feature_selection

August 31, 2020

[1]:
```
# store start time to get execution time of entire script
import time
start_time = time.time()
```

[2]:
```
import numpy as np
np.random.seed(2017) # set random seed value to get reproducible results
```

[3]:
```
from sksurv.ensemble import RandomSurvivalForest
from sklearn.model_selection import cross_validate
import matplotlib.pyplot as plt
from tqdm.notebook import tqdm
plt.rcParams["font.weight"] = "bold"
plt.rcParams["font.size"] = 14
plt.rcParams["figure.figsize"] = 10, 10

def forward_feature_selection(rsf, X, y, title):
    features = list(X.columns)
    selected_features = []
    scores = []

    for i in tqdm(range(X.shape[1])):
        best_score = 0
        next_feat = ''
        for feat in features:
            selected_features.append(feat)
            temp_X = X[selected_features]
            temp_scores = cross_validate(rsf, temp_X, y, cv=5)
            temp_score = temp_scores['test_score'].mean()
            if temp_score > best_score:
                best_score = temp_score
                next_feat = feat
            selected_features.pop()
        #print('Added Feature:', next_feat)
        selected_features.append(next_feat)
        features.remove(next_feat)
        scores.append(best_score)
```

```
    print('Ordering of Features:', selected_features)

    plt.title(title)
    plt.xlabel('# of Features')
    plt.ylabel('score')
    plt.plot(list(range(X.shape[1])), scores)
```

```
//anaconda3/lib/python3.7/importlib/_bootstrap.py:219: RuntimeWarning:
sklearn.tree._splitter.Splitter size changed, may indicate binary
incompatibility. Expected 360 from C header, got 368 from PyObject
  return f(*args, **kwds)
```

[4]:
```
def backward_feature_selection(rsf, X, y, title):
    features = list(X.columns)
    removed_features = []
    scores = []

    # calculate scores with all features
    temp_scores = cross_validate(rsf, X, y, cv=5)
    temp_score = temp_scores['test_score'].mean()
    scores.append(temp_score)

    for i in tqdm(range(X.shape[1]-1)):
        best_score = 0
        drop_feat = ''
        for feat in features:
            removed_features.append(feat)
            temp_X = X.drop(columns=removed_features, inplace=False)
            temp_scores = cross_validate(rsf, temp_X, y, cv=5)
            temp_score = temp_scores['test_score'].mean()
            if temp_score > best_score:
                best_score = temp_score
                drop_feat = feat
            removed_features.pop()
        #print('Removed Feature:', next_feat)
        removed_features.append(drop_feat)
        features.remove(drop_feat)
        scores.append(best_score)

    removed_features.extend(features) # add last element left in features
    removed_features.reverse()
    print('Ordering of Features:', removed_features)

    plt.title(title)
    plt.xlabel('# of Features')
    plt.ylabel('score')
```

```
    x = list(range(X.shape[1]))
    x.reverse()
    plt.plot(x, scores)
```

[5]:
```
import pandas as pd
pd.set_option('display.max_rows', 500)
pd.set_option('display.max_columns', 500)
import csv

df = pd.read_csv('../data/data_superset.csv')
df.head()
```

[5]:

	Unnamed: 0	Unnamed: 0.1	Unnamed: 0.1.1	ID	State	City	agyaddr	xobsyr_0	Illicit_Days	Illicit_Cens	female	nonwhite	unemplmt_cd	prsatx_cd	gvsg_cd	CWSg_0_cd	dssg_0_cd	epsg_0_cd	adhdg_0_cd	cdsg_0_cd	cjsig_0_cd	lrig_0_cd	srig_0_cd	SESg_0_cd	r4ag_0_cd	SUDSy_0_cd	homeless_0_cd	ncar_cd
0	0	1	6	11520	TX	Laredo	2386 E. Saunders, Suite 2	2007	78	1	0	1	0	0	2	0	1	1	0	0	2	1	2	1	2	3	0	1
1	1	2	7	19646	FL	Jacksonville	2671 Huffman Blvd	2011	365	0	0	1	0	0	0	0	2	1	1	0	0	1	2	1	0	0	1	0	1
2	2	3	8	11738	TX	San Antonio	7703 Floyd Curl Drive	2008	188	0	0	1	0	0	0	0	0	0	0	0	1	2	2	0	0	2	0	1
3	3	7	13	13054	AZ	Tucson	P.O. Box 3308	2007	365	0	0	1	1	1	2	0	1	1	1	1	2	2	2	0	1	3	0	0
4	4	10	16	15206	MA	Cambridge	349 Broadway	2008	337	0	1	1	0	0	2	0	0	2	0	0	0	1	2	0	1	1	1	1

```
   TRIg_0_cd  PYS9Sxg_cd  primsev_other  primsev_alcohol  \
0          1           0              0                0
1          1           0              0                1
2          0           0              0                0
3          0           0              0                0
4          1           0              0                0

   primsev_amphetamines  primsev_cocaine  primsev_marijuana  primsev_opioids  \
0                     0                0                  1                0
1                     0                0                  0                0
2                     0                0                  1                0
3                     1                0                  0                0
4                     1                0                  0                0

   B2a_0g                                          Address        lat  \
0       1  2386 E. Saunders, Suite 2                , L…  27.530608
1       1  2671 Huffman Blvd                        , J…  30.298713
2       1  7703 Floyd Curl Drive                    , S…  29.513085
3       1  P.O. Box 3308                            , T…  32.225221
4       2  349 Broadway                             , C…  42.370383

          lng     state_name  county_FIPS    block_FIPS  murder_numg  \
0  -99.472335          Texas      48479.0  4.847900e+14            0
1  -81.504950        Florida      12031.0  1.203101e+14            0
2  -98.577729          Texas      48029.0  4.802918e+14            0
3 -110.909508        Arizona       4019.0  4.019002e+13            0
4  -71.103350  Massachusetts      25017.0  2.501735e+14            0

   %_dropoutg  %_povertyg  %_public_assistanceg  %_unemployedg closest  gran  \
0         0.0         1.0                   0.0            0.0     NaN   0.0
1         0.0         0.0                   0.0            0.0     NaN   0.0
2         0.0         0.0                   0.0            0.0     NaN   0.0
3         0.0         0.0                   0.0            0.0     NaN   1.0
4         0.0         0.0                   0.0            0.0     NaN   0.0

                                        point  pop_deng
0                   ('27.530608', '-99.472335')       0.0
1  ('30.298712599999998', '-81.50495040000001')       0.0
2          ('29.5130847', '-98.57772890000001')       0.0
3        ('32.225221000000005', '-110.909508')       0.0
4                 ('42.3703833', '-71.1033498')       0.0
```

[6]:
```
# drop unnecessary columns
cols_to_drop = ['Address','lat','lng','xobsyr_0','Unnamed: 0','Unnamed: 0.
↪1','Unnamed: 0.1.1',
                ␣
↪'ID','State','City','agyaddr','state_name','gran','county_FIPS','block_FIPS',
```

```
␣
↪'point','closest','%_public_assistanceg','%_dropoutg','%_unemployedg']

df.drop(columns=cols_to_drop, inplace=True)
df.dropna(inplace=True) # drops any remaining rows with null values

# uncomment to get CONTROL statistics
#cols_to_drop =␣
↪['pop_deng','%_dropoutg','%_unemployedg','%_public_assistanceg','%_povertyg','murder_numg']
#df.drop(columns=cols_to_drop, inplace=True)

df = df.astype(int)
df = df.sample(frac=1).reset_index(drop=True) # shuffle rows
df.shape
```

[6]: (10683, 32)

Subclinical Feature Importance

[7]:
```
from sksurv.util import Surv

predictor_var = 'Illicit_Days'
censoring_var = 'Illicit_Cens'

X = df[df.SUDSy_0_cd == 1]
Y = X[[censoring_var, predictor_var]]
X.drop(columns=[censoring_var, predictor_var, 'SUDSy_0_cd'], inplace=True)

y = Surv.from_arrays(Y[censoring_var], Y[predictor_var]) # structured array to␣
↪ensure correct censoring

print(X.shape, y.shape)
```

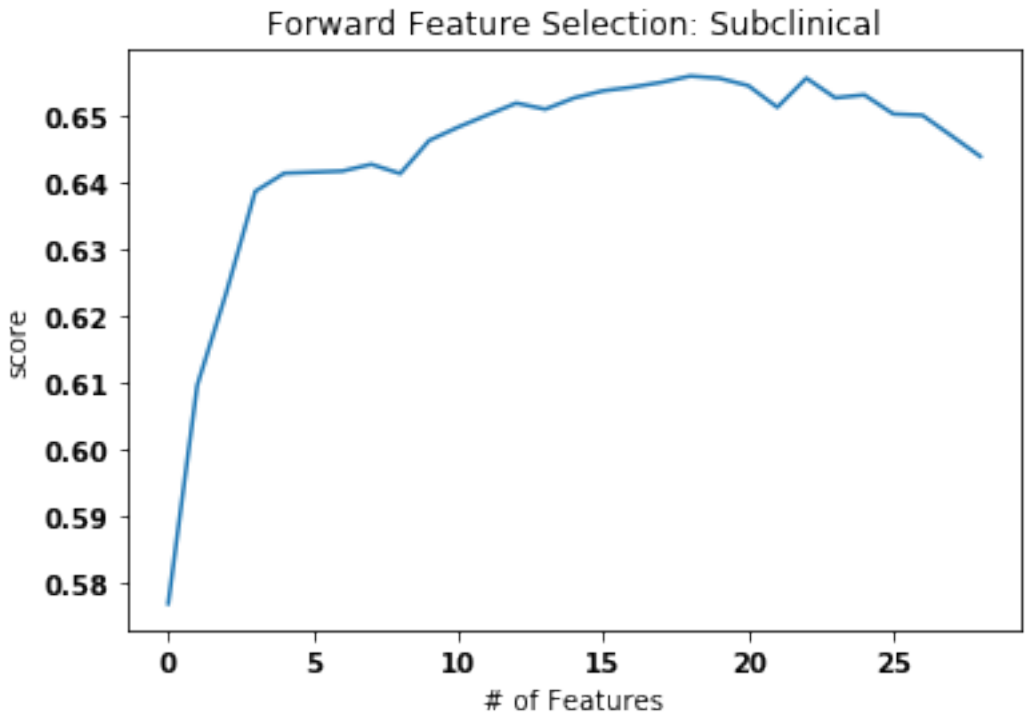
```
(3365, 29) (3365,)
```

```
//anaconda3/lib/python3.7/site-packages/pandas/core/frame.py:4097:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  errors=errors,
```

[8]:
```
%%time
rsf = RandomSurvivalForest()
forward_feature_selection(rsf, X, y, 'Forward Feature Selection: Subclinical')
```

```
HBox(children=(IntProgress(value=0, max=29), HTML(value='')))
```

```
Ordering of Features: ['r4ag_0_cd', 'murder_numg', 'B2a_0g', 'ncar_cd',
'primsev_cocaine', 'primsev_other', 'PYS9Sxg_cd', 'unemplmt_cd', '%_povertyg',
'nonwhite', 'primsev_opioids', 'primsev_marijuana', 'female', 'cjsig_0_cd',
'CWSg_0_cd', 'adhdg_0_cd', 'SESg_0_cd', 'prsatx_cd', 'cdsg_0_cd',
'homeless_0_cd', 'TRIg_0_cd', 'pop_deng', 'gvsg_cd', 'primsev_amphetamines',
'primsev_alcohol', 'epsg_0_cd', 'srig_0_cd', 'dssg_0_cd', 'lrig_0_cd']
CPU times: user 20min 14s, sys: 1min 2s, total: 21min 16s
Wall time: 21min 23s
```

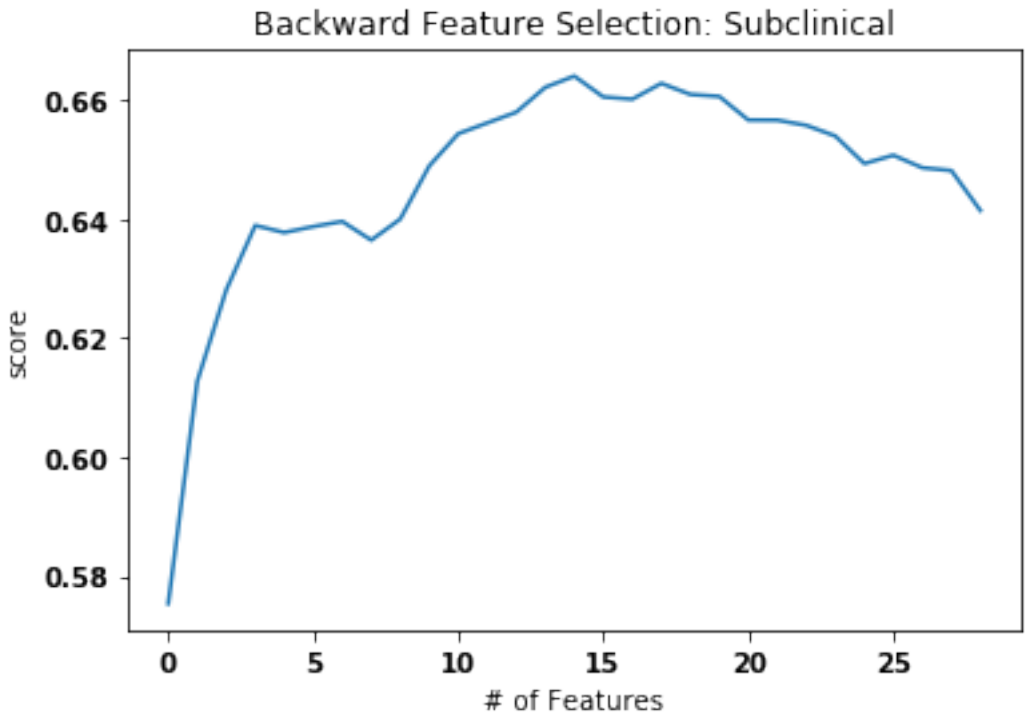


[9]:
```
%%time
rsf = RandomSurvivalForest()
backward_feature_selection(rsf, X, y, 'Backward Feature Selection: Subclinical')
```

```
HBox(children=(IntProgress(value=0, max=28), HTML(value='')))
```

```
Ordering of Features: ['B2a_0g', 'murder_numg', 'ncar_cd', 'r4ag_0_cd',
'cjsig_0_cd', 'female', '%_povertyg', 'prsatx_cd', 'TRIg_0_cd', 'SESg_0_cd',
'adhdg_0_cd', 'CWSg_0_cd', 'gvsg_cd', 'primsev_amphetamines', 'primsev_opioids',
'primsev_alcohol', 'unemplmt_cd', 'pop_deng', 'homeless_0_cd', 'dssg_0_cd',
'primsev_other', 'srig_0_cd', 'nonwhite', 'primsev_cocaine',
```

```
'primsev_marijuana', 'epsg_0_cd', 'lrig_0_cd', 'PYS9Sxg_cd', 'cdsg_0_cd']
CPU times: user 32min 47s, sys: 2min 14s, total: 35min 1s
Wall time: 35min 11s
```



Mild Feature Importance

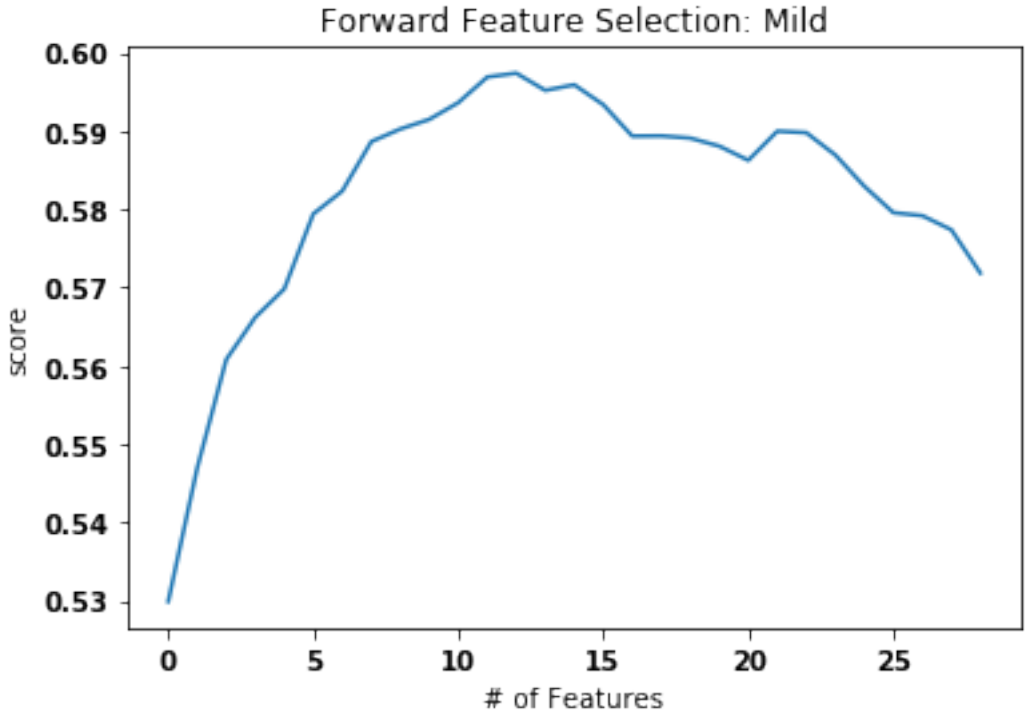
[10]:
```
X = df[df.SUDSy_0_cd == 2]
Y = X[[censoring_var, predictor_var]]
X.drop(columns=[censoring_var, predictor_var, 'SUDSy_0_cd'], inplace=True)

y = Surv.from_arrays(Y[censoring_var], Y[predictor_var]) # structured array to␣
 ↪ensure correct censoring

print(X.shape, y.shape)
```

```
(2964, 29) (2964,)
```

```
//anaconda3/lib/python3.7/site-packages/pandas/core/frame.py:4097:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  errors=errors,
```

[11]:
```
%%time
rsf = RandomSurvivalForest()
forward_feature_selection(rsf, X, y, 'Forward Feature Selection: Mild')
```

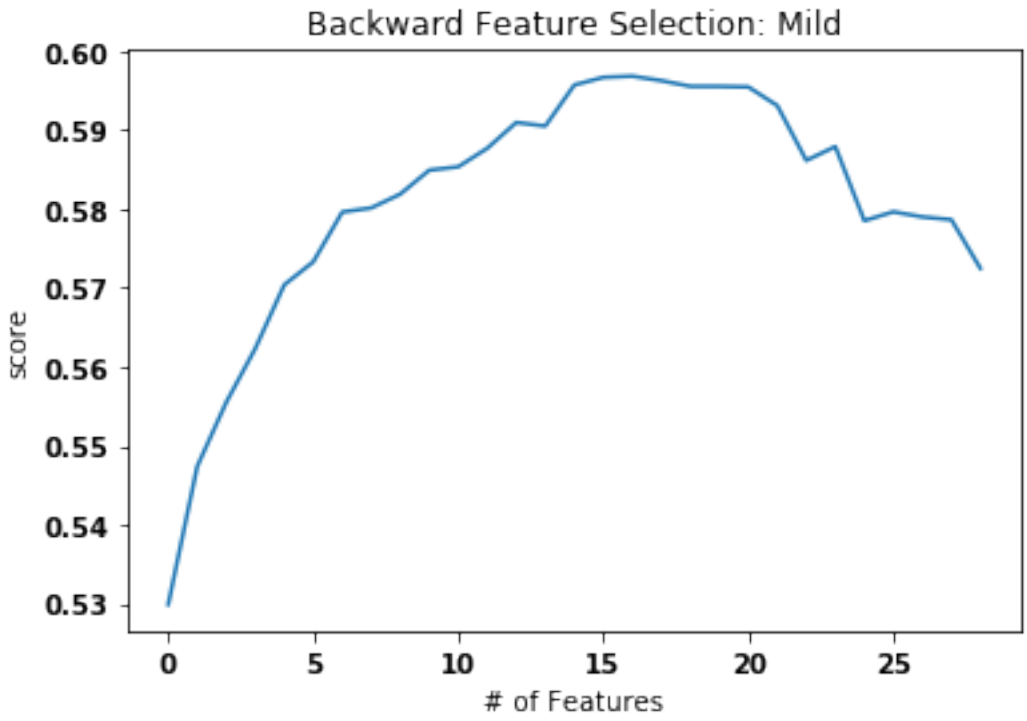
```
HBox(children=(IntProgress(value=0, max=29), HTML(value='')))


Ordering of Features: ['r4ag_0_cd', 'cjsig_0_cd', 'adhdg_0_cd', 'PYS9Sxg_cd',
'primsev_amphetamines', 'pop_deng', 'murder_numg', 'primsev_other',
'primsev_opioids', 'gvsg_cd', 'prsatx_cd', 'primsev_alcohol', 'primsev_cocaine',
'SESg_0_cd', 'unemplmt_cd', 'B2a_0g', 'TRIg_0_cd', '%_povertyg', 'female',
'nonwhite', 'homeless_0_cd', 'primsev_marijuana', 'CWSg_0_cd', 'ncar_cd',
'lrig_0_cd', 'cdsg_0_cd', 'srig_0_cd', 'epsg_0_cd', 'dssg_0_cd']
CPU times: user 20min 50s, sys: 1min 12s, total: 22min 3s
Wall time: 22min 9s
```



[12]:
```
%%time
rsf = RandomSurvivalForest()
backward_feature_selection(rsf, X, y, 'Backward Feature Selection: Mild')
```

```
HBox(children=(IntProgress(value=0, max=28), HTML(value='')))
```

```
Ordering of Features: ['r4ag_0_cd', 'cjsig_0_cd', 'PYS9Sxg_cd', 'murder_numg',
'pop_deng', 'B2a_0g', 'ncar_cd', 'primsev_amphetamines', 'gvsg_cd', 'lrig_0_cd',
'primsev_alcohol', 'unemplmt_cd', 'homeless_0_cd', 'female', 'adhdg_0_cd',
'prsatx_cd', 'primsev_other', 'primsev_marijuana', 'primsev_opioids',
'primsev_cocaine', '%_povertyg', 'nonwhite', 'srig_0_cd', 'cdsg_0_cd',
'CWSg_0_cd', 'dssg_0_cd', 'epsg_0_cd', 'SESg_0_cd', 'TRIg_0_cd']
CPU times: user 29min 40s, sys: 2min 13s, total: 31min 54s
Wall time: 31min 58s
```



Severe Feature Importance

[13]:
```
X = df[df.SUDSy_0_cd == 3]
Y = X[[censoring_var, predictor_var]]
X.drop(columns=[censoring_var, predictor_var, 'SUDSy_0_cd'], inplace=True)

y = Surv.from_arrays(Y[censoring_var], Y[predictor_var]) # structured array to␣
 ↪ensure correct censoring

print(X.shape, y.shape)
```

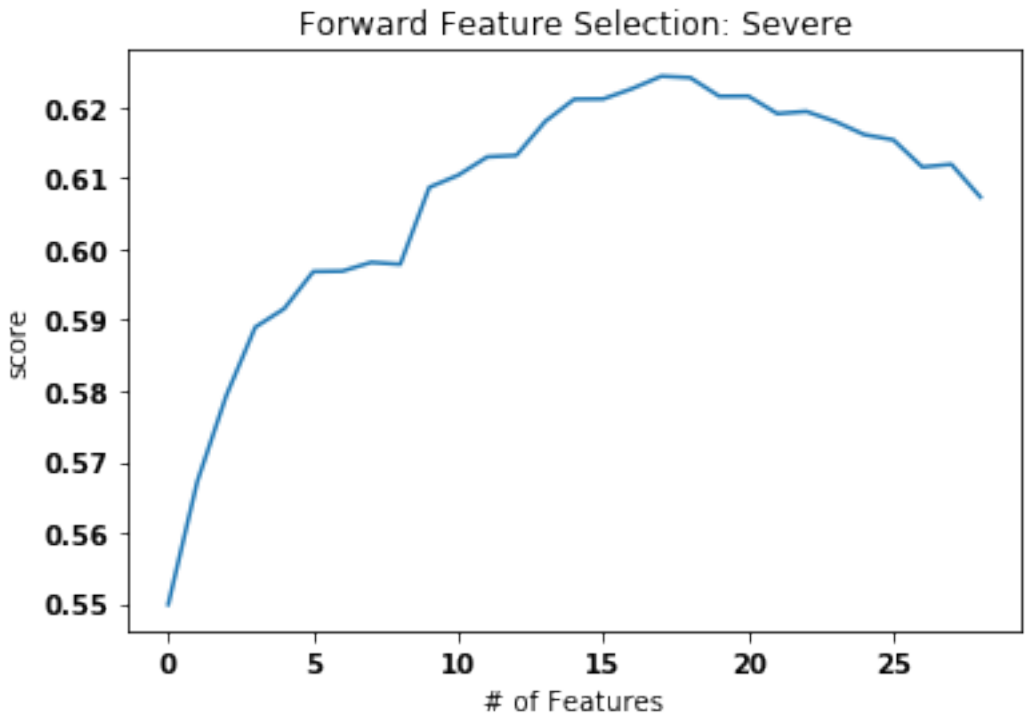
```
(4354, 29) (4354,)
```

```
//anaconda3/lib/python3.7/site-packages/pandas/core/frame.py:4097:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame
```

```
See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  errors=errors,
```

[14]:
```
%%time
rsf = RandomSurvivalForest()
forward_feature_selection(rsf, X, y, 'Forward Feature Selection: Severe')
```

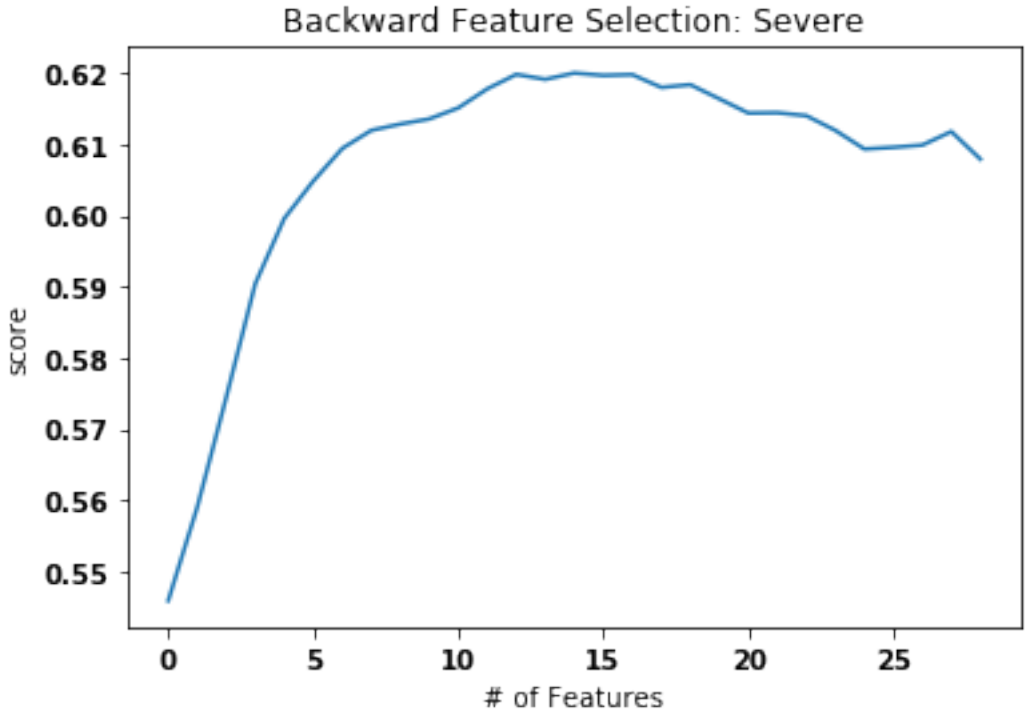
```
HBox(children=(IntProgress(value=0, max=29), HTML(value='')))


Ordering of Features: ['dssg_0_cd', 'r4ag_0_cd', 'primsev_opioids', 'B2a_0g',
'pop_deng', 'primsev_alcohol', 'murder_numg', 'primsev_other', '%_povertyg',
'PYS9Sxg_cd', 'unemplmt_cd', 'ncar_cd', 'SESg_0_cd', 'primsev_amphetamines',
'nonwhite', 'cjsig_0_cd', 'CWSg_0_cd', 'homeless_0_cd', 'female',
'primsev_cocaine', 'prsatx_cd', 'TRIg_0_cd', 'srig_0_cd', 'primsev_marijuana',
'lrig_0_cd', 'epsg_0_cd', 'gvsg_cd', 'adhdg_0_cd', 'cdsg_0_cd']
CPU times: user 30min 50s, sys: 2min 35s, total: 33min 25s
Wall time: 34min 49s
```



[15]:
```
%%time
rsf = RandomSurvivalForest()
```

```
backward_feature_selection(rsf, X, y, 'Backward Feature Selection: Severe')
```

```
HBox(children=(IntProgress(value=0, max=28), HTML(value='')))


Ordering of Features: ['r4ag_0_cd', 'PYS9Sxg_cd', 'B2a_0g', '%_povertyg',
'SESg_0_cd', 'primsev_opioids', 'primsev_other', 'primsev_amphetamines',
'nonwhite', 'unemplmt_cd', 'dssg_0_cd', 'pop_deng', 'srig_0_cd', 'murder_numg',
'primsev_alcohol', 'female', 'primsev_cocaine', 'primsev_marijuana',
'lrig_0_cd', 'CWSg_0_cd', 'homeless_0_cd', 'TRIg_0_cd', 'gvsg_cd', 'adhdg_0_cd',
'cdsg_0_cd', 'epsg_0_cd', 'ncar_cd', 'prsatx_cd', 'cjsig_0_cd']
CPU times: user 46min 37s, sys: 4min 38s, total: 51min 16s
Wall time: 54min 4s
```



[17]:
```
# print out total notebook execution time
total_seconds = int(time.time() - start_time)
hours = total_seconds // (60 * 60)
minutes = (total_seconds - hours*60) // 60
seconds = (total_seconds - hours*60) % 60
print("--- " + str(hours) + " hours " + str(minutes) + " minutes " +␣
 ↪str(seconds) + " seconds ---")
```

```
--- 10 hours 600 minutes 44 seconds ---
```

[18]:
```
%%bash
jupyter nbconvert --to html ./feature_selection.ipynb
```

```
[NbConvertApp] Converting notebook ./feature_selection.ipynb to html
[NbConvertApp] Writing 434026 bytes to ./feature_selection.html
```

[ ]:
```

```