Model Validation

```
import warnings
warnings.filterwarnings('ignore')
```

I. Model Capacity

- import Packages

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

- pandas DataFrame
  - 'Electric.csv' From github

```
Elec = pd.read_csv('https://raw.githubusercontent.com/rusita-ai/pyData/master/Electric.csv')

Elec.info()
```

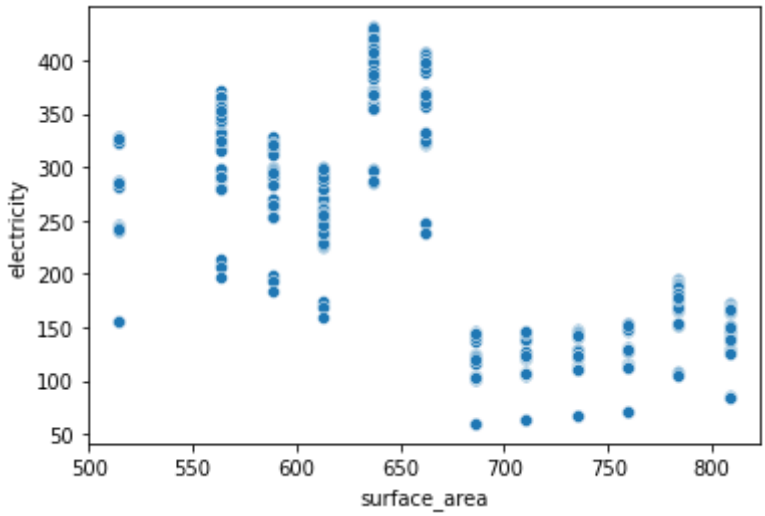
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 9 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   compactness               768 non-null    float64
 1   surface_area              768 non-null    float64
 2   wall_area                 768 non-null    float64
 3   roof_area                 768 non-null    float64
 4   height                    768 non-null    float64
 5   orientation               768 non-null    int64  
 6   glazing_area              768 non-null    float64
 7   glazing_area_distribution  768 non-null    int64  
 8   electricity               768 non-null    float64
dtypes: float64(7), int64(2)
memory usage: 54.1 KB
```

```
Elec.head()
```

	compactness	surface_area	wall_area	roof_area	height	orientation	glazing_a
0	0.98	514.5	294.0	110.25	7.0	2	
2	0.98	514.5	294.0	110.25	7.0	4	

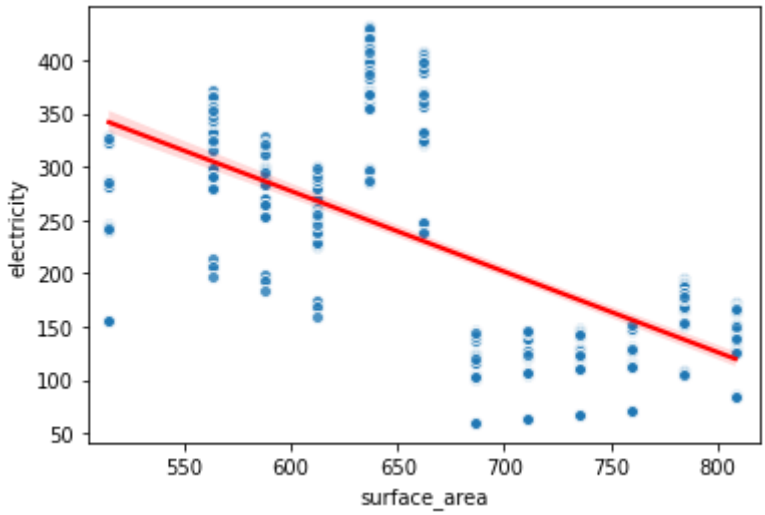
- 산점도(surface_area vs. electricity)

```
sns.scatterplot(Elec['surface_area'], Elec['electricity'])
plt.show()
```



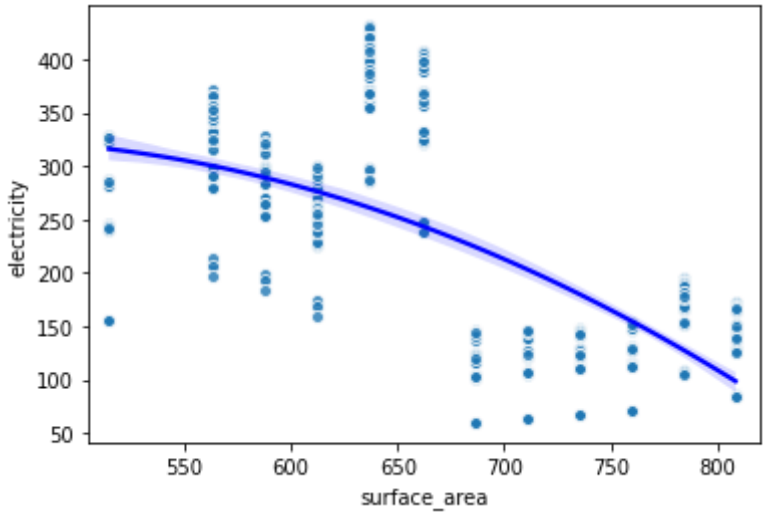
1) 1차 모델 시각화

```
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec,
            line_kws = {'color':'red'},
            scatter_kws = {'edgecolor' : 'white'})
plt.xlim(505, 820)
plt.show()
```



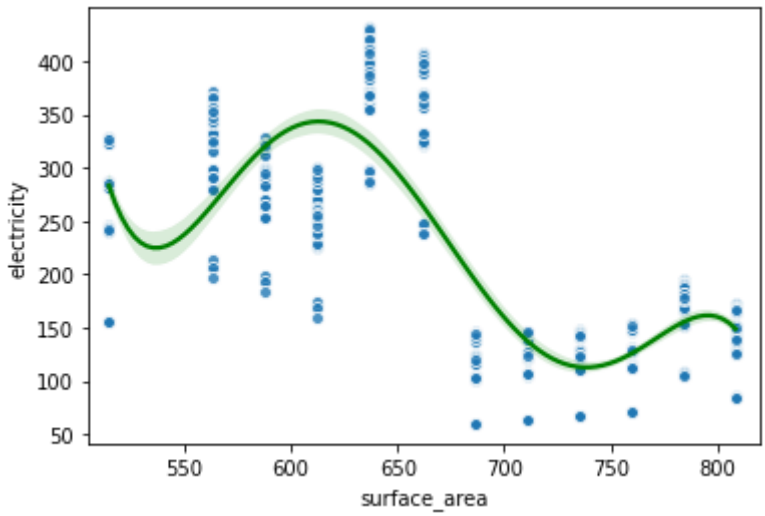
2) 2차 모델 시각화

```
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec,
            line_kws = {'color':'blue'},
            scatter_kws = {'edgecolor' : 'white'},
            order = 2)
plt.xlim(505, 820)
plt.show()
```



3) 5차 모델 시각화

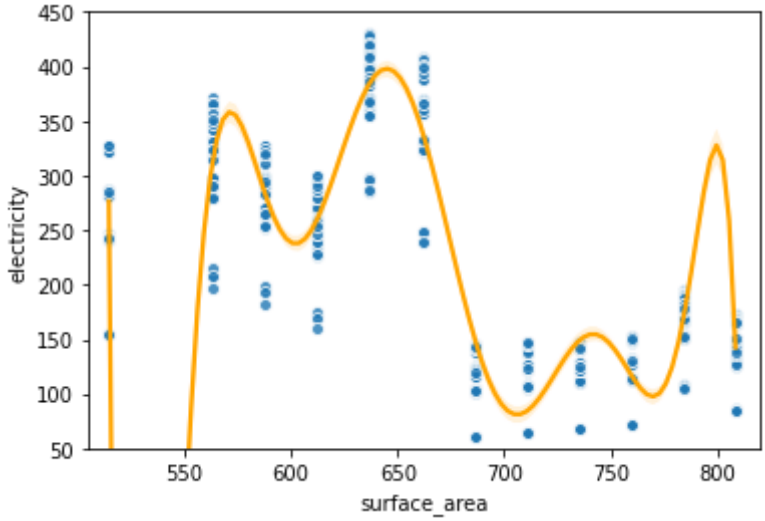
```
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec,
            line_kws = {'color':'green'},
            scatter_kws = {'edgecolor' : 'white'},
            order = 5)
plt.xlim(505, 820)
plt.show()
```



4) 9차 모델 시각화

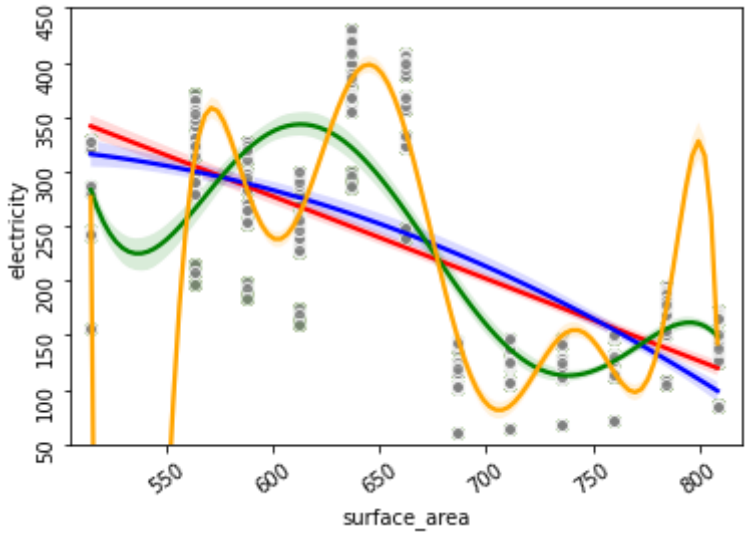
```
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec,
            line_kws = {'color':'orange'}
```

```
            line_kws = {'color':'orange'},
            scatter_kws = {'edgecolor':'white'},
            order = 9)
plt.xlim(505, 820)
plt.ylim(50, 450)
plt.show()
```



5) 4개 모델 비교 시각화

```
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec, line_kws = {'color':'red'})
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec, line_kws = {'color':'blue'}, order
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec, line_kws = {'color':'green'}, order
sns.regplot(x = 'surface_area', y = 'electricity', data = Elec, line_kws = {'color':'orange'}, orde
            scatter_kws = {'color':'gray', 'edgecolor':'white'})
plt.xlim(505, 820)
plt.ylim(50, 450)
plt.xticks(rotation = 35)
plt.yticks(rotation = 90)
plt.show()
```



6) ipywidgets Package

- reg_plot( ) 선언

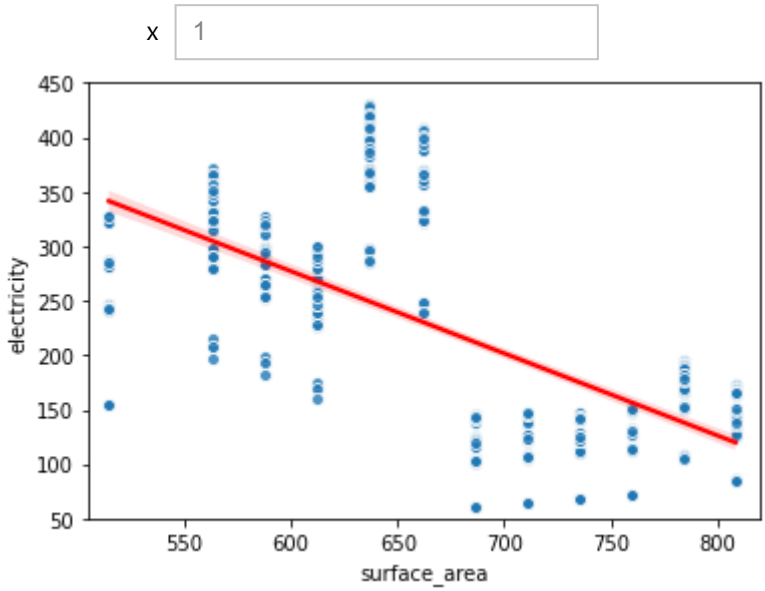
```
def reg_plot(x):
    sns.regplot(x = 'surface_area',
                y = 'electricity',
                data = Elec,
                order = x,
                line_kws = {'color':'red'},
                scatter_kws={'edgecolor':'white'})

    plt.xlim(505, 820)
    plt.ylim(50, 450)
    plt.show()
```

- interact( ) 실행

```
from ipywidgets import interact

order = [1, 2, 5, 9]
interact(reg_plot, x = order)
```




```
<function __main__.reg_plot>
```

II. Training Error

- import Packages

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

- pandas DataFrame
  - 'Electric.csv' From github

```
Elec = pd.read_csv('https://raw.githubusercontent.com/rusita-ai/pyData/master/Electric.csv')

Elec.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 9 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   compactness               768 non-null    float64
 1   surface_area              768 non-null    float64
 2   wall_area                 768 non-null    float64
 3   roof_area                 768 non-null    float64
 4   height                    768 non-null    float64
 5   orientation               768 non-null    int64  
 6   glazing_area              768 non-null    float64
 7   glazing_area_distribution  768 non-null    int64  
 8   electricity               768 non-null    float64
dtypes: float64(7), int64(2)
memory usage: 54.1 KB
```

1) 1차 모델 Training Error

- X_train and y_train

```
X_train = Elec[['surface_area']]
y_train = Elec['electricity']

X_train.shape, y_train.shape
```

```
((768, 1), (768,))
```

- 모델 생성

```
from sklearn.linear_model import LinearRegression

Model_1 = LinearRegression()
Model_1.fit(X_train, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- 모델 정보(학습결과) 확인

```
print(Model_1.coef_)
print(Model_1.intercept_)
```

```
[-0.75387157]
729.4538243006992
```

- y_hat(예측값) 생성

```
y_hat_1 = Model_1.predict(X_train)

len(y_hat_1)
```

```
768
```

- MSE(Mean Squared Error) 계산

```
TR_Err_1 = np.mean((y_train - y_hat_1) ** 2)
TR_Err_1
```

```
5763.983779426347
```

2) 5차 모델 Training Error

- X 다항차수 변환
  - (768, 1) to (768, 5)

```
from sklearn.preprocessing import PolynomialFeatures

poly = PolynomialFeatures(degree = 5, include_bias = False)
PX_5 = poly.fit_transform(X_train)
```

```
PX_5
```

```
array([[5.14500000e+02, 2.64710250e+05, 1.36193424e+08, 7.00715165e+10,
        3.60517952e+13],
       [5.14500000e+02, 2.64710250e+05, 1.36193424e+08, 7.00715165e+10,
        3.60517952e+13],
       [5.14500000e+02, 2.64710250e+05, 1.36193424e+08, 7.00715165e+10,
        3.60517952e+13],
       ...,
       [8.08500000e+02, 6.53672250e+05, 5.28494014e+08, 4.27287410e+11,
        3.45461871e+14],
       [8.08500000e+02, 6.53672250e+05, 5.28494014e+08, 4.27287410e+11,
        3.45461871e+14],
       [8.08500000e+02, 6.53672250e+05, 5.28494014e+08, 4.27287410e+11,
        3.45461871e+14]])
```

```
X_train.shape, PX_5.shape
```

```
((768, 1), (768, 5))
```

- 5차 모델 생성

```
from sklearn.linear_model import LinearRegression

Model_5 = LinearRegression()
Model_5.fit(PX_5, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- 모델 정보(학습결과) 확인

```
np.set_printoptions(suppress = True, precision = 10)

print(Model_5.coef_)
print(Model_5.intercept_)
```

```
[-0.0003155148 -0.1029296835  0.0003787616 -0.0000005032  0.0000000002]
2906.221625380881
```

- y_hat(예측값) 생성

```
PX_5_pred = poly.fit_transform(X_train)

y_hat_5 = Model_5.predict(PX_5_pred)

y_hat_5.shape
```

```
(768,)
```

- MSE(Mean Squared Error) 계산

```
TR_Err_5 = np.mean((y_train - y_hat_5) ** 2)
TR_Err_5
```

```
4177.726328606075
```

3) 9차 모델 Training Error

- X 다항차수 변환
  - (768, 1) to (768, 9)

```
from sklearn.preprocessing import PolynomialFeatures

poly = PolynomialFeatures(degree = 9, include_bias = False)
PX_9 = poly.fit_transform(X_train)
```

```
X_train.shape, PX_9.shape
```

```
((768, 1), (768, 9))
```

- 모델 생성

```
from sklearn.linear_model import LinearRegression

Model_9 = LinearRegression()
Model_9.fit(PX_9, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- 모델 정보(학습결과) 확인

```
print(Model_9.coef_)
print(Model_9.intercept_)
```

```
[ 0.  0.  0.  0.  0.  0. -0.  0. -0.]
-440.08258373871365
```

- y_hat(예측값) 생성

```
PX_9_pred = poly.fit_transform(X_train)

y_hat_9 = Model_9.predict(PX_9_pred)

y_hat_9.shape
```

```
(768,)
```

- MSE(Mean Squared Error) 계산

```
TR_Err_9 = np.mean((y_train - y_hat_9) ** 2)
TR_Err_9
```

```
4086.7199908150374
```

4) 3개 모델 Training Error 비교

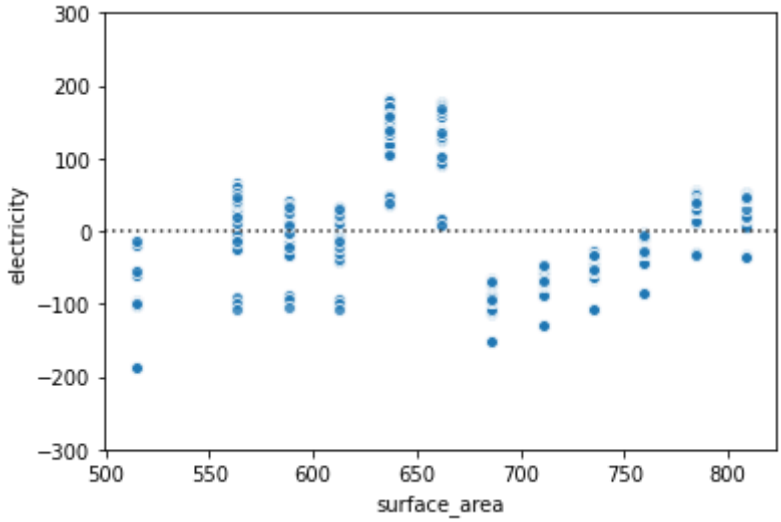
```
print('1차 모델 : ', TR_Err_1)
print('5차 모델 : ', TR_Err_5)
print('9차 모델 : ', TR_Err_9)
```

```
1차 모델 :  5763.983779426347
5차 모델 :  4177.726328606075
9차 모델 :  4086.7199908150374
```

5) 잔차(Residual) 시각화

- 1차 모델

```
sns.residplot(x = 'surface_area',
              y = 'electricity',
              data = Elec,
              order = 1,
              scatter_kws={'edgecolor':'white'})
plt.ylim(-300, 300)
plt.show()
```

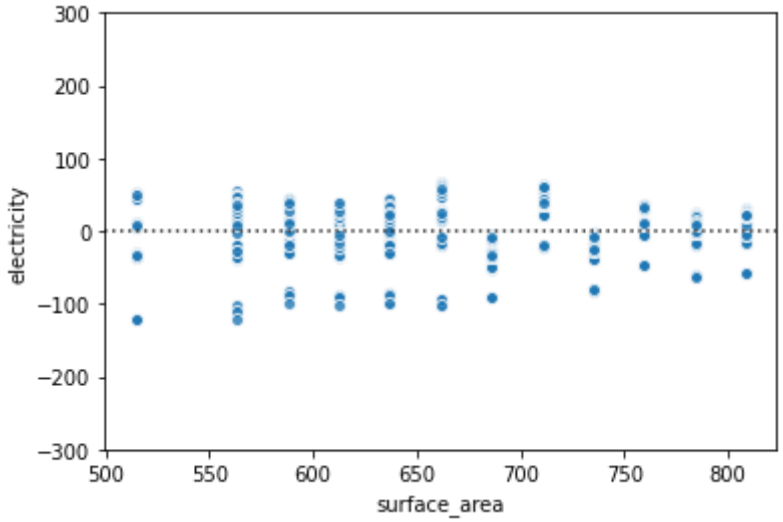


- 5차 모델

```
sns.residplot(x = 'surface_area',
              y = 'electricity',
              data = Elec,
              order = 5,
              scatter_kws={'edgecolor':'white'})
plt.ylim(-300, 300)
plt.show()
```

- 9차 모델


```
sns.residplot(x = 'surface_area',
              y = 'electricity',
              data = Elec,
              order = 9,
              scatter_kws={'edgecolor':'white'})
plt.ylim(-300, 300)
plt.show()
```



III. Testing Error

- import Packages

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

- pandas DataFrame
  - 'Electric.csv' From github

```
Elec = pd.read_csv('https://raw.githubusercontent.com/rusita-ai/pyData/master/Electric.csv')

Elec.shape
```

```
(768, 9)
```

Train_Data vs. Test_Data

(1) DataFram Split

- 8:2 Split(614:154)
- 80% Train_DF & 20% Test_DF

```
from sklearn.model_selection import train_test_split

TR_Elec, TE_Elec = train_test_split(Elec, test_size = 0.2, random_state = 2045)
```

```
TR_Elec.shape, TE_Elec.shape
```

```
((614, 9), (154, 9))
```

- 80% TR_Elec DataFrame

```
TR_Elec.head()
```

	compactness	surface_area	wall_area	roof_area	height	orientation	glazing
555	0.74	686.0	245.0	220.5	3.5	5	
355	0.79	637.0	343.0	147.0	7.0	5	
200	0.86	588.0	294.0	147.0	7.0	2	
669	0.62	808.5	367.5	220.5	3.5	3	
561	0.69	735.0	294.0	220.5	3.5	3	

- 20% TE_Elec DataFrame

```
TE_Elec.head()
```

	compactness	surface_area	wall_area	roof_area	height	orientation	glazing
414	0.71	710.5	269.5	220.50	3.5	4	
475	0.64	784.0	343.0	220.50	3.5	5	
511	0.71	710.5	269.5	220.50	3.5	5	
213	0.76	661.5	416.5	122.50	7.0	3	
339	0.98	514.5	294.0	110.25	7.0	5	

(2) Array Split

- X_train, X_test & y_train, y_test

```
from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(Elec[['surface_area']], Elec['electricity'],
                                                    test_size = 0.2, random_state = 2045)
```

```
X_train.shape, y_train.shape, X_test.shape, y_test.shape
```

```
((614, 1), (614,), (154, 1), (154,))
```

- 80% X_train Array

```
X_train.head()
```

	surface_area
555	686.0
355	637.0
200	588.0
669	808.5
561	735.0

- 80% y_train Array

```
y_train.head()
```

```
555    145.5
355    389.8
200    264.4
669    163.5
561    147.0
Name: electricity, dtype: float64
```

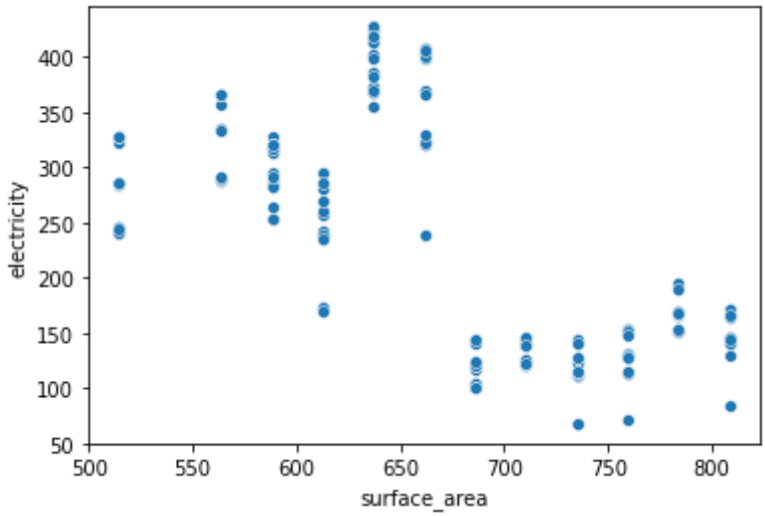
(3) Distribution Visualization

- Train Data

```
sns.scatterplot(TR_Elec['surface_area'], TR_Elec['electricity'])
plt.show()
```

- Test Data

```
sns.scatterplot(TE_Elec['surface_area'], TE_Elec['electricity'])
plt.show()
```



1) 1차 모델 Testing Error

- Train_Data로 모델 생성

```
from sklearn.linear_model import LinearRegression

Model_1 = LinearRegression()
Model_1.fit(X_train, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- Test_Data로 y_hat(예측값) 생성

```
y_hat_1 = Model_1.predict(X_test)

y_hat_1.shape
```

```
(154,)
```

- Test_Data로 MSE(Mean Squared Error) 계산

```
from sklearn.metrics import mean_squared_error
```

```
TE_Err_1 = mean_squared_error(y_test, y_hat_1)
TE_Err_1
```

```
6044.176547629271
```

2) 5차 모델 Testing Error

- Train_Data로 모델 생성

```
from sklearn.preprocessing import PolynomialFeatures

poly = PolynomialFeatures(degree = 5, include_bias = False)
PX_5_TR = poly.fit_transform(X_train)
```

```
from sklearn.linear_model import LinearRegression

Model_5 = LinearRegression()
Model_5.fit(PX_5_TR, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- Test_Data로 y_hat(예측값) 생성

```
PX_5_TE = poly.fit_transform(X_test)

y_hat_5 = Model_5.predict(PX_5_TE)
```

- Test_Data로 MSE(Mean Squared Error) 계산

```
from sklearn.metrics import mean_squared_error

TE_Err_5 = mean_squared_error(y_test, y_hat_5)
TE_Err_5
```

```
4330.604566409499
```

3) 9차 모델 Testing Error

- Train_Data로 모델 생성

```
from sklearn.preprocessing import PolynomialFeatures

poly = PolynomialFeatures(degree = 9, include_bias = False)
PX_9_TR = poly.fit_transform(X_train)
```

```
PX_9_TR = poly.fit_transform(X_train)
```

```
from sklearn.linear_model import LinearRegression

Model_9 = LinearRegression()
Model_9.fit(PX_9_TR, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- Test_Data로 y_hat(예측값) 생성

```
PX_9_TE = poly.fit_transform(X_test)

y_hat_9 = Model_9.predict(PX_9_TE)
```

- Test_Data로 MSE(Mean Squared Error) 계산

```
from sklearn.metrics import mean_squared_error

TE_Err_9 = mean_squared_error(y_test, y_hat_9)
TE_Err_9
```

```
4238.689067137633
```

4) 3개 모델 Testing Error 비교

```
print('1차 모델 : ', TE_Err_1)
print('5차 모델 : ', TE_Err_5)
print('9차 모델 : ', TE_Err_9)
```

```
1차 모델 :  6044.176547629271
5차 모델 :  4330.604566409499
9차 모델 :  4238.689067137633
```

IV. Validation Approach

- import Packages

```
import pandas as pd
```

- pandas DataFrame

```
Elec = pd.read_csv('https://raw.githubusercontent.com/rusita-ai/pyData/master/Electric.csv')

Elec.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 9 columns):
 #   Column                     Non-Null Count  Dtype  
---  ------                     --------------  -----  
 0   compactness                768 non-null    float64
 1   surface_area               768 non-null    float64
 2   wall_area                  768 non-null    float64
 3   roof_area                  768 non-null    float64
 4   height                     768 non-null    float64
 5   orientation                768 non-null    int64  
 6   glazing_area               768 non-null    float64
 7   glazing_area_distribution  768 non-null    int64  
 8   electricity                768 non-null    float64
dtypes: float64(7), int64(2)
memory usage: 54.1 KB
```

Train vs. Validation vs. Test

- 6:2:2 Split(462:153:153)

sklearn Package 사용

- train_test_split( )

- 20% Test_Data(153)

```
from sklearn.model_selection import train_test_split

X_remain, X_test, y_remain, y_test = train_test_split(Elec[['surface_area']], Elec['electricity'],
                                                      test_size = int(len(Elec) * 0.2),
                                                      random_state = 2045)

print(X_remain.shape, y_remain.shape)
print(X_test.shape, y_test.shape)
```

```
(615, 1) (615,)
(153, 1) (153,)
```

- 60% Train_Data(462) & 20% Validation_Data(153)

```
X_train, X_valid, y_train, y_valid = train_test_split(X_remain, y_remain,
                                                      test_size = int(len(Elec) * 0.2),
                                                      random_state = 2045)

print(X_train.shape, y_train.shape)
print(X_valid.shape, y_valid.shape)
print(X_test.shape, y_test.shape)
```

```
(462, 1) (462,)
(153, 1) (153,)
(153, 1) (153,)
```

1) 5차 모델 Validation Error

- Train_Data로 모델 생성

```
from sklearn.preprocessing import PolynomialFeatures

poly = PolynomialFeatures(degree = 5, include_bias = False)
PX_5_TR = poly.fit_transform(X_train)
```

```
from sklearn.linear_model import LinearRegression

Model_5 = LinearRegression()
Model_5.fit(PX_5_TR, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- Validation_Data로 y_hat(예측값) 생성 및 MSE 계산

```
PX_5_VD = poly.fit_transform(X_valid)

y_hat_5 = Model_5.predict(PX_5_VD)
```

```
from sklearn.metrics import mean_squared_error

MSE_5 = mean_squared_error(y_valid, y_hat_5)
MSE_5
```

```
4136.4312593408395
```

2) 9차 모델 Validation Error

- Train_Data로 모델 생성

```
from sklearn.preprocessing import PolynomialFeatures

poly = PolynomialFeatures(degree = 9, include_bias = False)
PX_9_TR = poly.fit_transform(X_train)
```

```
Model_9 = LinearRegression()
Model_9.fit(PX_9_TR, y_train)
```

```
Model_9.fit(PX9_tr, y_train)
```

```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

- Validation_Data로 y_hat(예측값) 생성 및 MSE 계산

```
PX9_valid = poly.fit_transform(X_valid)

y_hat_9 = Model_9.predict(PX9_valid)
```

```
MSE_9 = mean_squared_error(y_valid, y_hat_9)
MSE_9
```

```
3955.9733124909912
```

3) 2개 모델 Validation Error 비교

```
print('5차 모델 MSE_5  : ', MSE_5)
print('9차 모델 MSE_9  : ', MSE_9)
```

```
5차 모델 MSE_5  :  4136.4312593408395
9차 모델 MSE_9  :  3955.9733124909912
```

4) 최종 9차 모델을 Test_Data에 적용

- Test_Data로 y_hat(예측값) 생성 및 MSE 계산

```
PX9_TE = poly.fit_transform(X_test)

mean_squared_error(y_test, Model_9.predict(PX9_TE))
```

```
4220.88573210769
```

#

#

#

The End

#

#

#