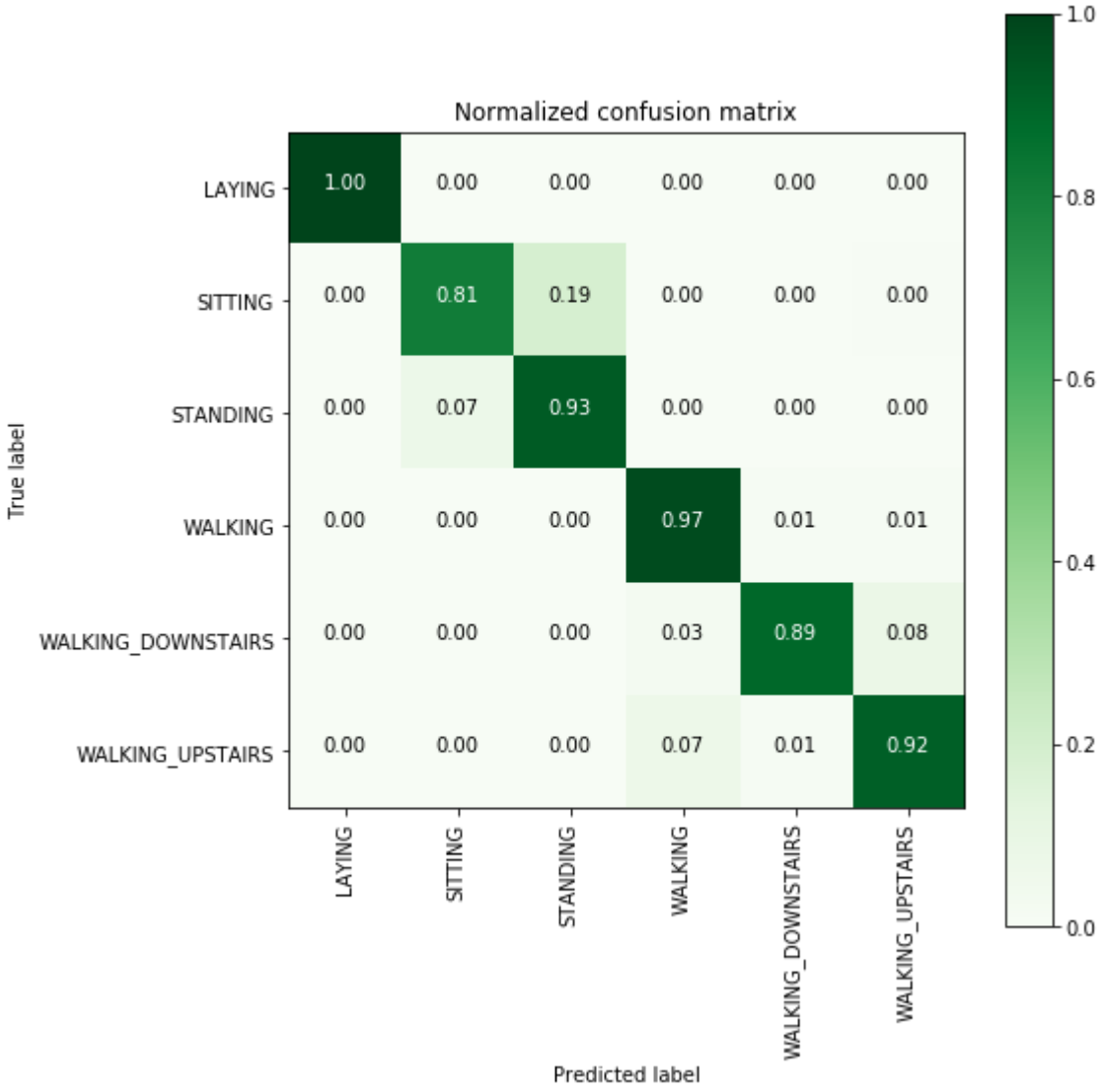

Normalized confusion matrix
True label
Predicted label
LAYING
SITTING
STANDING
WALKING
WALKING_DOWNSTAIRS
WALKING_UPSTAIRS
1.00 0.00 0.00 0.00 0.00 0.00
0.00 0.86 0.14 0.00 0.00 0.00
0.00 0.09 0.91 0.00 0.00 0.00
0.00 0.00 0.00 0.98 0.02 0.00
0.00 0.00 0.00 0.08 0.81 0.11
0.00 0.00 0.00 0.10 0.01 0.88
1.0
0.8
0.6
0.4
0.2
0.0

```
-------------------------
| Classifiction Report |
-------------------------
                    precision    recall  f1-score   support

           LAYING       1.00      1.00      1.00       537
          SITTING       0.90      0.86      0.88       491
         STANDING       0.87      0.91      0.89       532
          WALKING       0.86      0.98      0.91       496
WALKING_DOWNSTAIRS       0.96      0.81      0.88       420
  WALKING_UPSTAIRS       0.90      0.88      0.89       471

         micro avg       0.91      0.91      0.91      2947
         macro avg       0.91      0.91      0.91      2947
      weighted avg       0.91      0.91      0.91      2947

-------------------------
|      Best Estimator     |
-------------------------

        RandomForestClassifier(bootstrap=True, class_weight=None, criterion
='gini',
            max_depth=7, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=70, n_jobs=None,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)

-------------------------
|     Best parameters     |
-------------------------
        Parameters of best estimator :

        {'max_depth': 7, 'n_estimators': 70}

--------------------------------
|   No of CrossValidation sets   |
--------------------------------

        Total numbre of cross validation sets: 3

-------------------------
|        Best Score       |
-------------------------

        Average Cross Validate scores of best estimator :

        0.9148531011969532
```

6. Gradient Boosted Decision Trees With GridSearch

In [22]:
```
from sklearn.ensemble import GradientBoostingClassifier
param_grid = {'max_depth': np.arange(5,8,1), \
              'n_estimators':np.arange(130,170,10)}
gbdt = GradientBoostingClassifier()
gbdt_grid = GridSearchCV(gbdt, param_grid=param_grid, n_jobs=-1)
gbdt_grid_results = perform_model(gbdt_grid, X_train, y_train, X_test, y_test,
class_labels=labels)
print_grid_search_attributes(gbdt_grid_results['model'])
```

```
training the model..

C:\Users\Raftaar Singh\Anaconda3\lib\site-packages\sklearn\model_selection\_s
plit.py:2053: FutureWarning: You should specify a value for 'cv' instead of r
elying on the default value. The default value will change from 3 to 5 in ver
sion 0.22.
  warnings.warn(CV_WARNING, FutureWarning)

Done


training_time(HH:MM:SS.ms) - 2:41:53.788148


Predicting test data
Done


testing time(HH:MM:SS:ms) - 0:00:00.198170


---------------------
|      Accuracy      |
---------------------

    0.9222938581608415


--------------------
| Confusion Matrix |
--------------------

 [[537   0   0   0   0   0]
 [  0 398  91   0   0   2]
 [  0  38 494   0   0   0]
 [  0   0   0 483   7   6]
 [  0   0   0  11 374  35]
 [  0   1   0  32   6 432]]
```


Normalized confusion matrix
True label
Predicted label
LAYING
SITTING
STANDING
WALKING
WALKING_DOWNSTAIRS
WALKING_UPSTAIRS
1.00 0.00 0.00 0.00 0.00 0.00
0.00 0.81 0.19 0.00 0.00 0.00
0.00 0.07 0.93 0.00 0.00 0.00
0.00 0.00 0.00 0.97 0.01 0.01
0.00 0.00 0.00 0.03 0.89 0.08
0.00 0.00 0.00 0.07 0.01 0.92
1.0
0.8
0.6
0.4
0.2
0.0

```
-------------------------
| Classifiction Report |
-------------------------
                    precision    recall  f1-score   support

           LAYING       1.00      1.00      1.00       537
          SITTING       0.91      0.81      0.86       491
         STANDING       0.84      0.93      0.88       532
          WALKING       0.92      0.97      0.95       496
WALKING_DOWNSTAIRS       0.97      0.89      0.93       420
  WALKING_UPSTAIRS       0.91      0.92      0.91       471

         micro avg       0.92      0.92      0.92      2947
         macro avg       0.92      0.92      0.92      2947
      weighted avg       0.92      0.92      0.92      2947

-------------------------
|      Best Estimator     |
-------------------------

        GradientBoostingClassifier(criterion='friedman_mse', init=None,
              learning_rate=0.1, loss='deviance', max_depth=5,
              max_features=None, max_leaf_nodes=None,
              min_impurity_decrease=0.0, min_impurity_split=None,
              min_samples_leaf=1, min_samples_split=2,
              min_weight_fraction_leaf=0.0, n_estimators=160,
              n_iter_no_change=None, presort='auto', random_state=None,
              subsample=1.0, tol=0.0001, validation_fraction=0.1,
              verbose=0, warm_start=False)

-------------------------
|     Best parameters     |
-------------------------
        Parameters of best estimator :

        {'max_depth': 5, 'n_estimators': 160}

--------------------------------
|   No of CrossValidation sets   |
--------------------------------

        Total numbre of cross validation sets: 3

-------------------------
|        Best Score       |
-------------------------

        Average Cross Validate scores of best estimator :

        0.9030195865070729
```

7. Comparing all models

In [23]:
```
print('\n                    Accuracy     Error')
print('                  ----------   --------')
print('Logistic Regression : {:.04}%       {:.04}%'.format(log_reg_grid_result
s['accuracy'] * 100,\
                                                100-(log_reg_grid_results['a
ccuracy'] * 100)))

print('Linear SVC          : {:.04}%       {:.04}% '.format(lr_svc_grid_result
s['accuracy'] * 100,\
                                                    100-(lr_svc_grid_resul
ts['accuracy'] * 100)))

print('rbf SVM classifier  : {:.04}%      {:.04}% '.format(rbf_svm_grid_result
s['accuracy'] * 100,\
                                                      100-(rbf_svm_grid_re
sults['accuracy'] * 100)))

print('DecisionTree        : {:.04}%      {:.04}% '.format(dt_grid_results['ac
curacy'] * 100,\
                                                    100-(dt_grid_results[
'accuracy'] * 100)))

print('Random Forest       : {:.04}%      {:.04}% '.format(rfc_grid_results['a
ccuracy'] * 100,\
                                                     100-(rfc_grid_resul
ts['accuracy'] * 100)))
print('GradientBoosting DT : {:.04}%      {:.04}% '.format(rfc_grid_results['a
ccuracy'] * 100,\
                                                    100-(rfc_grid_results[
'accuracy'] * 100)))
```

```
                    Accuracy     Error
                  ----------   --------
Logistic Regression : 96.27%       3.733%
Linear SVC          : 96.57%       3.427%
rbf SVM classifier  : 96.27%      3.733%
DecisionTree        : 86.46%      13.54%
Random Forest       : 91.11%      8.89%
GradientBoosting DT : 91.11%      8.89%
```

> We can choose ***Logistic regression*** or ***Linear SVC*** or ***rbf SVM***.

Conclusion :

In the real world, domain-knowledge, EDA and feature-engineering matter most.