

cancer_survival_LASSOCV_linear-Log-Odds

November 11, 2018

1 Breast Cancer Survival Time after Diagnosis

Linear Model, LASSO, Cross Validation by Log Odds Data source: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute Surveillance, Epidemiology, and End Results (SEER) Program - Incidences of Breast Cancer <https://seer.cancer.gov/>

Purpose The purpose of this analysis is to determine the factors that contribute to mortality after a breast cancer diagnosis. Such analysis will be used to uncover treatment strategies and provide a baseline for effectiveness.

```
In [1]: # Standard module set
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

# Statistical analysis
import statsmodels.api as sm
import scipy.stats as stats

# Supervised modeling
from sklearn.linear_model import LassoCV
from sklearn.model_selection import train_test_split

import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
```

Data set The data set has been formatted and cleaned, then read into a csv file. Many of the independent variables are categorical, dummy variables were constructed to ease analysis. The data set contains patient by patient data, covering survival times, some basic patient and neoplasm characteristics. The variables are:

srv_time_mon - Main dependent variable. Number of months the patient survives after a diagnosis.

p_srv - Constructed from the dependent variable, the probability of survival after a diagnosis.

c_srv - Constructed from the dependent variable, the count of patients surviving to the time point.

log_odds - An alternate dependent variable and constructed from the dependent variable, the log odds of the patient survival after a diagnosis.

REG - Independent variable, the US region where the diagnosis occurred.

MAR_STAT - Independent variable, marital status of the patient.

RACE1V - Independent variable, ethnicity of the patient.

NHIADE - Independent variable, for hispanic ethnicities, further classifications.

SEX - Independent variable, gender of the patient.

AGE_DX - Independent variable, age of the patient at diagnosis.

SEQ_NUM - Independent variable, number of previous diagnoses.

LATERAL - Independent variable, side of body of the diagnosis.

HISTO3V - Independent variable, histologic characteristics of the diagnosis.

BEHO3V - Independent variable, behavior characterization of the neoplasm.

GRADE - Independent variable, a classification of the severity of the neoplasm.

HST_STGA - Independent variable, histologic stage of the neoplasm.

MALIGCOUNT - Independent variable, the number of malignant neoplasms at diagnosis.

BENBORDCOUNT - Independent variable, the number of benign neoplasms at diagnosis.

PRIMSITE_coded - Independent variable, the primary site of the diagnosis.

```
In [2]: #Dataset that has been organized and formatted
cancer_sruviv = pd.read_csv('./data/dummied.csv')

#Remove old index
cancer_sruviv = cancer_sruviv.drop('Unnamed: 0', axis=1)
```

```
In [3]: #Split training and testing sets
train, test = train_test_split(cancer_sruviv)
```

Analysis The linear model to survival time in months has a relatively low coefficient of determination. Other models may show improvement.

```
In [4]: #Set up response and factors
x = train.drop(['srv_time_mon', 'p_srv', 'c_srv', 'log_odds'], axis=1)
y = train.log_odds

#Fit model
model = LassoCV(cv=20, random_state=0).fit(x, y)
print(f'Coefficient of determination: {np.round(model.score(x, y), 2)}')
```

Coefficient of determination: 0.32

```
In [5]: #Make a list of dependent variables and coefficients.
a = list()
for i in enumerate(np.round(model.coef_,2)):
    b = (x.columns[i[0]], i[1])
    a.append(b)
# a.insert(0,('intercept:',np.round(model.intercept_)))
```

```
In [6]: coefficients = pd.DataFrame(a, columns = ['variable', 'coefficient'])
        coefficients.sort_values(['coefficient'], axis=0, ascending=False,
                                inplace=True, kind='quicksort', na_position='last')
        best_coefficients = coefficients[coefficients['coefficient'] > 0]
```

Residuals The distribution of residuals show deviation from normal and possible heteroskedasticity (against fitted values). The training set and testing set look similar. Check for correct model specification.

```
In [7]: #Residual analysis
        y_pred = model.predict(x)
        resid = y_pred - y
        resid_stand = (resid.mean() - resid) / resid.std()

        ks = stats.kstest(resid_stand, 'norm')[1]
        rsd = np.round(np.sqrt(np.sum(resid**2) / (len(resid) - len(x.columns))), 2)
        rrse = np.round(np.sqrt(np.sum(resid**2) / np.sum((y.mean() - y)**2)), 2)
        print(f'Residual sd: {rsd}\n'
              f'Relative root residual error: {rrse}\n'
              f'KS test for normal residual distribution: '
              f'{ks}')
```

Residual sd: 1.43

Relative root residual error: 0.82

KS test for normal residual distribution: 5.0871928514038134e-33

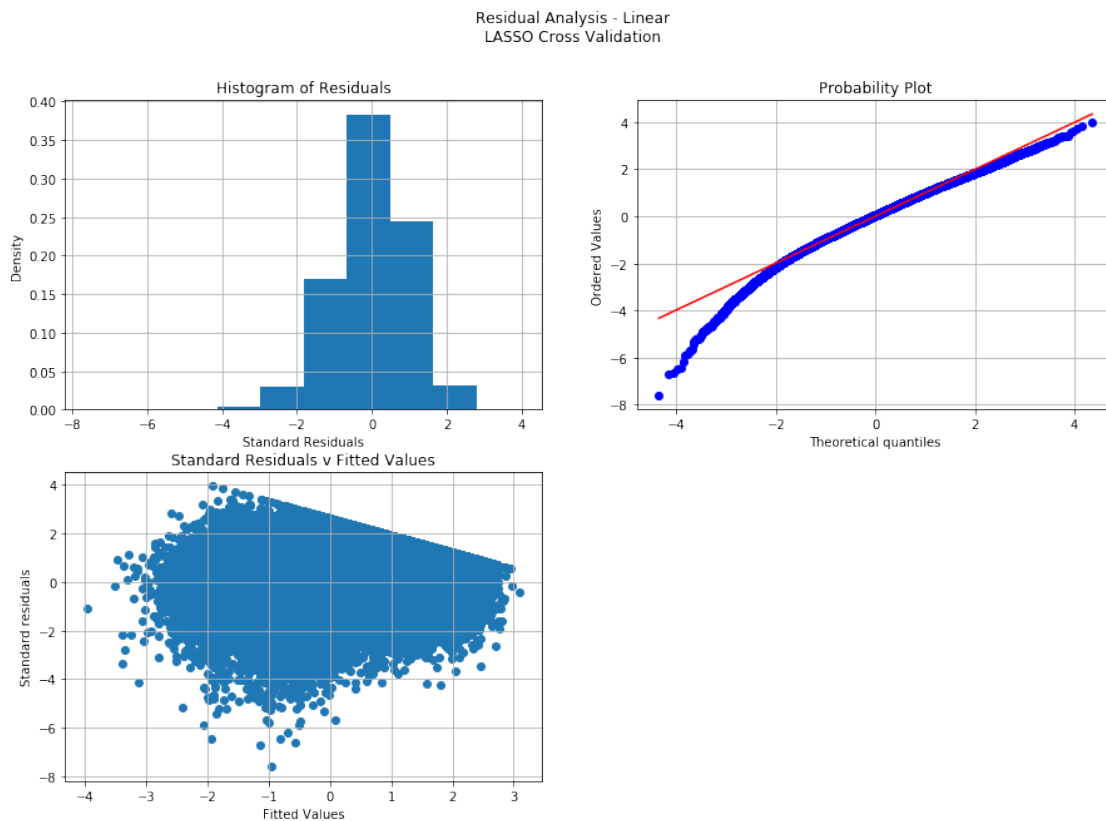
```
In [8]: #Grapnical residual analysis
        plt.figure(figsize=(15,10))
        plt.suptitle('Residual Analysis - Linear\nLASSO Cross Validation')

        ax1 = plt.subplot(221)
        plt.hist(resid_stand, density=True)
        plt.title('Histogram of Residuals')
        plt.xlabel('Standard Residuals')
        plt.ylabel('Density')
        plt.grid()

        ax2 = plt.subplot(222)
        plot = stats.probplot(resid_stand, plot=plt)
        plt.grid()

        ax= plt.subplot(223)
        plt.scatter(y_pred, resid_stand)
        plt.title('Standard Residuals v Fitted Values')
        plt.xlabel('Fitted Values')
        plt.ylabel('Standard residuals')
```

```
plt.grid()
plt.savefig('./images/fig_1_resid_log_odds.png', transparent=True)
plt.show()
```



```
In [9]: x_test = test.drop(['srv_time_mon', 'p_srv', 'c_srv', 'log_odds'], axis=1)
        y_test = test.log_odds
        print(f'Coefficient of determination: {np.round(model.score(x_test, y_test), 2)}')
```

Coefficient of determination: 0.32

```
In [18]: #Residual analysis of the test set
```

```
test_fit = model.predict(x_test)
test_resid = test_fit - y_test
test_resid_stand = (test_resid.mean() - test_resid) / test_resid.std()
```

```
ks_test = stats.kstest(test_resid_stand, 'norm')[1]
rsd_test = np.round(np.sqrt(np.sum(test_resid**2) / (len(test_resid) - len(x_test.col
rrse_test = np.round(np.sqrt(np.sum(test_resid**2) / np.sum((y_test.mean() - y_test)*
print(f'Residual sd: {rsd_test}\n'
      f'Relative root residual error: {rrse_test}\n')
```

```
f'KS test for normal residual distribution: '  
f'{ks_test}')
```

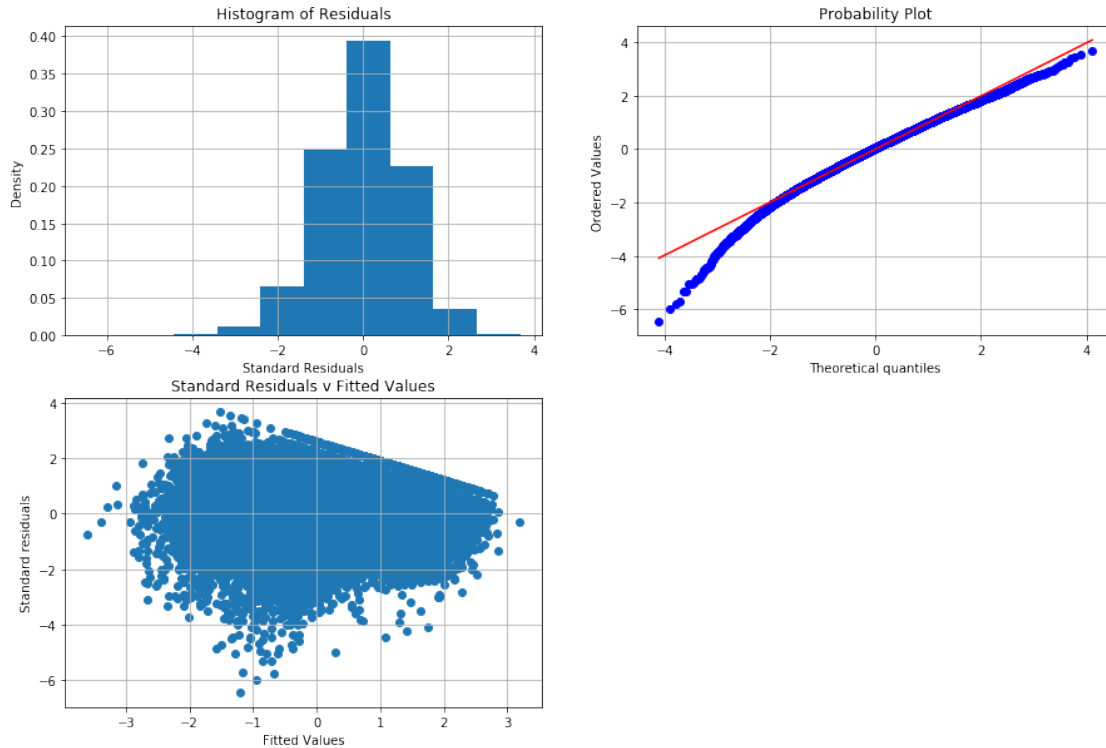
Residual sd: 1.43

Relative root residual error: 0.83

KS test for normal residual distribution: 7.554089993978055e-13

```
In [11]: plt.figure(figsize=(15,10))  
         plt.suptitle('Residual Analysis\nLASSO')  
  
         ax1 = plt.subplot(221)  
         plt.hist(test_resid_stand, density=True)  
         plt.title('Histogram of Residuals')  
         plt.xlabel('Standard Residuals')  
         plt.ylabel('Density')  
         plt.grid()  
  
         ax2 = plt.subplot(222)  
         plot = stats.probplot(test_resid_stand, plot=plt)  
         plt.grid()  
  
         ax3 = plt.subplot(223)  
         plt.scatter(test_fit, test_resid_stand)  
         plt.title('Standard Residuals v Fitted Values')  
         plt.xlabel('Fitted Values')  
         plt.ylabel('Standard residuals')  
  
         plt.grid()  
  
         plt.savefig('./images/fig_2_log_odds.png', transparent=True)  
         plt.show()
```

Residual Analysis LASSO



```
In [12]: # for i in enumerate(x_test.columns):
#         plt.figure(figsize=(15,(np.floor(len(x_test.columns)/2)+1)*5))
#         plt.subplot(np.floor(len(x_test.columns)/2)+1,2,i[0]+1)
#         plt.scatter(test[i[1]], test_resid_stand)
#         plt.title(f'Residuals to {i[1]}')
#         plt.ylabel('Standardized Residuals')
#         plt.xlabel(f'{i[1]} values')
#         plt.grid()
#         plt.show()
```

```
In [13]: weights = train
weights['y_pred'] = model.predict(x)

weights['resid'] = (weights['y_pred'] - weights['srv_time_mon'])**2

resid_sum = weights.groupby('srv_time_mon')['resid'].sum()
mon_count = weights.groupby('srv_time_mon')['srv_time_mon'].count()

weights['resid_sum'] = weights['srv_time_mon'].map(resid_sum)
weights['mon_count'] = weights['srv_time_mon'].map(mon_count)
weights['weight'] = np.sqrt(weights['resid_sum'] / weights['mon_count'])
```

```

x_weights = weights.drop(['srv_time_mon', 'p_srv', 'c_srv', 'log_odds',
                          'y_pred', 'resid', 'resid_sum', 'mon_count',
                          'weight'], axis=1)
y_weights = weights['log_odds']
w_weights = weights['weight']

In [14]: wls_model = sm.WLS(y_weights, x_weights, weights=w_weights).fit()
         print(f'Coefficient of determination: {np.round(wls_model.rsquared, 2)}')

Coefficient of determination: 0.24

In [19]: y_pred_wls = wls_model.predict(x_weights)
         resid_wls = y_pred_wls - y_weights
         resid_stand_wls = (resid_wls.mean() - resid_wls) / resid_wls.std()

         ks_wls = stats.kstest(resid_stand_wls, 'norm')[1]
         rsd_wls = np.round(np.sqrt(np.sum(resid_wls**2) / (len(resid_wls) - len(x_weights.columns))))
         rrse_wls = np.round(np.sqrt(np.sum(resid_wls**2) / np.sum((y.mean() - y_weights)**2)))
         print(f'Residual sd: {rsd_wls}\n'
               f'Relative root residual error: {rrse_wls}\n'
               f'KS test for normal residual distribution: '
               f'{ks_wls}')

Residual sd: 1.87
Relative root residual error: 1.08
KS test for normal residual distribution: 5.568984947510128e-10

In [16]: #Grapnical residual analysis
         plt.figure(figsize=(15,10))
         plt.suptitle('Residual Analysis - Linear\nWeighted Least Squares')

         ax1 = plt.subplot(221)
         plt.hist(resid_stand_wls, density=True)
         plt.title('Histogram of Residuals')
         plt.xlabel('Standard Residuals')
         plt.ylabel('Density')
         plt.grid()

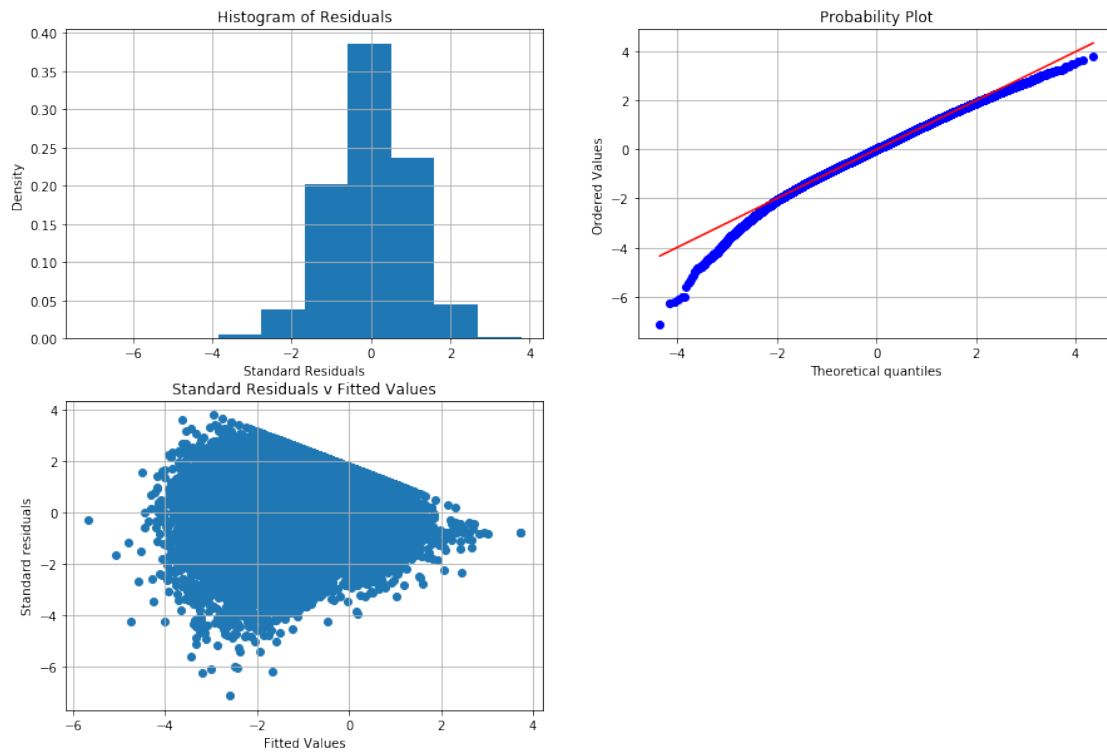
         ax2 = plt.subplot(222)
         plot = stats.probplot(resid_stand_wls, plot=plt)
         plt.grid()

         ax= plt.subplot(223)
         plt.scatter(y_pred_wls, resid_stand_wls)
         plt.title('Standard Residuals v Fitted Values')
         plt.xlabel('Fitted Values')
         plt.ylabel('Standard residuals')

```

```
plt.grid()
plt.savefig('./images/fig_3_resid_log_oods.png', transparent=True)
plt.show()
```

Residual Analysis - Linear
Weighted Least Squares



In []: