REGRESSION

Get the data and performing data visualization

```python
import matplotlib
import pylab as plt
import numpy as np
import pandas as pd
```

```python
from numpy import random
np.random.seed(42)
df = pd.read_csv('GHG_Emission.csv',na_values=['NA','?',' ', 'NaN'])#na values may be like NA, ? , ' '
df = df.reindex(np.random.permutation(df.index))  #shuffle data
#permutation of index
#index of pandas, randomly select indices, redindex our inces
df.reset_index(inplace=True, drop=True) # Reset index

df[0:5] # Display top five rows
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Classification	Emissi Ra (m3/da
0	588.1	476.3	NaN	NaN	True	NaN	177.8	695.7	0.0	Non Serious	44.4326
1	62.4	666.9	491.7	NaN	False	35.7	139.7	1.0	0.0	Non Serious	29.9985
2	534.4	391.8	NaN	15.690192	True	NaN	177.8	2204.9	0.0	Serious	55.4241
3	298.7	583.0	NaN	NaN	True	35.7	139.7	32683.5	0.0	Serious	53.0769
4	513.8	434.9	2598.2	9.273310	False	NaN	114.3	32683.5	843.0	Serious	50.5069

REMOVE OUTLIERS

```python
def outlier_remove(df, n,name):
    """Delete rows for a specified column where values are out of +/- n*sd standard deviations
    df  : Pandas dataframe
    n   : n in the equation m±nσ
    name: Column name
    """
    mean=df[name].mean() # Calclute mean of column
    sd=df[name].std()    # Calclute standard deviation of column
    drop_r = df.index[(mean -n * sd> df[name]) | (mean+n * sd< df[name])]# vertical line is or
    df.drop(drop_r, axis=0, inplace=True)# dropping rows that dont satisfy the code
    df.reset_index(inplace=True, drop=True) # Reset index

# Drop outliers in last column 'OIL Prod. (e3m3/month)'
outlier_remove(df, n=2.5,name='Emission Rate (m3/day)') #based on oil production
df.describe()
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Emission Rate (m3/day)
count	1478.000000	1478.000000	1056.000000	552.000000	1122.000000	1371.000000	1.391000e+03	1478.000000	1478.000000
mean	444.461367	489.886333	1424.863636	31.357534	41.972282	144.075565	5.869690e+04	178.505007	50.291586
std	174.610273	219.042216	943.815439	19.010916	12.636631	26.083016	2.144858e+05	249.017701	9.362271
min	10.900000	1.400000	158.600000	0.231718	13.700000	73.000000	1.000000e+00	0.000000	25.516553
25%	336.475000	369.575000	675.800000	14.533434	35.700000	114.300000	5.752000e+02	0.000000	43.557511
50%	509.850000	494.000000	1104.850000	31.641928	35.700000	139.700000	5.077600e+03	0.000000	50.280065
75%	592.500000	595.275000	1922.625000	44.343357	48.100000	177.800000	3.268350e+04	322.750000	56.625944
max	649.600000	1186.100000	5418.900000	76.894237	107.200000	244.500000	2.273275e+06	1264.000000	74.168289

The outliers have been removed since the number of rows have reduced.

REGRESSION MODELLING

```python
df_reg=df.copy()
df_reg.drop(['Classification'], axis=1, inplace=True)# we will use it for regression
df_reg[0:5]
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Emission Rate (m3/day)
0	588.1	476.3	NaN	NaN	True	NaN	177.8	695.7	0.0	44.432680
1	62.4	666.9	491.7	NaN	False	35.7	139.7	1.0	0.0	29.998576
2	534.4	391.8	NaN	15.690192	True	NaN	177.8	2204.9	0.0	55.424137
3	298.7	583.0	NaN	NaN	True	35.7	139.7	32683.5	0.0	53.076994
4	513.8	434.9	2598.2	9.273310	False	NaN	114.3	32683.5	843.0	50.506939

STRATIFIED SAMPLING FOR EVEN DISTRIBUTION

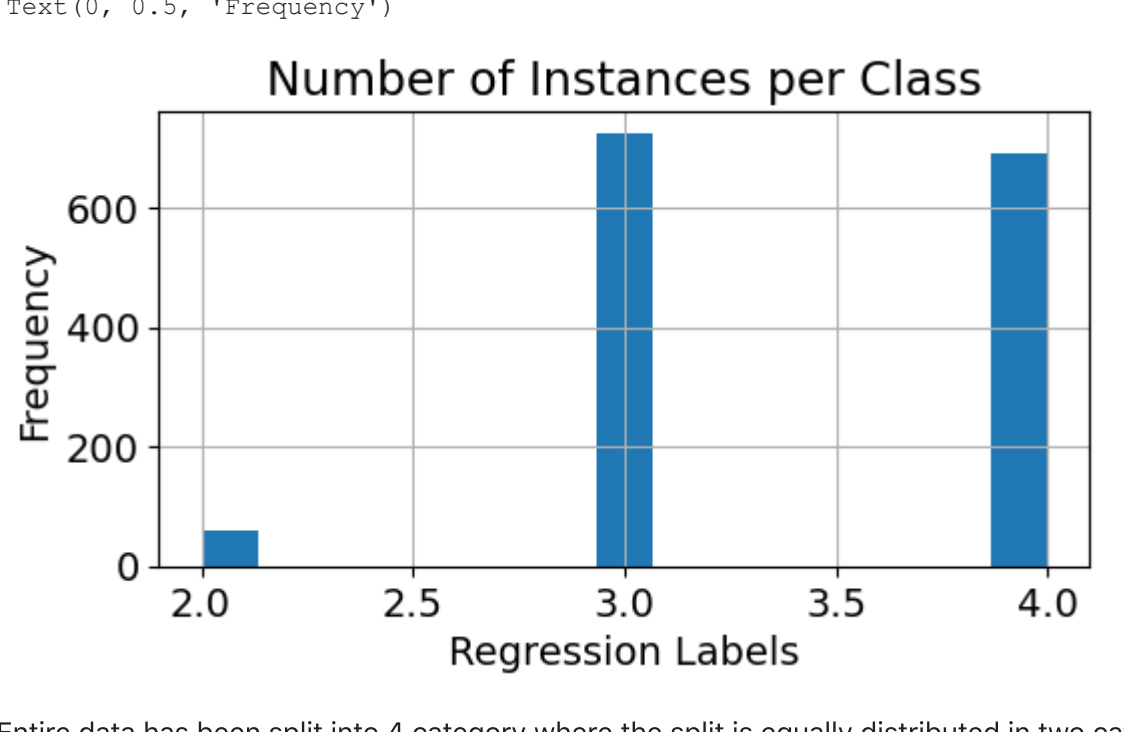
```python
df_reg["emission_rate_cat"]=np.ceil(df_reg["Emission Rate (m3/day)"] /17) # 10 leads to most data in categor
#22 will work as well, just looking for an even distribution
df_reg["emission_rate_cat"].where(df_reg["emission_rate_cat"] < 4, 4, inplace=True) #anything more than 4 as
#any number will work, 4 is generally chosen, bigger the # more the computation time
df_reg[0:4]
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Emission Rate (m3/day)	emission_ra
0	588.1	476.3	NaN	NaN	True	NaN	177.8	695.7	0.0	44.432680	
1	62.4	666.9	491.7	NaN	False	35.7	139.7	1.0	0.0	29.998576	
2	534.4	391.8	NaN	15.690192	True	NaN	177.8	2204.9	0.0	55.424137	
3	298.7	583.0	NaN	NaN	True	35.7	139.7	32683.5	0.0	53.076994	

```python
def histplt (val,bins,title,xlabl,xlimt,axt=None): #python function
    """ Function for histogram plotting"""
    from matplotlib.offsetbox import AnchoredText

    ax1 = axt or plt.axes()# left or right plot
    val=np.array(val) # values in the plot
    plt.hist(val, bins=bins,ec='black')
    n=len(val) # number of values in the plot
    Mean=np.mean(val)
    SD=np.sqrt(np.var(val))
    Max=np.amax(val)
    Min=np.amin(val)
    txt='n=%.0f \n $\mu$=%.1f \n $\sigma$=%.1f \n Max=%.1f \n Min=%.1f'
    anchored_text = AnchoredText(txt %(n,Mean,SD,Max,Min), loc=0)
    ax1.add_artist(anchored_text)
    plt.title(title,fontsize=font['size']*1.25)
    plt.xlabel(xlabl,fontsize=font['size'])
    plt.ylabel('Frequency',fontsize=font['size'])
    plt.xlim(xlimt)
    ax1.grid(linewidth='0.35')
```

```python
# Plot histogram of categories of entire
font = {'size'   : 14}
matplotlib.rc('font', **font)

fig = plt.subplots(figsize=(6, 3), dpi= 100, facecolor='w', edgecolor='k')


df_reg["emission_rate_cat"].hist(bins=15)
plt.title("Number of Instances per Class")
plt.xlabel("Regression Labels")
plt.ylabel("Frequency")
#plt.xlimt(0.68,4.3)


#histplt(df_reg["emission_rate_cat"],bins=15,title='Number of Instances per Class ',xlabl='Regression Labels
     #   xlimt=(0.68,4.3))# since x or number of categoreies is from 0 to 4
```

```
Text(0, 0.5, 'Frequency')
```



Entire data has been split into 4 category where the split is equally distributed in two categories.

```python
df_reg['emission_rate_cat'].value_counts()
```

```
3.0    726
4.0    691
2.0     61
Name: emission_rate_cat, dtype: int64
```

COMMENT

The distribution of data has the following regression labels:

Regression Label 1 - 0% distribution

Regression Label 2 - 4.1% distribution

Regression Label 3 - 49.1% distribution

Regression Label 4 - 46.8% distribution

CATEGORIES HAVE CREATED TO SPLIT DATA INTO TEST AND TRAIN

SPLITTING TRAINING AND TESTING DATA BASED ON EMISSIONS RATE CATEGORY CREATED

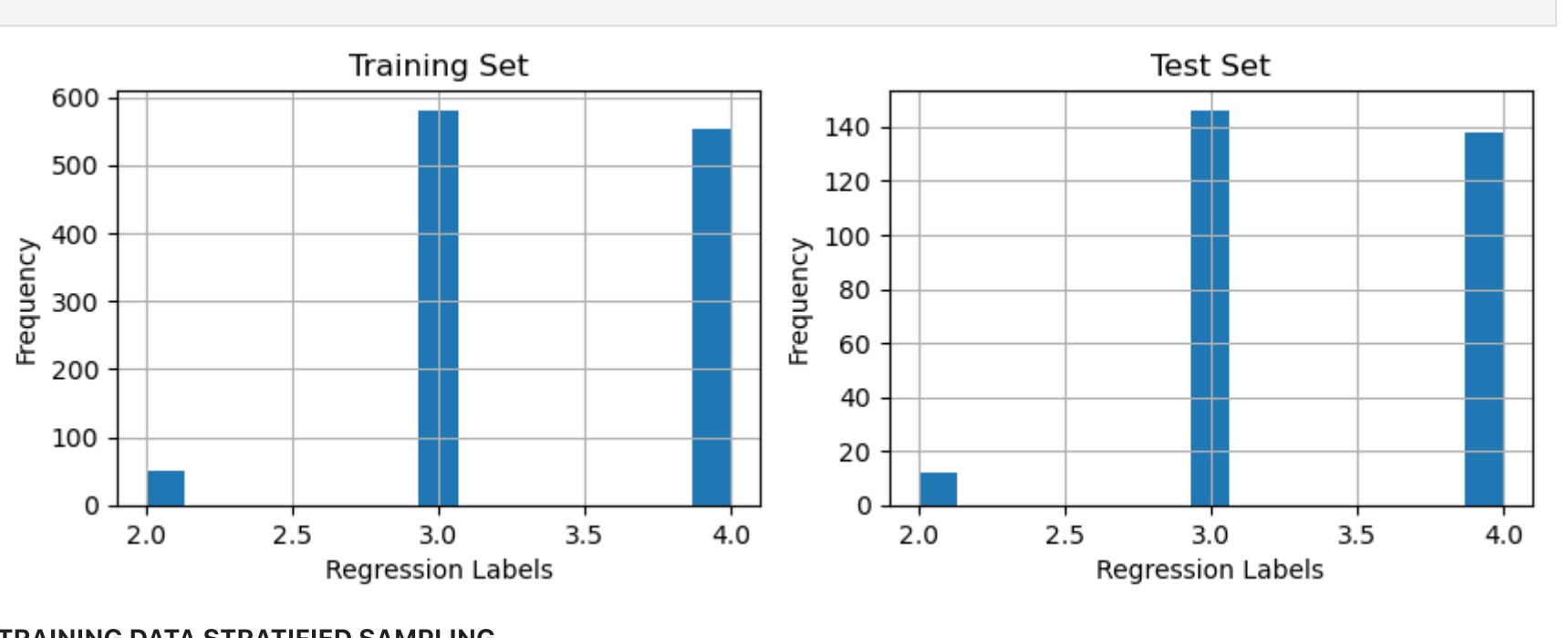
```python
from sklearn.model_selection import StratifiedShuffleSplit #from sky learn used to divide data into data and

spt = StratifiedShuffleSplit(n_splits=1, test_size=0.2, random_state=42)
# 20 % is test and put some random # otherwise data will chnge
# n_split as once as test and traing data set
#n_split =2 is good for cross validation
for train_idx, test_idx in spt.split(df_reg, df_reg["emission_rate_cat"]): #split ratio of this data and in
    train_set_strat = df_reg.loc[train_idx]
    test_set_strat = df_reg.loc[test_idx]
```

```python
train_set_strat
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Emission Rate (m3/day)	emissio
478	294.3	548.7	2504.7	47.479024	False	NaN	177.8	84776.5	0.0	51.237935	
669	611.4	448.0	870.7	19.626487	False	48.7	177.8	10270.5	0.0	45.630606	
1327	407.2	176.2	3269.1	NaN	True	35.7	139.7	23327.1	533.0	64.327602	
962	480.2	478.5	1102.3	NaN	True	NaN	114.3	138.0	0.0	47.891883	
56	379.7	638.8	1953.6	48.966279	True	35.7	114.3	59959.4	616.0	54.767542	
...	...	...	...	...	...	...	...	...	...	...	
992	385.7	615.9	603.3	NaN	True	NaN	114.3	54822.2	323.0	61.370796	
1156	604.5	483.0	610.0	NaN	True	53.6	177.8	32683.5	0.0	52.178626	
855	601.1	517.9	NaN	NaN	True	48.1	177.8	851.4	0.0	61.319530	
958	348.7	697.9	600.2	NaN	True	81.1	177.8	15003.3	438.0	64.793491	
487	502.6	1.4	NaN	NaN	True	35.7	114.3	76.3	0.0	43.892625	

1182 rows × 11 columns

```python
font = {'size'   : 10}
matplotlib.rc('font', **font)

fig = plt.subplots(figsize=(10, 3), dpi= 100, facecolor='w', edgecolor='k')

ax1=plt.subplot(1,2,1)
train_set_strat['emission_rate_cat'].hist(bins=15)
plt.title("Training Set")
plt.xlabel("Regression Labels")
plt.ylabel("Frequency")

ax2=plt.subplot(1,2,2)
test_set_strat['emission_rate_cat'].hist(bins=15)
plt.title("Test Set")
plt.xlabel("Regression Labels")
plt.ylabel("Frequency")
plt.show()
```



TRAINING DATA STRATIFIED SAMPLING

```python
train_set_strat['emission_rate_cat'].value_counts()
```

```
3.0    580
4.0    553
2.0     49
Name: emission_rate_cat, dtype: int64
```

COMMENT

The distribution of training data has the following regression labels:

Regression Label 1 - 0% distribution

Regression Label 2 - 4.1% distribution

Regression Label 3 - 49.1% distribution

Regression Label 4 - 46.8% distribution

TEST DATA STRATIFIED SAMPLING

```python
test_set_strat['emission_rate_cat'].value_counts()
```

```
3.0    146
4.0    138
2.0     12
Name: emission_rate_cat, dtype: int64
```

The distribution of testing data has the following regression labels:

Regression Label 1 - 0% distribution

Regression Label 2 - 4.1% distribution

Regression Label 3 - 49.3% distribution

Regression Label 4 - 46.6% distribution

The distribution of trainnig and testing data is almost the same as the original data.

Removing the emission_rate_cat

The column - emission_rate_cat that was created for stratified sampling has now been deleted as it is no longer needed

```python
for dataset in (train_set_strat, test_set_strat):
    dataset.drop('emission_rate_cat', axis=1, inplace=True)
    dataset.reset_index(inplace=True, drop=True) # Reset index
```

```python
train_set_strat
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Emission Rate (m3/day)
0	294.3	548.7	2504.7	47.479024	False	NaN	177.8	84776.5	0.0	51.237935
1	611.4	448.0	870.7	19.626487	False	48.7	177.8	10270.5	0.0	45.630606
2	407.2	176.2	3269.1	NaN	True	35.7	139.7	23327.1	533.0	64.327602
3	480.2	478.5	1102.3	NaN	True	NaN	114.3	138.0	0.0	47.891883
4	379.7	638.8	1953.6	48.966279	True	35.7	114.3	59959.4	616.0	54.767542
...	...	...	...	...	...	...	...	...	...	...
1177	385.7	615.9	603.3	NaN	True	NaN	114.3	54822.2	323.0	61.370796
1178	604.5	483.0	610.0	NaN	True	53.6	177.8	32683.5	0.0	52.178626
1179	601.1	517.9	NaN	NaN	True	48.1	177.8	851.4	0.0	61.319530
1180	348.7	697.9	600.2	NaN	True	81.1	177.8	15003.3	438.0	64.793491
1181	502.6	1.4	NaN	NaN	True	35.7	114.3	76.3	0.0	43.892625

1182 rows × 10 columns

Now setting emission Rate (m3/day) as target in both X and y tarining dataset.

```python
# Note that drop() creates a copy and does not affect train_set_strat
X_train = train_set_strat.drop("Emission Rate (m3/day)", axis=1)# remove target
y_train = train_set_strat["Emission Rate (m3/day)"].values# only taget values
```

```python
X_train
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	294.3	548.7	2504.7	47.479024	False	NaN	177.8	84776.5	0.0
1	611.4	448.0	870.7	19.626487	False	48.7	177.8	10270.5	0.0
2	407.2	176.2	3269.1	NaN	True	35.7	139.7	23327.1	533.0
3	480.2	478.5	1102.3	NaN	True	NaN	114.3	138.0	0.0
4	379.7	638.8	1953.6	48.966279	True	35.7	114.3	59959.4	616.0
...	...	...	...	...	...	...	...	...	...
1177	385.7	615.9	603.3	NaN	True	NaN	114.3	54822.2	323.0
1178	604.5	483.0	610.0	NaN	True	53.6	177.8	32683.5	0.0
1179	601.1	517.9	NaN	NaN	True	48.1	177.8	851.4	0.0
1180	348.7	697.9	600.2	NaN	True	81.1	177.8	15003.3	438.0
1181	502.6	1.4	NaN	NaN	True	35.7	114.3	76.3	0.0

1182 rows × 9 columns

```python
y_train
```

```
array([51.23793486, 45.63060645, 64.32760219, ..., 61.31952954,
       64.79349141, 43.89262468])
```

The target column -Emission Rate (m3/day) has been removed from the X_train datatset The target column -Emission Rate (m3/day) has been set as the the y_train datatset

DATA VISUALIZATION

Coverting all text to number in the data.

```python
X_train['Abandoned (True/False)']=X_train['Abandoned (True/False)'].replace(False, 0) # Replace False with 0

X_train['Abandoned (True/False)']=X_train['Abandoned (True/False)'].replace(True, 1)
```

```python
X_train
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	294.3	548.7	2504.7	47.479024	0.0	NaN	177.8	84776.5	0.0
1	611.4	448.0	870.7	19.626487	0.0	48.7	177.8	10270.5	0.0
2	407.2	176.2	3269.1	NaN	1.0	35.7	139.7	23327.1	533.0
3	480.2	478.5	1102.3	NaN	1.0	NaN	114.3	138.0	0.0
4	379.7	638.8	1953.6	48.966279	1.0	35.7	114.3	59959.4	616.0
...	...	...	...	...	...	...	...	...	...
1177	385.7	615.9	603.3	NaN	1.0	NaN	114.3	54822.2	323.0
1178	604.5	483.0	610.0	NaN	1.0	53.6	177.8	32683.5	0.0
1179	601.1	517.9	NaN	NaN	1.0	48.1	177.8	851.4	0.0
1180	348.7	697.9	600.2	NaN	1.0	81.1	177.8	15003.3	438.0
1181	502.6	1.4	NaN	NaN	1.0	35.7	114.3	76.3	0.0

1182 rows × 9 columns

CORRELATION MATRIX

```python
corr_matrix=X_train.corr() #data is Oil_Prod
corr_matrix
```

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
X Coordinate (km)	1.000000	-0.494075	0.068508	0.041788	0.026718	0.001398	0.158294	0.015402	0.043883
Y Coordinate (km)	-0.494075	1.000000	-0.069223	0.009084	-0.052023	0.229480	0.145616	0.006670	0.007067
Measured Depth (m)	0.068508	-0.069223	1.000000	0.430259	0.237139	-0.019581	0.028805	0.362970	0.451046
Deviation (deg)	0.041788	0.009084	0.430259	1.000000	0.131768	-0.007176	0.024468	0.334734	0.292734
Abandoned (True/False)	0.026718	-0.052023	0.237139	0.131768	1.000000	-0.042870	-0.030663	0.114492	0.178240
Surface-Casing Weight (kg/m)	0.001398	0.229480	-0.019581	-0.007176	-0.042870	1.000000	0.745228	-0.045194	-0.042497
Production-Casing Size (mm)	0.158294	0.145616	0.028805	0.024468	-0.030663	0.745228	1.000000	0.020703	-0.002146
Cumulative GAS Prod. (e3m3)	0.015402	0.006670	0.362970	0.334734	0.114492	-0.045194	0.020703	1.000000	0.159453
Month Well Spudded	0.043883	0.007067	0.451046	0.292734	0.178240	-0.042497	-0.002146	0.159453	1.000000

Here we observe strong positive linear coorelation between the following features ranked in the order of highest to lowest:

- Production-Casing Size (mm) and Surface-Casing Weight (kg/m)

Here we observe strong negative linear coorelation between the following features ranked in the order of highest to lowest:

- Y Coordinate (km)and X Coordinate (km)

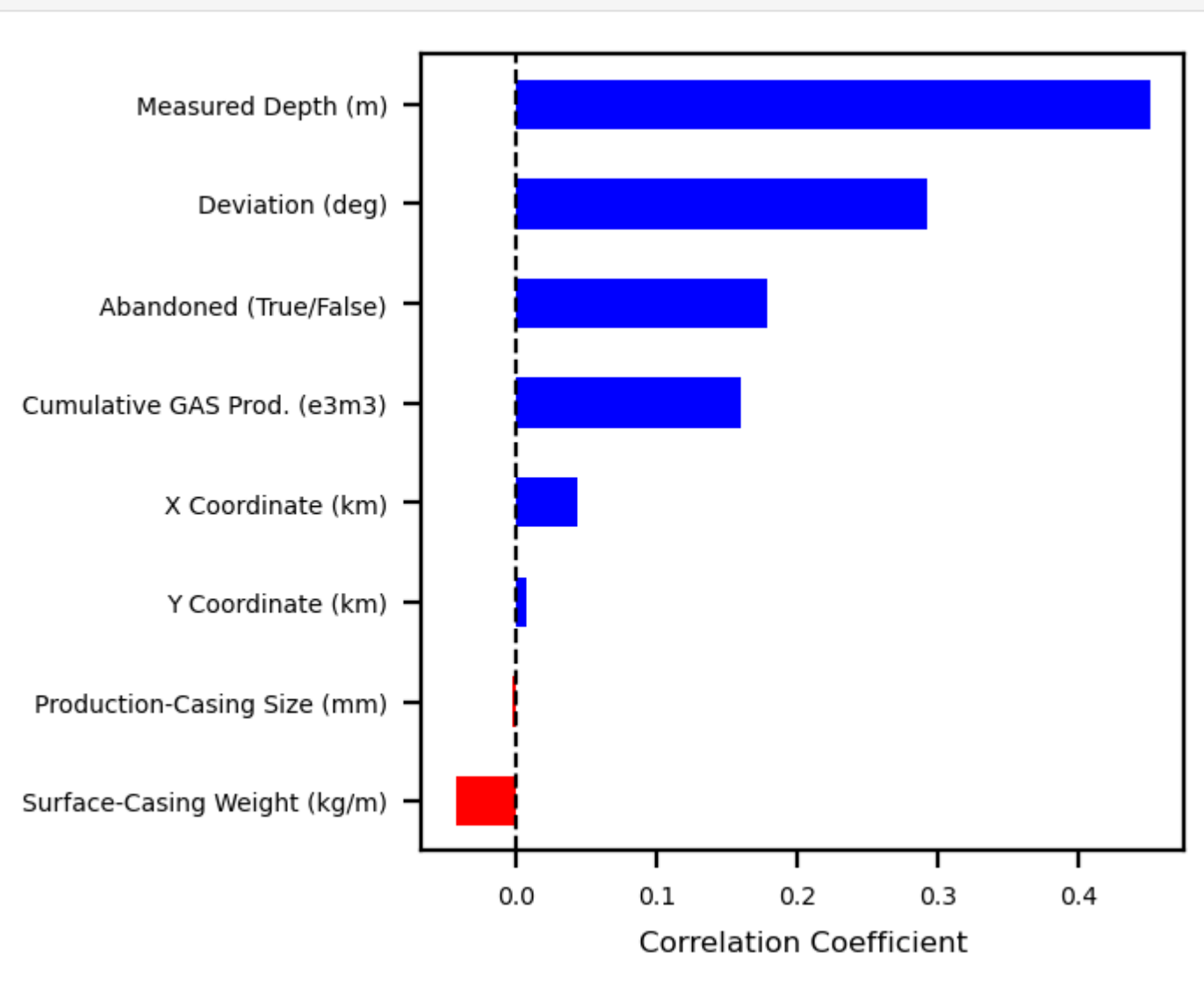
```python
corr_matrix["Measured Depth (m)"].sort_values(ascending=False)
```

```
Measured Depth (m)              1.000000
Month Well Spudded              0.451046
Deviation (deg)                 0.430259
Cumulative GAS Prod. (e3m3)     0.362970
Abandoned (True/False)          0.237139
X Coordinate (km)               0.068508
Production-Casing Size (mm)     0.028805
Surface-Casing Weight (kg/m)   -0.019581
Y Coordinate (km)              -0.069223
Name: Measured Depth (m), dtype: float64
```

Measured Depth, Month Well Spuded, Deviation, followed by Cumulative GAS Prod. (e3m3) have the strongest positive correlation

```python
def corr_bar(df):#python function is creted
    """Plot correlation bar with the pair of atrribute with last column"""
    corr=df.corr()#ft.correlation
    Colms_sh=list(list(corr.columns))# list of column
    coefs=corr.values[:,-1][:-1]
    names=Colms_sh[:-1]
    r_ = pd.DataFrame( { 'coef': coefs, 'positive': coefs>=0  }, index = names )
    r_ = r_.sort_values(by=['coef'])
    r_['coef'].plot(kind='barh', color=r_['positive'].map({True: 'b', False: 'r'}))
    plt.xlabel('Correlation Coefficient',fontsize=6)
    plt.vlines(x=0,ymin=-0.5, ymax=10, color = 'k',linewidth=0.8,linestyle="dashed")
    plt.show()
```

```python
font = {'size'   : 5}
matplotlib.rc('font', **font)
ax1 = plt.subplots(figsize=(2.8, 3), dpi= 200, facecolor='w', edgecolor='k')#backcolour white and edge colou

# Plot correlations of attributes with the last column
corr_bar(X_train) # make the plot of this function
```

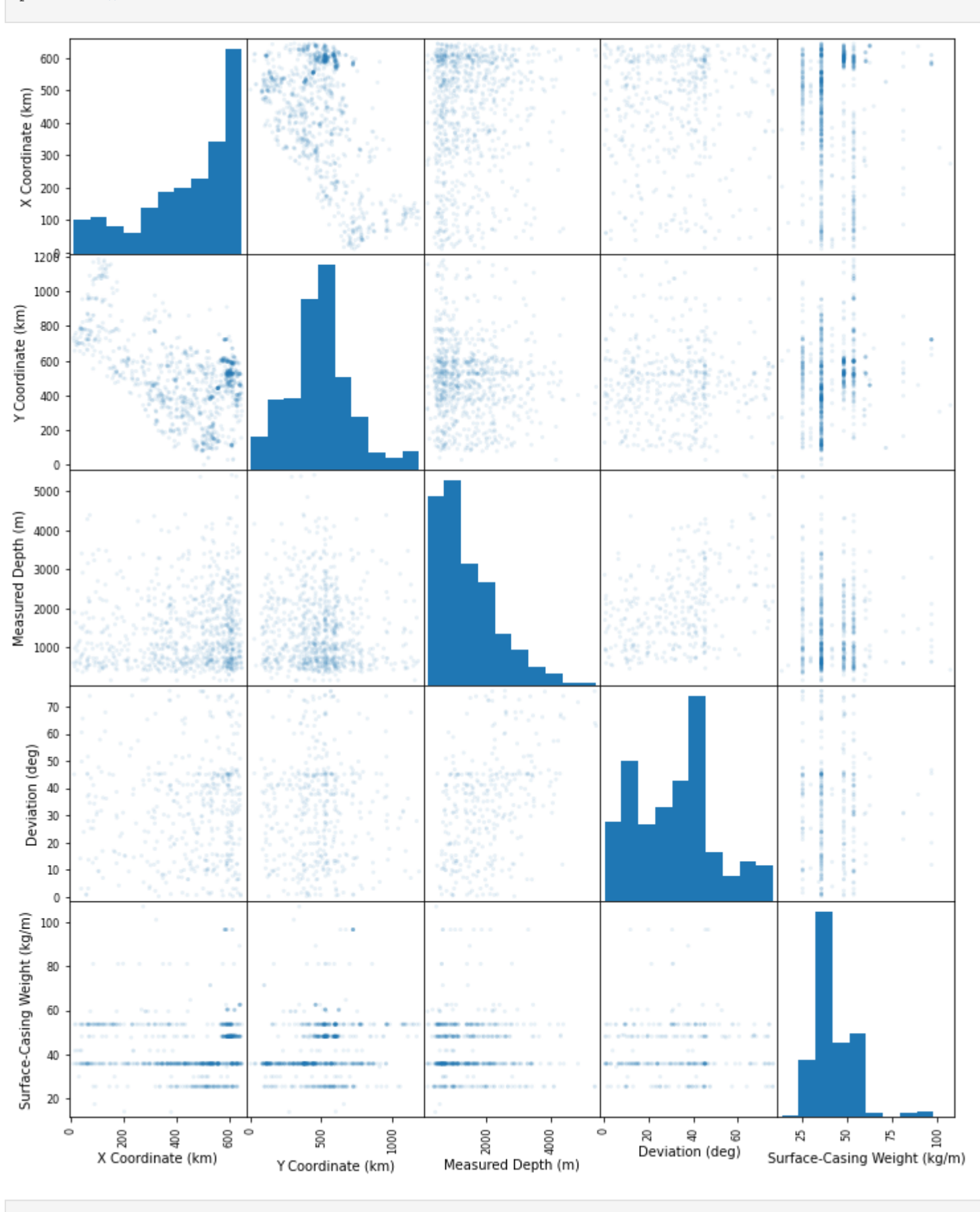


Measured Depth, Deviation, followed by abandoned have the strongest positive correlation. Production -Casing Weight and Surface-Casing Weight have a negative coorelation.

CROSS PLOT

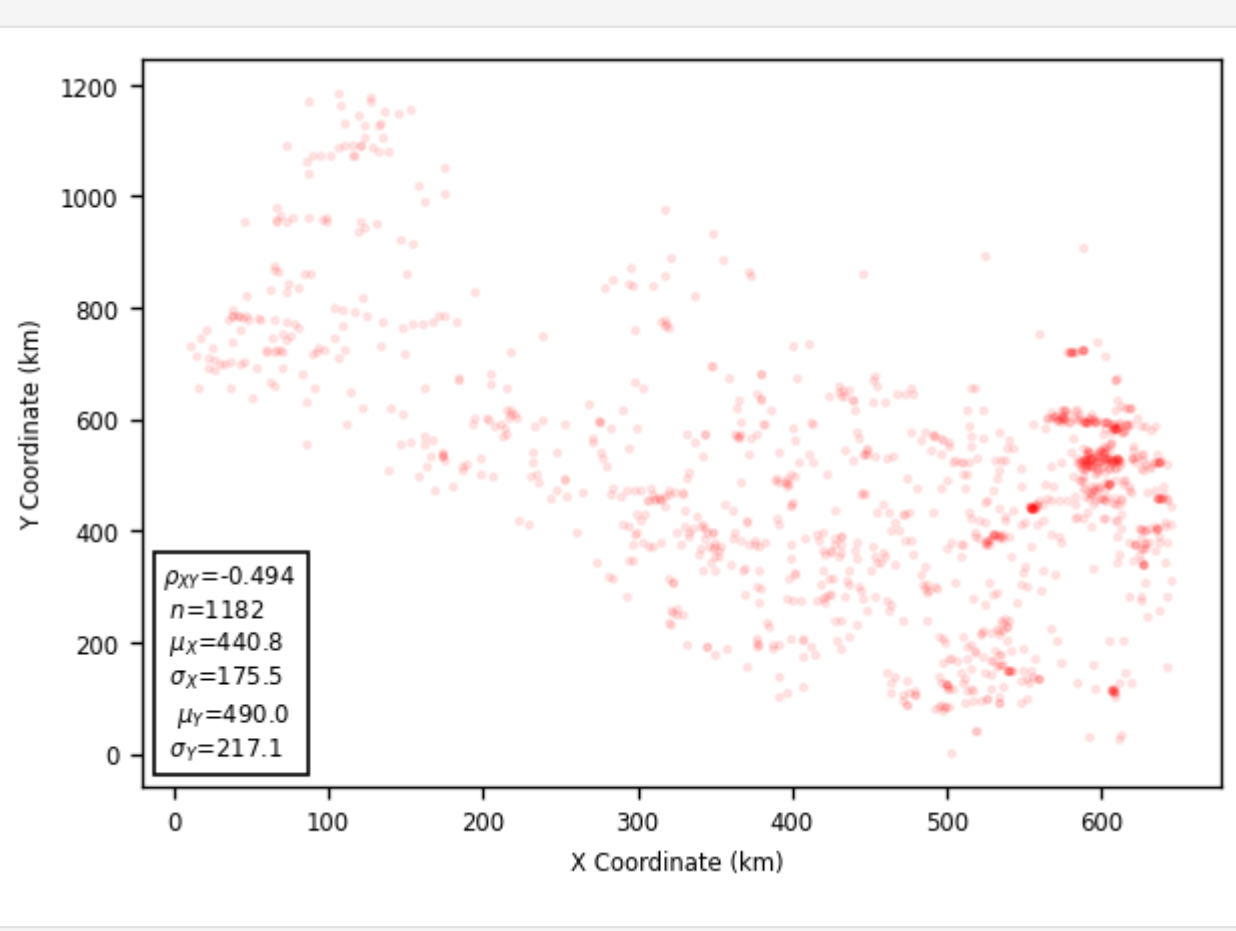
```python
columns=['X Coordinate (km)','Y Coordinate (km)','Measured Depth (m)','Deviation (deg)', 'Surface-Casing Wei
```

```python
font = {'size'   : 10}
matplotlib.rc('font', **font)
from pandas.plotting import scatter_matrix # histrogram matrix diagonal u have a histogram of each variable

scatter_matrix(X_train[columns[0:5]],figsize=(12, 15),alpha=0.1)
plt.show()
```



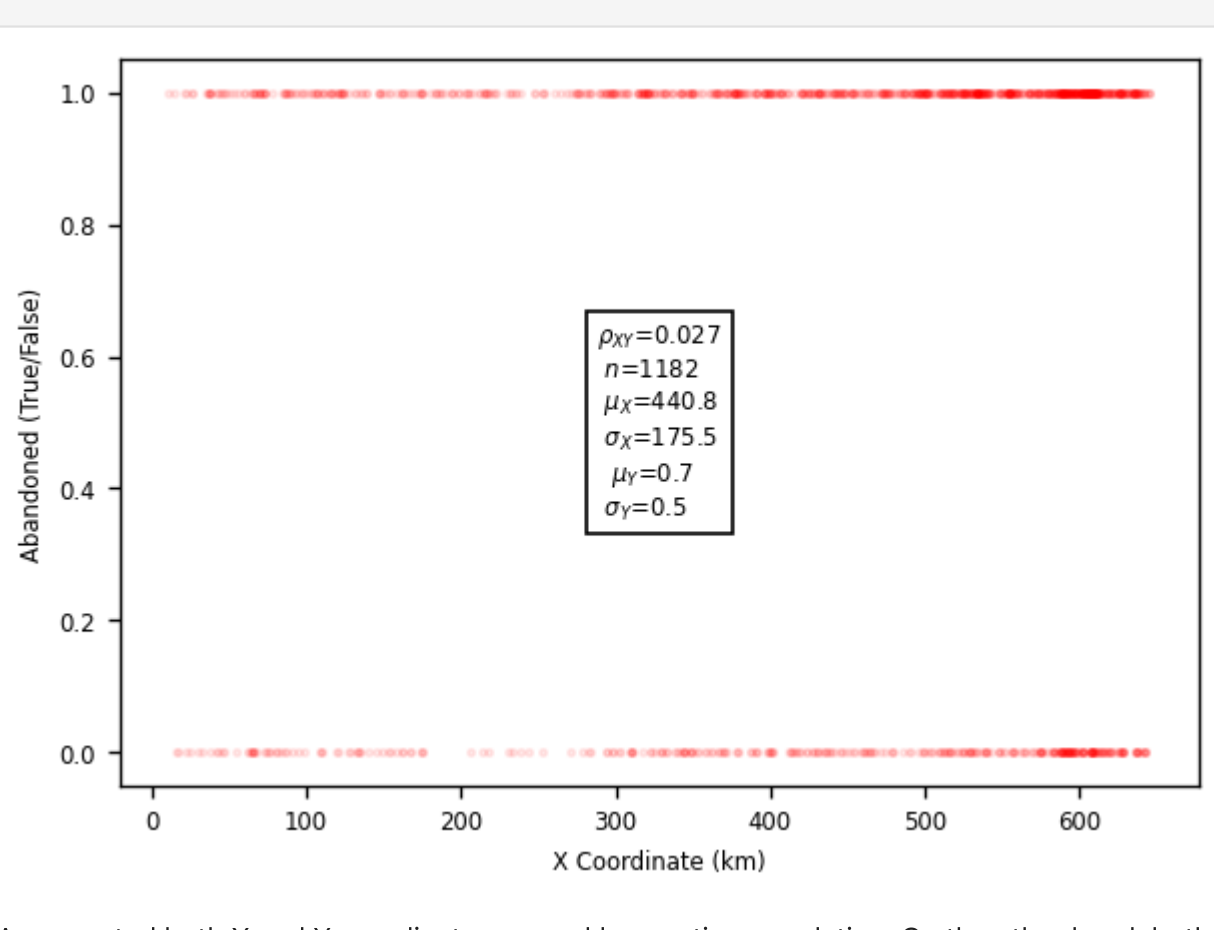

```python
def CrossPlot (x,y,xlabl,ylabl,axt=None):
    '''Cross plot between two variables'''
    from matplotlib.offsetbox import AnchoredText
    ax1 = axt or plt.axes()
    x=np.array(x)
    y=np.array(y)
    n_x=len(x) #number of varibles
    Mean_x=np.mean(x)
    SD_x=np.sqrt(np.var(x))
    n_y=len(y)
    Mean_y=np.mean(y)
    SD_y=np.sqrt(np.var(y))
    corr=np.corrcoef(x,y)
    plt.plot(x,y,'ro',markersize=2,alpha=0.08)
    txt='$\\rho_{XY}$=%.3f \n $n$=%.0f \n $\mu_{X}$=%.1f \n $\sigma_{X}$=%.1f \n '
    txt+=' $\mu_{Y}$=%.1f \n $\sigma_{Y}$=%.1f'
    anchored_text = AnchoredText(txt %(corr[1,0], n_x,Mean_x,SD_x,Mean_y,SD_y),loc=3)

    ax1.add_artist(anchored_text)
    plt.xlabel(xlabl,fontsize=font['size'])
    plt.ylabel(ylabl,fontsize=font['size'])
```

```python
font = {'size'   :7 }
matplotlib.rc('font', **font)
fig=plt.figure(figsize=(12.75,4), dpi= 120, facecolor='w', edgecolor='k')

ax1 = plt.subplot(1,2,1)
CrossPlot (x=X_train['X Coordinate (km)'],y=X_train['Y Coordinate (km)'],xlabl='X Coordinate (km) ',
          ylabl='Y Coordinate (km)',axt=ax1)
```




```python
def CrossPlot (x,y,xlabl,ylabl,axt=None):
    '''Cross plot between two variables'''
    from matplotlib.offsetbox import AnchoredText
    ax1 = axt or plt.axes()
    x=np.array(x)
    y=np.array(y)
    n_x=len(x) #number of varibles
    Mean_x=np.mean(x)
    SD_x=np.sqrt(np.var(x))
    n_y=len(y)
    Mean_y=np.mean(y)
    SD_y=np.sqrt(np.var(y))
    corr=np.corrcoef(x,y)
    plt.plot(x,y,'ro',markersize=2,alpha=0.08)
    txt='$\\rho_{XY}$=%.3f \n $n$=%.0f \n $\mu_{X}$=%.1f \n $\sigma_{X}$=%.1f \n '
    txt+=' $\mu_{Y}$=%.1f \n $\sigma_{Y}$=%.1f'
    anchored_text = AnchoredText(txt %(corr[1,0], n_x,Mean_x,SD_x,Mean_y,SD_y),loc=10)

    ax1.add_artist(anchored_text)
    plt.xlabel(xlabl,fontsize=font['size'])
    plt.ylabel(ylabl,fontsize=font['size'])
```

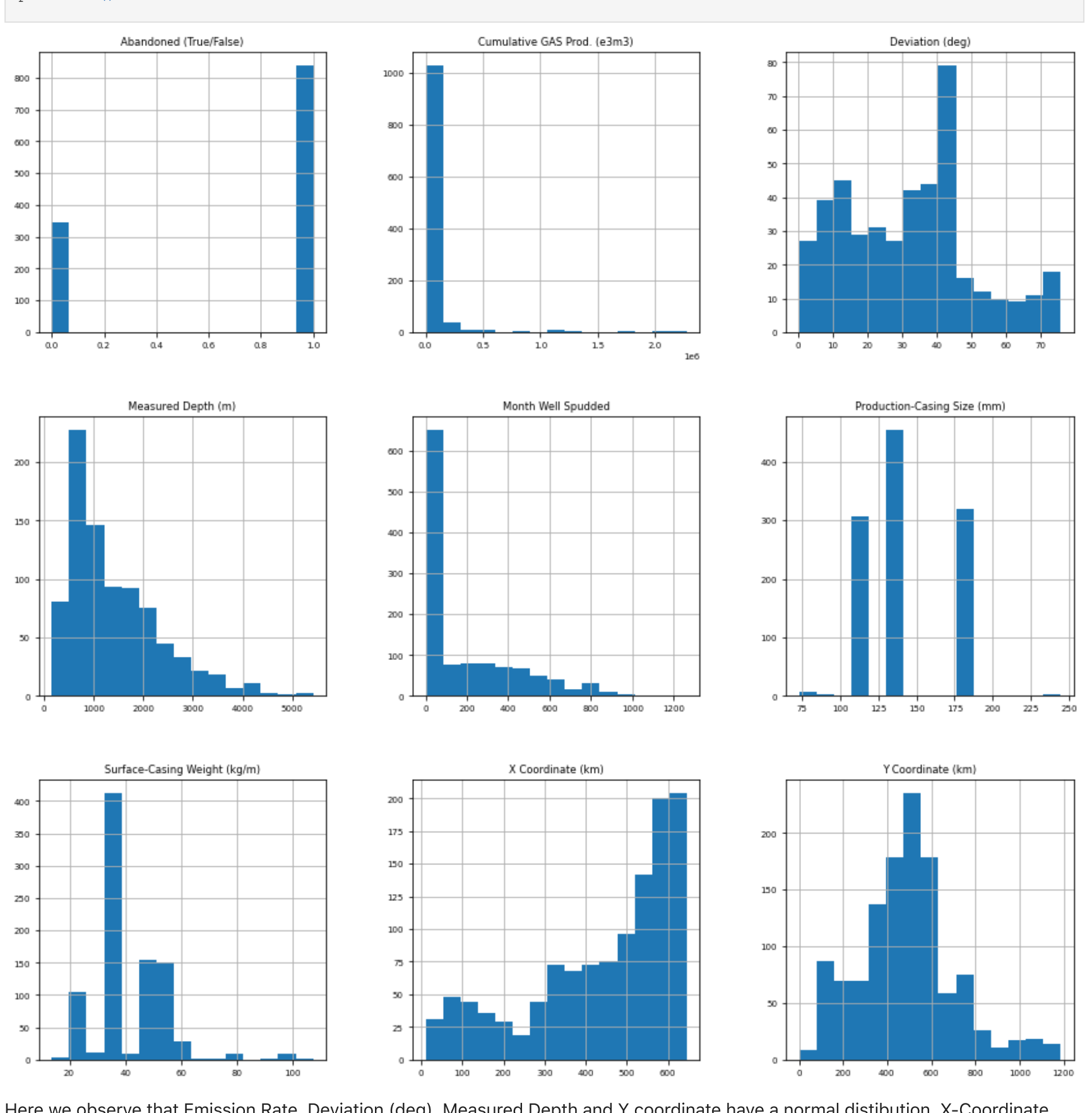
```python
font = {'size'   :7 }
matplotlib.rc('font', **font)
fig=plt.figure(figsize=(12.75,4), dpi= 120, facecolor='w', edgecolor='k')

ax2 = plt.subplot(1,2,2)
CrossPlot (x=X_train['X Coordinate (km)'],y=X_train['Abandoned (True/False)'],xlabl='X Coordinate (km)',
          ylabl='Abandoned (True/False)',axt=ax2)
```



As expected both X and Y coordinate are weakly negative correlation. On the other hand, both Abandoned(True/False) and X coordinate are weak positive correlation. The mean and standard deviation of of the plot between X and Y coordinate is high owing to the high values. On the contary, the standard deviation and mean of abandoned wells is less than 1 since the values its value ranages from 0 to 1.

HISTOGRAM

```python
columns=columns=['X Coordinate (km)','Y Coordinate (km)','Measured Depth (m)','Deviation (deg)', 'Surface-Ca
# names of columns for which u want to make a histogram
X_train[columns].hist(bins=15, layout=(3, 3), figsize=(15,15)) # 3 rows and 3 columns # figure size is the s
plt.show()
```



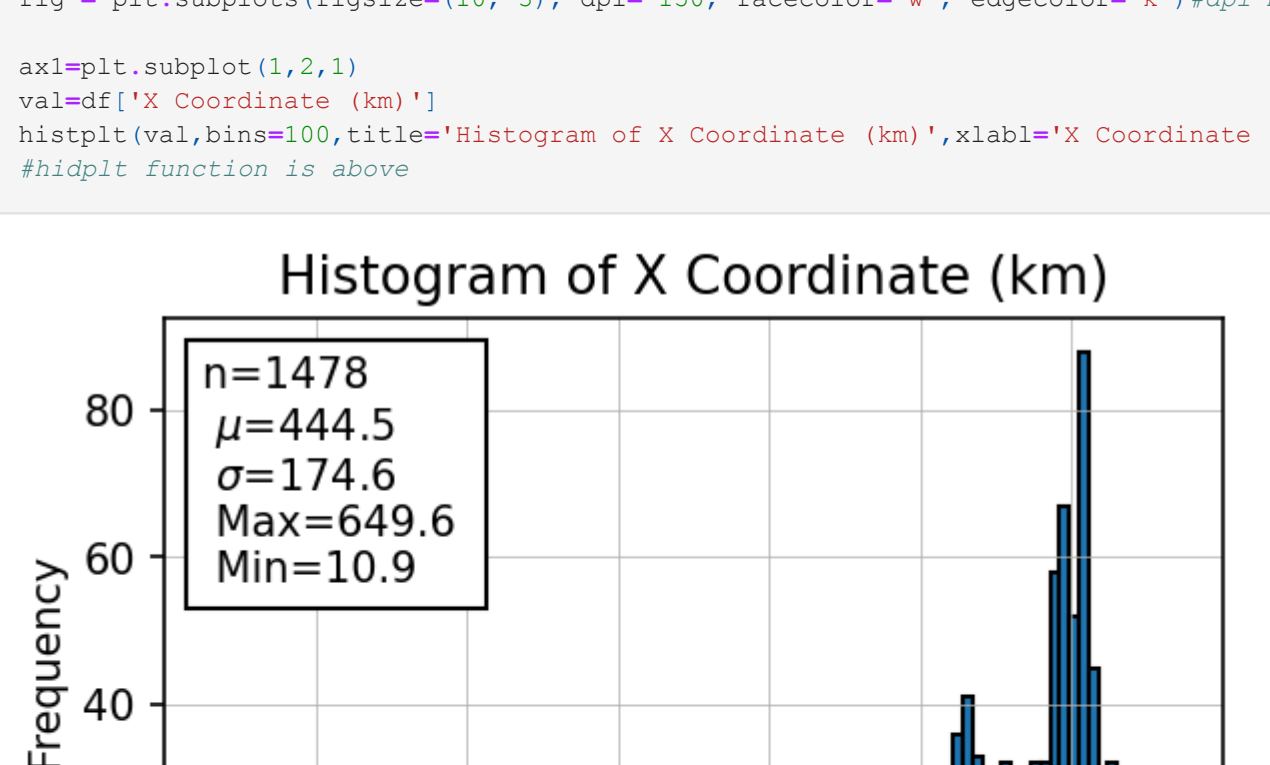
Here we observe that Emission Rate, Deviation (deg), Measured Depth and Y coordinate have a normal distibution. X-Coordinate is negatively skewed distribution. Cumulative Gas, measured Depth, Month Well Spudded are positively skewed distribution. The histograms are very similar to the intial dataset,and not much has changed in them.

Here are better histograms of training data

```python
def histplt (val,bins,title,xlabl,xlimt,axt=None): #python function
    """ Function for histogram plotting"""
    from matplotlib.offsetbox import AnchoredText

    ax1 = axt or plt.axes()# left or right plot
    val=np.array(val) # values in the plot
    plt.hist(val, bins=bins,ec='black')
    n=len(val) # number of values in the plot
    Mean=np.mean(val)
    SD=np.sqrt(np.var(val))
    Max=np.amax(val)
    Min=np.amin(val)
    txt='n=%.0f \n $\mu$=%.1f \n $\sigma$=%.1f \n Max=%.1f \n Min=%.1f'
```

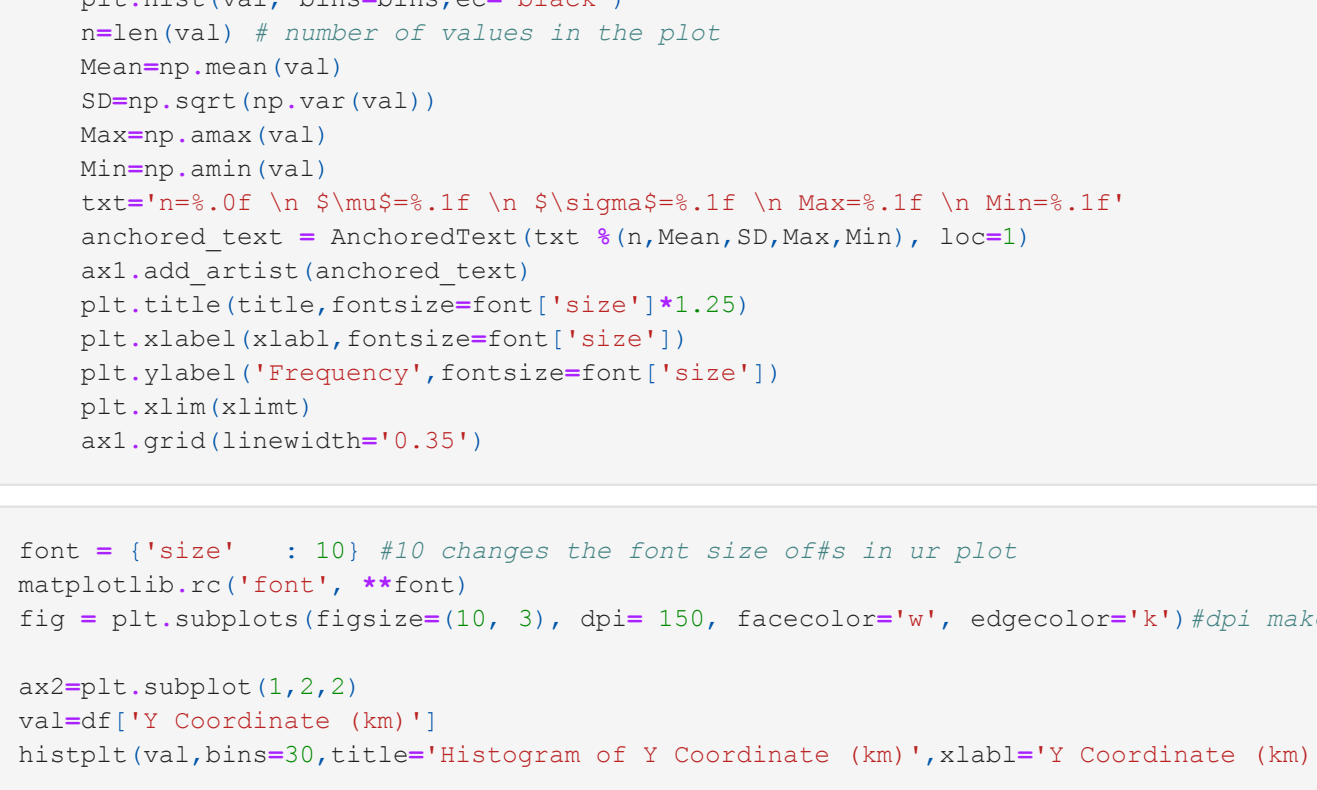
```
    anchored_text = AnchoredText(txt %(n,Mean,SD,Max,Min), loc=2)
    ax1.add_artist(anchored_text)
    plt.title(title,fontsize=font['size']*1.25)
    plt.xlabel(xlabl,fontsize=font['size'])
    plt.ylabel('Frequency',fontsize=font['size'])
    plt.xlim(xlimt)
    ax1.grid(linewidth='0.35')
```

In [84]:
```
font = {'size'   : 10} #10 changes the font size of#s in ur plot
matplotlib.rc('font', **font)
fig = plt.subplots(figsize=(10, 3), dpi= 150, facecolor='w', edgecolor='k')#dpi makesplot small, dpi=100 to

ax1=plt.subplot(1,2,1)
val=df['X Coordinate (km)']
histplt(val,bins=100,title='Histogram of X Coordinate (km)',xlabl='X Coordinate (km) ',xlimt=(0,700),axt=ax1
#hidplt function is above
```



In [85]:
```
def histplt (val,bins,title,xlabl,xlimt,axt=None): #python function
    """ Function for histogram plotting"""
    from matplotlib.offsetbox import AnchoredText

    ax1 = axt or plt.axes()# left or right plot
    val=np.array(val) # values in the plot
    plt.hist(val, bins=bins,ec='black')
    n=len(val) # number of values in the plot
    Mean=np.mean(val)
    SD=np.sqrt(np.var(val))
    Max=np.amax(val)
    Min=np.amin(val)
    txt='n=%.0f \n $\mu$=%.1f \n $\sigma$=%.1f \n Max=%.1f \n Min=%.1f'
    anchored_text = AnchoredText(txt %(n,Mean,SD,Max,Min), loc=1)
    ax1.add_artist(anchored_text)
    plt.title(title,fontsize=font['size']*1.25)
    plt.xlabel(xlabl,fontsize=font['size'])
    plt.ylabel('Frequency',fontsize=font['size'])
    plt.xlim(xlimt)
    ax1.grid(linewidth='0.35')
```

In [86]:
```
font = {'size'   : 10} #10 changes the font size of#s in ur plot
matplotlib.rc('font', **font)
fig = plt.subplots(figsize=(10, 3), dpi= 150, facecolor='w', edgecolor='k')#dpi makesplot small, dpi=100 to

ax2=plt.subplot(1,2,2)
val=df['Y Coordinate (km)']
histplt(val,bins=30,title='Histogram of Y Coordinate (km)',xlabl='Y Coordinate (km)',xlimt=(0,1200),axt=ax2)
```



Even though both the graphs have the same number of data poits, X Coordinate has a lower mean and lower standard deviation as compared to Y axis. The max values for the Y coordinate histogram are higher than X coordinate. X Coordiante histogram is skewed towards right i.e. it depicts as negatively skewed distribution. On the contary, Y Coordinate histogram depicts a uniform distribution.

In [ ]:

IMPUTATION

Applying imputation to missing values in emission dataset Note that imputation is not applied to text data, or to target data. The target data has already been removed so we ust need to remove the text variable - Abandoned (True/False) from the dataset.

Column - Abandoned (True/False) has been removed from the datatset.

In [36]:
```
df2 = X_train.copy()
df2 = X_train.drop(["Abandoned (True/False)" ], axis=1)# for ordinal encoding
df2
```

Out[36]:

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	294.3	548.7	2504.7	47.479024	NaN	177.8	84776.5	0.0
1	611.4	448.0	870.7	19.626487	48.7	177.8	10270.5	0.0
2	407.2	176.2	3269.1	NaN	35.7	139.7	23327.1	533.0
3	480.2	478.5	1102.3	NaN	NaN	114.3	138.0	0.0
4	379.7	638.8	1953.6	48.966279	35.7	114.3	59959.4	616.0
...	...	...	...	...	...	...	...	...
1177	385.7	615.9	603.3	NaN	NaN	114.3	54822.2	323.0
1178	604.5	483.0	610.0	NaN	53.6	177.8	32683.5	0.0
1179	601.1	517.9	NaN	NaN	48.1	177.8	851.4	0.0
1180	348.7	697.9	600.2	NaN	81.1	177.8	15003.3	438.0
1181	502.6	1.4	NaN	NaN	35.7	114.3	76.3	0.0

1182 rows × 8 columns

Column - Abandoned (True/False) has been removed from the df2 datatset.

In [37]:
```
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1182 entries, 0 to 1181
Data columns (total 8 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   X Coordinate (km)             1182 non-null   float64
 1   Y Coordinate (km)             1182 non-null   float64
 2   Measured Depth (m)            857 non-null    float64
 3   Deviation (deg)               439 non-null    float64
 4   Surface-Casing Weight (kg/m)  900 non-null    float64
 5   Production-Casing Size (mm)   1097 non-null   float64
 6   Cumulative GAS Prod. (e3m3)   1108 non-null   float64
 7   Month Well Spudded            1182 non-null   float64
dtypes: float64(8)
memory usage: 74.0 KB
```

All variables except X Coordinate (km), Y Coordinate (km) and Month Well Spudded neeed to be imputed.

Imputation has been applied on the entire dataset and not just on the columns that are mising values as it does not matter. Also median has been chosen as the imputation measurement. Applying median on all the numerical values. We will apply this same imputation on the target dataset.

In [38]:
```
from sklearn.impute import SimpleImputer

imput_mdn = SimpleImputer(strategy="median")
```

In [39]:
```
imput_mdn.fit(df2) # fit is the function u called to ur data set #imput_mdn is now a new dataset following f
imput_mdn.statistics_# after fitting it will calculate the statics that u chose in SimpleImputer # statics i
```

Out[39]:
```
array([ 500.8       ,  493.4       , 1104.9       ,   33.17004428,
         35.7       ,  139.7       , 5005.4       ,    0.        ])
```

In [40]:
```
im = imput_mdn.transform(df2)
```

In [41]:
```
im
```

Out[41]:
```
array([[2.94300e+02, 5.48700e+02, 2.50470e+03, ..., 1.77800e+02,
        8.47765e+04, 0.00000e+00],
       [6.11400e+02, 4.48000e+02, 8.70700e+02, ..., 1.77800e+02,
        1.02705e+04, 0.00000e+00],
       [4.07200e+02, 1.76200e+02, 3.26910e+03, ..., 1.39700e+02,
        2.33271e+04, 5.33000e+02],
       ...,
       [6.01100e+02, 5.17900e+02, 1.10490e+03, ..., 1.77800e+02,
        8.51400e+02, 0.00000e+00],
       [3.48700e+02, 6.97900e+02, 6.00200e+02, ..., 1.77800e+02,
        1.50033e+04, 4.38000e+02],
       [5.02600e+02, 1.40000e+00, 1.10490e+03, ..., 1.14300e+02,
        7.63000e+01, 0.00000e+00]])
```

In [42]:
```
X_train_im = pd.DataFrame(im, columns=df2.columns)#numpy(nmerical data) to pd
#im is numerical dataframe,#Oil_Prod_num.columns -apply on all the column of the newly created data-oil_prod
#im numerical data frame and convert it to pandas
#pandas as before imputation
X_train_im
```

Out[42]:

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	294.3	548.7	2504.7	47.479024	35.7	177.8	84776.5	0.0
1	611.4	448.0	870.7	19.626487	48.7	177.8	10270.5	0.0
2	407.2	176.2	3269.1	33.170044	35.7	139.7	23327.1	533.0
3	480.2	478.5	1102.3	33.170044	35.7	114.3	138.0	0.0
4	379.7	638.8	1953.6	48.966279	35.7	114.3	59959.4	616.0
...	...	...	...	...	...	...	...	...
1177	385.7	615.9	603.3	33.170044	35.7	114.3	54822.2	323.0
1178	604.5	483.0	610.0	33.170044	53.6	177.8	32683.5	0.0
1179	601.1	517.9	1104.9	33.170044	48.1	177.8	851.4	0.0
1180	348.7	697.9	600.2	33.170044	81.1	177.8	15003.3	438.0
1181	502.6	1.4	1104.9	33.170044	35.7	114.3	76.3	0.0

1182 rows × 8 columns

In [43]:
```
X_train_im.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1182 entries, 0 to 1181
Data columns (total 8 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   X Coordinate (km)             1182 non-null   float64
 1   Y Coordinate (km)             1182 non-null   float64
 2   Measured Depth (m)            1182 non-null   float64
 3   Deviation (deg)               1182 non-null   float64
 4   Surface-Casing Weight (kg/m)  1182 non-null   float64
 5   Production-Casing Size (mm)   1182 non-null   float64
 6   Cumulative GAS Prod. (e3m3)   1182 non-null   float64
 7   Month Well Spudded            1182 non-null   float64
dtypes: float64(8)
memory usage: 74.0 KB
```

CONCLUSION - All the values have been replaced with median

In [ ]:

ONE HOT ENCODING THE NUMBERICAL COLUMN - Abandoned (True/False)

One Hot Encoding has been selected for the Abandoned (True/False) column as True and False.

In [44]:
```
Abandoned_cat = X_train[['Abandoned (True/False)']]
Abandoned_cat[0:10]
```

Out[44]:

	Abandoned (True/False)
0	0.0
1	0.0
2	1.0
3	1.0
4	1.0
5	1.0
6	1.0
7	1.0
8	1.0
9	0.0

In [45]:
```
from sklearn.preprocessing import OneHotEncoder

cat_encoder = OneHotEncoder()
Abandoned_cat_2hot = cat_encoder.fit_transform(Abandoned_cat) # fit_trasfer of data
Abandoned_cat_toarray_2=Abandoned_cat_2hot.toarray()#NUMPY TO ARRAY
Abandoned_cat_toarray_2[0:10]
```

Out[45]:
```
array([[1., 0.],
       [1., 0.],
       [0., 1.],
       [0., 1.],
       [0., 1.],
       [0., 1.],
       [0., 1.],
       [0., 1.],
       [0., 1.],
       [1., 0.]])
```

In [ ]:

STANDARDIZATION OF IMPUTED VARIABLES

In [46]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()#call StandardScaler.
X_train_im_Std=scaler.fit_transform(X_train_im)#fit transform
X_train_im_Std
```

Out[46]:
```
array([[-0.83487717,  0.27013885,  1.45281486, ...,  1.39593683,
         0.13719989, -0.7320854 ],
       [ 0.97223857, -0.19362726, -0.57425854, ...,  1.39593683,
        -0.21711555, -0.7320854 ],
       [-0.1914733 , -1.44538127,  2.40109816, ..., -0.13971303,
        -0.15502451,  1.41005972],
       ...,
       [ 0.91354008,  0.12829182, -0.28371962, ...,  1.39593683,
        -0.26190835, -0.7320854 ],
       [-0.52485795,  0.95726798, -0.90982975, ...,  1.39593683,
        -0.19460858,  1.02825149],
       [ 0.35220012, -2.25040924, -0.28371962, ..., -1.1634796 ,
        -0.26559436, -0.7320854 ]])
```

In [47]:
```
X_train_im_Std.mean()
```

Out[47]:
```
3.214198976537467e-16
```

In [48]:
```
X_train_im_Std.std()
```

Out[48]:
```
1.0
```

The mean is 0 and the standard deviation is 1 for the new X_train dataset. So, the X_train dataset is now stanrdardized.

In [49]:
```
X_train_im_Std = pd.DataFrame(X_train_im_Std, columns=X_train_im.columns)#numpy(nmerical data) to pd
#im is numerical dataframe,#X_train_im.columns -use those column names for the newly created data
#im numerical data frame and convert it to pandas
X_train_im_Std
```

Out[49]:

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	-0.834877	0.270139	1.452815	1.283786	-0.410919	1.395937	0.137200	-0.732085
1	0.972239	-0.193627	-0.574259	-1.151244	0.745630	1.395937	-0.217116	-0.732085
2	-0.191473	-1.445381	2.401098	0.032812	-0.410919	-0.139713	-0.155025	1.410060
3	0.224545	-0.053162	-0.286945	0.032812	-0.410919	-1.163480	-0.265301	-0.732085
4	-0.348193	0.685087	0.769143	1.413811	-0.410919	-1.163480	0.019181	1.743640
...	...	...	...	...	...	...	...	...
1177	-0.313999	0.579623	-0.905984	0.032812	-0.410919	-1.163480	-0.005249	0.566063
1178	0.932916	-0.032437	-0.897672	0.032812	1.181560	1.395937	-0.110530	-0.732085
1179	0.913540	0.128292	-0.283720	0.032812	0.692251	1.395937	-0.261908	-0.732085
1180	-0.524858	0.957268	-0.909830	0.032812	3.628106	1.395937	-0.194609	1.028251
1181	0.352200	-2.250409	-0.283720	0.032812	-0.410919	-1.163480	-0.265594	-0.732085

1182 rows × 8 columns

In [ ]:

CONCATANATION of STANRARDIZED DATA AND ONE-HOT ENCODNG column

In [98]:
```
concatenated_X_train=np.concatenate((X_train_im_Std, Abandoned_cat_toarray_2), axis=1)# concanate columns to
#X_train_im_Std is just created above
concatenated_X_train[0:4]
```

Out[98]:
```
array([[-0.83487717,  0.27013885,  1.45281486,  1.28378614, -0.41091886,
         1.39593683,  0.13719989, -0.7320854 ,  1.        ,  0.        ],
       [ 0.97223857, -0.19362726, -0.57425854, -1.15124352,  0.74563013,
         1.39593683, -0.21711555, -0.7320854 ,  1.        ,  0.        ],
       [-0.1914733 , -1.44538127,  2.40109816,  0.03281248, -0.41091886,
        -0.13971303, -0.15502451,  1.41005972,  0.        ,  1.        ],
       [ 0.22454514, -0.05316186, -0.28694507,  0.03281248, -0.41091886,
        -1.1634796 , -0.26530094, -0.7320854 ,  0.        ,  1.        ]])
```

In [154…
```
X_train_new = pd.DataFrame(concatenated_X_train)
X_train_new [0:10]
```

Out[154…

	0	1	2	3	4	5	6	7	8	9
0	-0.834877	0.270139	1.452815	1.283786	-0.410919	1.395937	0.137200	-0.732085	1.0	0.0
1	0.972239	-0.193627	-0.574259	-1.151244	0.745630	1.395937	-0.217116	-0.732085	1.0	0.0
2	-0.191473	-1.445381	2.401098	0.032812	-0.410919	-0.139713	-0.155025	1.410060	0.0	1.0
3	0.224545	-0.053162	-0.286945	0.032812	-0.410919	-1.163480	-0.265301	-0.732085	0.0	1.0
4	-0.348193	0.685087	0.769143	1.413811	-0.410919	-1.163480	0.019181	1.743640	0.0	1.0
5	0.530575	-1.241822	3.512887	0.911871	-0.410919	1.395937	-0.110530	-0.732085	0.0	1.0
6	-0.949425	0.482909	2.543887	0.882627	-0.410919	-0.139713	1.670498	2.207436	0.0	1.0
7	-1.167692	-0.004344	-0.283720	0.427193	0.113976	-0.139713	-0.110530	3.005616	0.0	1.0
8	0.935196	0.254480	1.807739	0.032812	-0.410919	1.395937	-0.110530	1.420911	0.0	1.0
9	0.440533	0.759235	-0.283720	-2.730205	-1.336158	-1.163480	-0.265762	-0.732085	1.0	0.0

In [155…
```
X_train_new = X_train_new.rename({0: 'X Coordinate (km)', 1: 'Y Coordinate (km)', 2: 'Measured Depth (m)', 3

X_train_new
```

Out[155…

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Abandoned (False)	Abandoned (True)
0	-0.834877	0.270139	1.452815	1.283786	-0.410919	1.395937	0.137200	-0.732085	1.0	0.0
1	0.972239	-0.193627	-0.574259	-1.151244	0.745630	1.395937	-0.217116	-0.732085	1.0	0.0
2	-0.191473	-1.445381	2.401098	0.032812	-0.410919	-0.139713	-0.155025	1.410060	0.0	1.0
3	0.224545	-0.053162	-0.286945	0.032812	-0.410919	-1.163480	-0.265301	-0.732085	0.0	1.0
4	-0.348193	0.685087	0.769143	1.413811	-0.410919	-1.163480	0.019181	1.743640	0.0	1.0
...	...	...	...	...	...	...	...	...	...	...
1177	-0.313999	0.579623	-0.905984	0.032812	-0.410919	-1.163480	-0.005249	0.566063	0.0	1.0
1178	0.932916	-0.032437	-0.897672	0.032812	1.181560	1.395937	-0.110530	-0.732085	0.0	1.0
1179	0.913540	0.128292	-0.283720	0.032812	0.692251	1.395937	-0.261908	-0.732085	0.0	1.0
1180	-0.524858	0.957268	-0.909830	0.032812	3.628106	1.395937	-0.194609	1.028251	0.0	1.0
1181	0.352200	-2.250409	-0.283720	0.032812	-0.410919	-1.163480	-0.265594	-0.732085	0.0	1.0

1182 rows × 10 columns

In [ ]:

Model Training and Evaluation

LINEAR REGRESSION

In [63]:
```
from sklearn.linear_model import LinearRegression # call functopn
from sklearn.model_selection import cross_val_score

clf= LinearRegression()#call linear regression
clf.fit(X_train_new,y_train) # fit ur final data that is standaized and one hot coded(look above) and ur tar
```

Out[63]: LinearRegression()

In [64]:
```
neg_mse=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="neg_mean_squared_error")
linear_rmse_scores = np.sqrt(-neg_mse)
linear_rmse = np.mean(linear_rmse_scores)
linear_rmse
```

Out[64]:
```
8.226802076502988
```

Root mean square error is 8.22 for the Linear Regression.

In [ ]:

SUPPORT VECTOR MACHINE-POLYNOMINAL KERNEL Fine-tune 'degree', 'coef0', 'C'.

In [66]:
```
from sklearn.model_selection import RandomizedSearchCV
from sklearn.svm import SVR
from scipy.stats import randint

np.random.seed(42)
model = SVR()

param_grid = [{
'kernel': ['poly'], 'C' : randint(low=0.001, high=200),'degree': randint(low=1, high=20),
    'coef0' : randint(low=0, high=2)
              }]

gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 40, scoring="neg_mean_squared_error",random_state =
gs.fit(X_train_new, y_train)
gs.best_params_
```

Out[66]: {'C': 8, 'coef0': 1, 'degree': 1, 'kernel': 'poly'}

In [67]:
```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for mean_score, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):

    print(np.mean(np.sqrt(-mean_score)), params)
```

```
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242670.55834496237 {'C': 102, 'coef0': 1, 'degree': 15, 'kernel': 'poly'}
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8.235491849399365 {'C': 8, 'coef0': 1, 'degree': 1, 'kernel': 'poly'}
```

In [ ]:
```
METHOD 1
```

In [68]:
```
from sklearn.pipeline import Pipeline
clf = Pipeline([("svm_clf",SVR(kernel="poly", degree=1, coef0=1, C=8))])
clf.fit(X_train_new,y_train)

neg_rmse=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="neg_mean_squared_error")
rmse_scores = np.sqrt(-neg_rmse)
np.mean(rmse_scores)
```

Out[68]:
```
8.224762598388708
```

In [ ]:
```
METHOD 2
```

In [69]:
```
clf = SVR(kernel="poly", degree=1, coef0=1, C=8)
clf.fit(X_train_new,y_train)

neg_rmse=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="neg_root_mean_squared_error")
svm_poly_scores = (-neg_rmse)
svm_poly_rmse = np.mean(svm_poly_scores)
svm_poly_rmse
```

Out[69]:
```
8.224762598388708
```

The RMSE is 8.22 for Support Vector Machine - Polynominal

In [ ]:

Decision Tree - Fine-tune 'max_depth','min_samples_split','min_samples_leaf'.

In [71]:
```
from sklearn.tree import DecisionTreeRegressor
from scipy.stats import randint

np.random.seed(42)
model = DecisionTreeRegressor(random_state=42)

import warnings
warnings.filterwarnings('ignore')

param_grid = [{
'max_depth': randint(low=1, high=100),'min_samples_leaf': randint(low=0.0001, high=10),
    'min_samples_split': randint(low=0.0001, high=10)
              }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 1000, scoring="neg_mean_squared_error",random_state=
gs.fit(X_train_new, y_train)
gs.best_params_
```

Out[71]: {'max_depth': 4, 'min_samples_leaf': 9, 'min_samples_split': 9}

In [91]:
```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for mean_score, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):

    print(np.mean(np.sqrt(-mean_score)), params)
```

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In [92]:

```
clf = DecisionTreeRegressor(max_depth=4, min_samples_leaf=5, min_samples_split=5, random_state = 42)
clf.fit(X_train_new,y_train)

neg_rmse=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="neg_mean_squared_error")
dt_rmse_scores = np.sqrt(-neg_rmse)
dt_rmse = np.mean(dt_rmse_scores)
dt_rmse
```

Out[92]: 7.600048737727536

Applying decion tree algorithm results in further lower rmse of 7.6 as compared to all the algorithms run so far.

In [ ]:

RANDOM FOREST Fine-tune 'n_estimators','max_depth','min_samples_split','bootstrap'.

In [93]:

```
from sklearn.ensemble import RandomForestRegressor
from scipy.stats import randint
np.random.seed(42)
model_rnd = RandomForestRegressor(random_state =42)
import warnings
warnings.filterwarnings('ignore')

param_grid = [{
'max_depth': randint(low=1, high=100),'n_estimators': randint(low=0.1, high=1000), 'min_samples_split': rand
            }]
gs = RandomizedSearchCV(model_rnd,param_grid,cv=5, n_iter = 100, scoring="neg_mean_squared_error", random_st
gs.fit(X_train_new, y_train)
gs.best_params_
```

Out[93]:

```
{'bootstrap': True,
 'max_depth': 8,
 'min_samples_split': 2,
 'n_estimators': 205}
```

In [94]:

```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for mean_score, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):

    print(np.mean(np.sqrt(-mean_score)), params)
```

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7.4151186676507725 {'bootstrap': True, 'max_depth': 48, 'min_samples_split': 3, 'n_estimators': 503}
7.413031396028524 {'bootstrap': True, 'max_depth': 22, 'min_samples_split': 5, 'n_estimators': 229}
7.401945815217312 {'bootstrap': True, 'max_depth': 75, 'min_samples_split': 7, 'n_estimators': 122}
7.378529040366222 {'bootstrap': True, 'max_depth': 38, 'min_samples_split': 7, 'n_estimators': 836}
nan {'bootstrap': True, 'max_depth': 16, 'min_samples_split': 0, 'n_estimators': 200}
7.382467484690358 {'bootstrap': True, 'max_depth': 37, 'min_samples_split': 7, 'n_estimators': 348}
7.367029409799745 {'bootstrap': True, 'max_depth': 52, 'min_samples_split': 8, 'n_estimators': 928}
nan {'bootstrap': False, 'max_depth': 39, 'min_samples_split': 1, 'n_estimators': 871}
7.4118669524664265 {'bootstrap': True, 'max_depth': 44, 'min_samples_split': 4, 'n_estimators': 517}
7.3479946027316325 {'bootstrap': True, 'max_depth': 16, 'min_samples_split': 9, 'n_estimators': 623}
7.313693470612244 {'bootstrap': True, 'max_depth': 11, 'min_samples_split': 8, 'n_estimators': 472}
nan {'bootstrap': True, 'max_depth': 60, 'min_samples_split': 0, 'n_estimators': 1}
nan {'bootstrap': False, 'max_depth': 75, 'min_samples_split': 0, 'n_estimators': 967}
nan {'bootstrap': True, 'max_depth': 93, 'min_samples_split': 1, 'n_estimators': 895}
nan {'bootstrap': False, 'max_depth': 82, 'min_samples_split': 1, 'n_estimators': 821}
7.403662577931626 {'bootstrap': True, 'max_depth': 51, 'min_samples_split': 5, 'n_estimators': 775}
7.3668954747192466 {'bootstrap': True, 'max_depth': 80, 'min_samples_split': 8, 'n_estimators': 995}
nan {'bootstrap': True, 'max_depth': 68, 'min_samples_split': 0, 'n_estimators': 397}
nan {'bootstrap': True, 'max_depth': 27, 'min_samples_split': 1, 'n_estimators': 276}
nan {'bootstrap': False, 'max_depth': 97, 'min_samples_split': 0, 'n_estimators': 452}
nan {'bootstrap': True, 'max_depth': 64, 'min_samples_split': 0, 'n_estimators': 511}
```

In [95]:

```
clf = RandomForestRegressor(bootstrap = True, max_depth=11, min_samples_split=8, n_estimators = 472, random_
clf.fit(X_train_new,y_train)

neg_rmse=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="neg_mean_squared_error")
rf_rmse_scores = np.sqrt(-neg_rmse)
rf_rmse = np.mean(rf_rmse_scores)
rf_rmse
```

Out[95]: 7.30416219410449

The RMSE values of Randomforest classifer of 7.3 are is lower than decision tree

In [ ]:

ENSEMBLED TECHNQIUES

Gradient Boosting. Fine-tune 'n_estimators','learning_rate','algorithm'

XGBoost stands for "Extreme Gradient Boosting" and it is an implementation of gradient boosting trees algorithm. The XGBoost is a popular supervised machine learning model with characteristics like computation speed, parallelization, and performance.

In [100…

```
import xgboost as xgb
from scipy.stats import randint
np.random.seed(42)
model = xgb.XGBRegressor(random_state=42)
import warnings
warnings.filterwarnings('ignore')

param_grid = [{
'learning_rate': randint(low=0.1, high=20),'n_estimators': randint(low=0.1, high=20), 'algorithm': ['SAMME',
            }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 150, scoring="neg_mean_squared_error",random_state=4
gs.fit(X_train_new, y_train)
gs.best_params_
```

```
[04:05:43] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480:
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  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


[04:05:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480: 
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.
```

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7/7 [==============================] - 0s 655us/step - loss: 88.7032
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```

In [108…

```
# Best result
print("Best parameters: %f using %s" % (np.sqrt(-grid_result.best_score_), grid_result.best_params_))
```

```
Best parameters: 8.125925 using {'activation': 'tanh', 'dropout_rate': 0.0, 'neurons': 100}
```

The RMSE of shallow neural network with 3 hidden layers using k-fold cross-validation is is 8.13.

In [109…

```
rmse_snn = np.sqrt(-grid_result.best_score_)

print("Accuracy for shallow neural network: " , rmse_snn)
```

```
Accuracy for shallow neural network:  8.125924770839788
```

In [ ]:

MAKING PLOTS USING SLECTED HYPERPARAMTERS

In [110…

```
clf_early=ANN (input_dim=Smaller_Training.shape[1],neurons=100,dropout_rate= 0.0,activation= 'tanh',
loss='mse',metrics=None,activation_out=None)

# Early stopping to avoid overfitting
monitor= keras.callbacks.EarlyStopping(min_delta=1e-3,patience=5)
history=clf_early.fit(Smaller_Training,Smaller_Training_Target,batch_size=32,validation_data=
          (Validation,Validation_Target),callbacks=[monitor],verbose=1,epochs=1000)
```

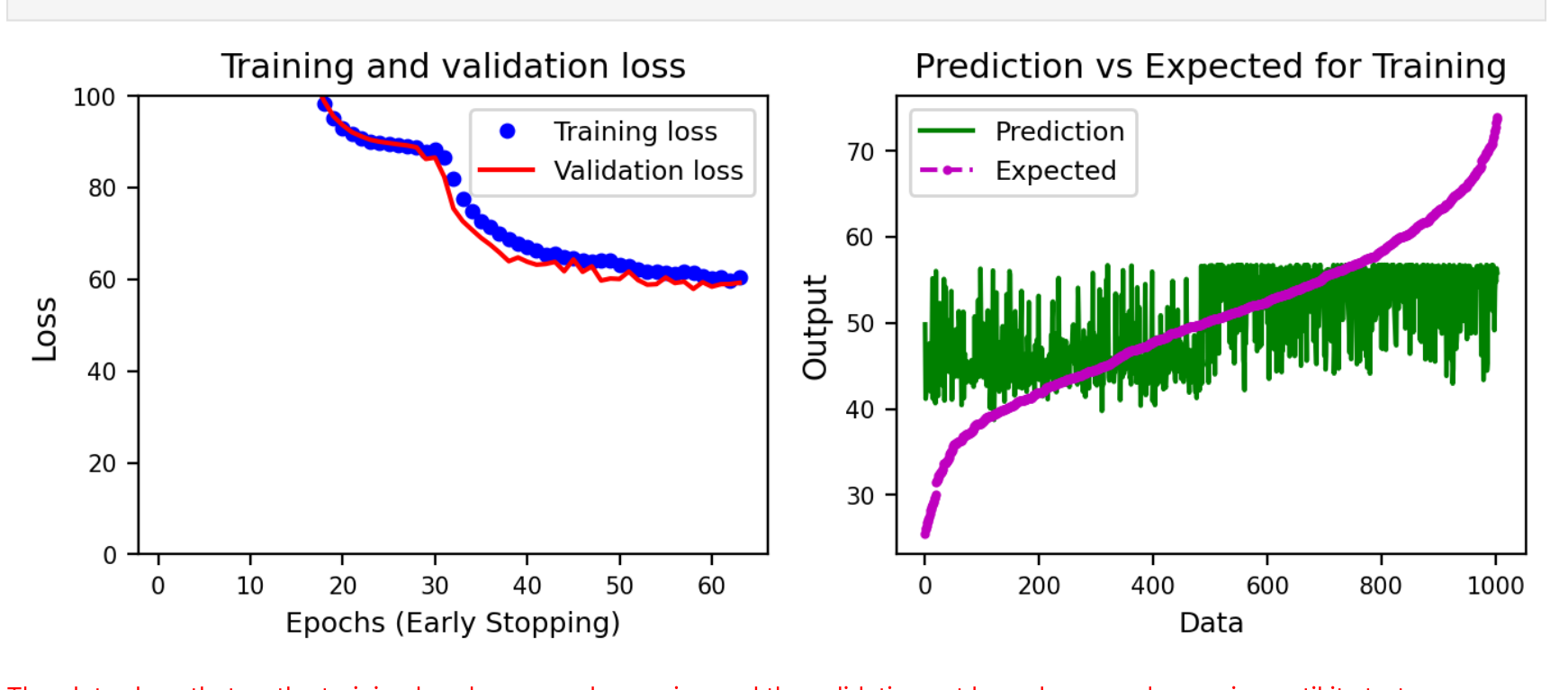
```
Epoch 1/1000
32/32 [==============================] - 0s 5ms/step - loss: 2269.4485 - val_loss: 1725.4347
Epoch 2/1000
32/32 [==============================] - 0s 2ms/step - loss: 1377.6711 - val_loss: 1199.5297
Epoch 3/1000
32/32 [==============================] - 0s 3ms/step - loss: 1053.0566 - val_loss: 958.5938
Epoch 4/1000
32/32 [==============================] - 0s 3ms/step - loss: 845.8032 - val_loss: 775.1951
Epoch 5/1000
32/32 [==============================] - 0s 3ms/step - loss: 683.2059 - val_loss: 628.1581
Epoch 6/1000
32/32 [==============================] - 0s 3ms/step - loss: 552.9108 - val_loss: 509.7902
Epoch 7/1000
32/32 [==============================] - 0s 2ms/step - loss: 447.9984 - val_loss: 414.9404
Epoch 8/1000
32/32 [==============================] - 0s 3ms/step - loss: 363.7707 - val_loss: 338.6638
Epoch 9/1000
32/32 [==============================] - 0s 4ms/step - loss: 297.1128 - val_loss: 277.4570
Epoch 10/1000
32/32 [==============================] - 0s 3ms/step - loss: 244.3221 - val_loss: 230.2752
Epoch 11/1000
32/32 [==============================] - 0s 2ms/step - loss: 203.7044 - val_loss: 193.7147
Epoch 12/1000
32/32 [==============================] - 0s 2ms/step - loss: 172.6190 - val_loss: 165.8763
Epoch 13/1000
32/32 [==============================] - 0s 2ms/step - loss: 149.4938 - val_loss: 144.7885
Epoch 14/1000
32/32 [==============================] - 0s 2ms/step - loss: 131.8784 - val_loss: 129.5583
Epoch 15/1000
32/32 [==============================] - 0s 2ms/step - loss: 119.0286 - val_loss: 117.6254
Epoch 16/1000
32/32 [==============================] - 0s 2ms/step - loss: 109.7244 - val_loss: 109.1577
Epoch 17/1000
32/32 [==============================] - 0s 2ms/step - loss: 103.1319 - val_loss: 103.0734
Epoch 18/1000
32/32 [==============================] - 0s 2ms/step - loss: 98.3864 - val_loss: 98.8590
Epoch 19/1000
32/32 [==============================] - 0s 2ms/step - loss: 95.2595 - val_loss: 95.5897
Epoch 20/1000
32/32 [==============================] - 0s 2ms/step - loss: 93.0275 - val_loss: 93.6468
Epoch 21/1000
32/32 [==============================] - 0s 2ms/step - loss: 91.6926 - val_loss: 92.1335
Epoch 22/1000
32/32 [==============================] - 0s 2ms/step - loss: 90.6910 - val_loss: 91.2381
Epoch 23/1000
32/32 [==============================] - 0s 2ms/step - loss: 90.1386 - val_loss: 90.4658
Epoch 24/1000
32/32 [==============================] - 0s 2ms/step - loss: 89.7367 - val_loss: 90.0527
Epoch 25/1000
32/32 [==============================] - 0s 2ms/step - loss: 89.4907 - val_loss: 89.7658
Epoch 26/1000
32/32 [==============================] - 0s 2ms/step - loss: 89.2900 - val_loss: 89.4804
Epoch 27/1000
32/32 [==============================] - 0s 2ms/step - loss: 89.1366 - val_loss: 89.2321
Epoch 28/1000
32/32 [==============================] - 0s 2ms/step - loss: 88.9098 - val_loss: 88.8234
Epoch 29/1000
32/32 [==============================] - 0s 2ms/step - loss: 87.7656 - val_loss: 86.2838
Epoch 30/1000
32/32 [==============================] - 0s 2ms/step - loss: 88.3897 - val_loss: 86.5855
Epoch 31/1000
32/32 [==============================] - 0s 2ms/step - loss: 86.6871 - val_loss: 82.4191
Epoch 32/1000
32/32 [==============================] - 0s 2ms/step - loss: 82.0598 - val_loss: 75.4703
Epoch 33/1000
32/32 [==============================] - 0s 1ms/step - loss: 77.6582 - val_loss: 72.7238
Epoch 34/1000
32/32 [==============================] - 0s 2ms/step - loss: 75.0094 - val_loss: 70.8499
Epoch 35/1000
32/32 [==============================] - 0s 2ms/step - loss: 72.6951 - val_loss: 69.0582
Epoch 36/1000
32/32 [==============================] - 0s 2ms/step - loss: 71.4219 - val_loss: 67.5658
Epoch 37/1000
32/32 [==============================] - 0s 2ms/step - loss: 70.0332 - val_loss: 65.8520
Epoch 38/1000
32/32 [==============================] - 0s 2ms/step - loss: 68.8211 - val_loss: 63.9772
Epoch 39/1000
32/32 [==============================] - 0s 2ms/step - loss: 67.7270 - val_loss: 64.7906
Epoch 40/1000
32/32 [==============================] - 0s 3ms/step - loss: 67.0526 - val_loss: 63.8557
Epoch 41/1000
32/32 [==============================] - 0s 2ms/step - loss: 66.3682 - val_loss: 63.2090
Epoch 42/1000
32/32 [==============================] - 0s 2ms/step - loss: 65.3860 - val_loss: 63.3722
Epoch 43/1000
32/32 [==============================] - 0s 2ms/step - loss: 65.5089 - val_loss: 63.8304
Epoch 44/1000
32/32 [==============================] - 0s 2ms/step - loss: 64.7868 - val_loss: 61.7880
Epoch 45/1000
32/32 [==============================] - 0s 2ms/step - loss: 64.7341 - val_loss: 64.3503
Epoch 46/1000
32/32 [==============================] - 0s 2ms/step - loss: 64.1635 - val_loss: 61.6632
Epoch 47/1000
32/32 [==============================] - 0s 2ms/step - loss: 63.8377 - val_loss: 62.8422
Epoch 48/1000
32/32 [==============================] - 0s 2ms/step - loss: 64.1371 - val_loss: 59.7660
Epoch 49/1000
32/32 [==============================] - 0s 2ms/step - loss: 64.2102 - val_loss: 60.1916
Epoch 50/1000
32/32 [==============================] - 0s 2ms/step - loss: 63.0559 - val_loss: 60.0990
Epoch 51/1000
32/32 [==============================] - 0s 2ms/step - loss: 62.9268 - val_loss: 61.7199
Epoch 52/1000
32/32 [==============================] - 0s 2ms/step - loss: 62.2028 - val_loss: 59.8677
Epoch 53/1000
32/32 [==============================] - 0s 2ms/step - loss: 61.7331 - val_loss: 58.8579
Epoch 54/1000
32/32 [==============================] - 0s 2ms/step - loss: 61.8213 - val_loss: 58.9724
Epoch 55/1000
32/32 [==============================] - 0s 2ms/step - loss: 61.4425 - val_loss: 60.4281
Epoch 56/1000
32/32 [==============================] - 0s 2ms/step - loss: 61.0921 - val_loss: 59.2081
Epoch 57/1000
32/32 [==============================] - 0s 2ms/step - loss: 61.7198 - val_loss: 59.5220
Epoch 58/1000
32/32 [==============================] - 0s 2ms/step - loss: 61.5106 - val_loss: 57.9392
Epoch 59/1000
32/32 [==============================] - 0s 2ms/step - loss: 60.6329 - val_loss: 59.3901
Epoch 60/1000
32/32 [==============================] - 0s 2ms/step - loss: 60.1988 - val_loss: 58.4292
Epoch 61/1000
32/32 [==============================] - 0s 2ms/step - loss: 60.4732 - val_loss: 58.9676
Epoch 62/1000
32/32 [==============================] - 0s 2ms/step - loss: 59.8459 - val_loss: 59.0063
Epoch 63/1000
32/32 [==============================] - 0s 2ms/step - loss: 60.3814 - val_loss: 59.2676
```

In [111…

```
def plot_NN(model,history,x_train,y_train):
    """ Plot training loss versus validation loss and
    training accuracy versus validation accuracy"""

    font = {'size'   : 7.5}
    plt.rc('font', **font)
    fig, ax=plt.subplots(figsize=(7, 5), dpi= 200, facecolor='w', edgecolor='k')

    ax1 = plt.subplot(2,2,1)
    history_dict = history.history
    loss_values = history_dict['loss']
    val_loss_values = history_dict['val_loss']
    epochs = range(1, len(loss_values) + 1)
    ax1.plot(epochs, loss_values, 'bo',markersize=4, label='Training loss')
    ax1.plot(epochs, val_loss_values, 'r-', label='Validation loss')
    plt.title('Training and validation loss',fontsize=11)
    plt.xlabel('Epochs (Early Stopping)',fontsize=9)
    plt.ylabel('Loss',fontsize=10)
    plt.legend(fontsize='8.5')
    plt.ylim((0, 100))

    ax2 = plt.subplot(2,2,2)
    pred=model.predict(x_train)
    t = pd.DataFrame({'pred': pred.flatten(), 'y': y_train.flatten()})
    t.sort_values(by=['y'], inplace=True)

    epochs = range(1, len(loss_values) + 1)
    ax2.plot(t['pred'].tolist(), 'g', label='Prediction')
    ax2.plot(t['y'].tolist(), 'm--o',markersize=2, label='Expected')
    plt.title('Prediction vs Expected for Training',fontsize=11)
    plt.xlabel('Data',fontsize=9)
    plt.ylabel('Output',fontsize=10)
    plt.legend(fontsize='8.5')
    fig.tight_layout(w_pad=1.42)
    plt.show()
```

In [112…

```
plot_NN(clf_early,history,Smaller_Training,Smaller_Training_Target)
```



The plots show that as the training loss keeps on decreasing and the validation set loses keep on decreasing until it starts increasing after epoch 64. The performance of the training set is higher than validation set since the validation data set has not been seen before. Also, we see the code stopped well at epoch 64 after which overfitting started.

In [ ]:

NO EARLY STOPPING

In [113…

```
def DNN (input_dim,neurons=50,loss="mse",activation="relu",Nout=1,L2_regularizer=False,
         metrics=None,activation_out=None,init_mode=None,BatchOpt=False,
         dropout_rate=True):
    """ Function to run Deep Neural Network (5 hidden layer) for different hyperparameters"""
    # neurons is 50
    # dropout_rate is false we are not appplying it
    #batch optimization does not help that much
    np.random.seed(42)
    tf.random.set_seed(42)

    if(activation=='Leaky_relu'): activation = keras.layers.LeakyReLU(alpha=0.2)
    if(L2_regularizer): kernel_regularizer=keras.regularizers.l2()
    else: kernel_regularizer=None

    # create model
    model = keras.models.Sequential()

    # Input & Hidden Layer 1
    model.add(keras.layers.Dense(neurons,input_dim=input_dim, activation=activation,
                                 kernel_initializer=init_mode,kernel_regularizer=kernel_regularizer))
    if(BatchOpt): model.add(keras.layers.BatchNormalization())
    if(dropout_rate):  model.add(keras.layers.Dropout(dropout_rate))

    # Hidden Layer 2
    model.add(keras.layers.Dense(neurons,activation=activation,
                                 kernel_initializer=init_mode,kernel_regularizer=kernel_regularizer))
    if(BatchOpt): model.add(keras.layers.BatchNormalization())
    if(dropout_rate):  model.add(keras.layers.Dropout(dropout_rate))

    # Hidden Layer 3
    model.add(keras.layers.Dense(neurons,activation=activation,
                                 kernel_initializer=init_mode,kernel_regularizer=kernel_regularizer))
    if(BatchOpt): model.add(keras.layers.BatchNormalization())
    if(dropout_rate):  model.add(keras.layers.Dropout(dropout_rate))

    # Output Layer
    model.add(keras.layers.Dense(Nout))

    # Compile model
    model.compile(optimizer='adam',loss='mse',metrics=metrics)
    return model
```

In [114…

```
from keras.wrappers.scikit_learn import KerasRegressor
from sklearn.model_selection import RandomizedSearchCV
import warnings
warnings.filterwarnings('ignore')


# define the grid search parameters
#param_grid = {'init_mode' : ['he_normal', 'he_uniform'],'neurons' : [150,500,1000]
#             ,'dropout_rate' : [False,0.3, 0.4,0.5],'BatchOpt':[True,False],
#             'activation' : ['relu','elu', 'Leaky_relu'],'L2_regularizer':[True,False]}

param_grid = {'init_mode' : [None,'he_normal', 'he_uniform'],'neurons' : [50,100,150,200],'L2_regularizer':[
             ,'dropout_rate' : [True, 0.1,0.2, 0.3, 0.4,0.5,0.6],'activation': ['relu','elu', 'Leaky_relu']}

# Run Keras KerasRegressor
model = KerasRegressor(build_fn=DNN,input_dim=Smaller_Training.shape[1],metrics=None,
                       activation_out=None,loss='mse')

# Apply Scikit Learn RandomizedSearchCV
grid = RandomizedSearchCV(model,param_grid,n_iter=40,scoring='neg_mean_squared_error', cv=5)

# Early stopping to avoid overfitting
#monitor= keras.callbacks.EarlyStopping(min_delta=1e-3,patience=5, verbose=0)
grid_result = grid.fit(Smaller_Training,Smaller_Training_Target,batch_size=32,validation_data=
                      (Validation,Validation_Target),callbacks=False,verbose=0,epochs=200)
```

In [161…

```
# Best result
print("Best parameters: %f using %s" % (np.sqrt(-grid_result.best_score_), grid_result.best_params_))
```

```
Best parameters: 8.125193 using {'neurons': 150, 'init_mode': None, 'dropout_rate': 0.2, 'activation': 'rel
u', 'L2_regularizer': False}
```

In [ ]:

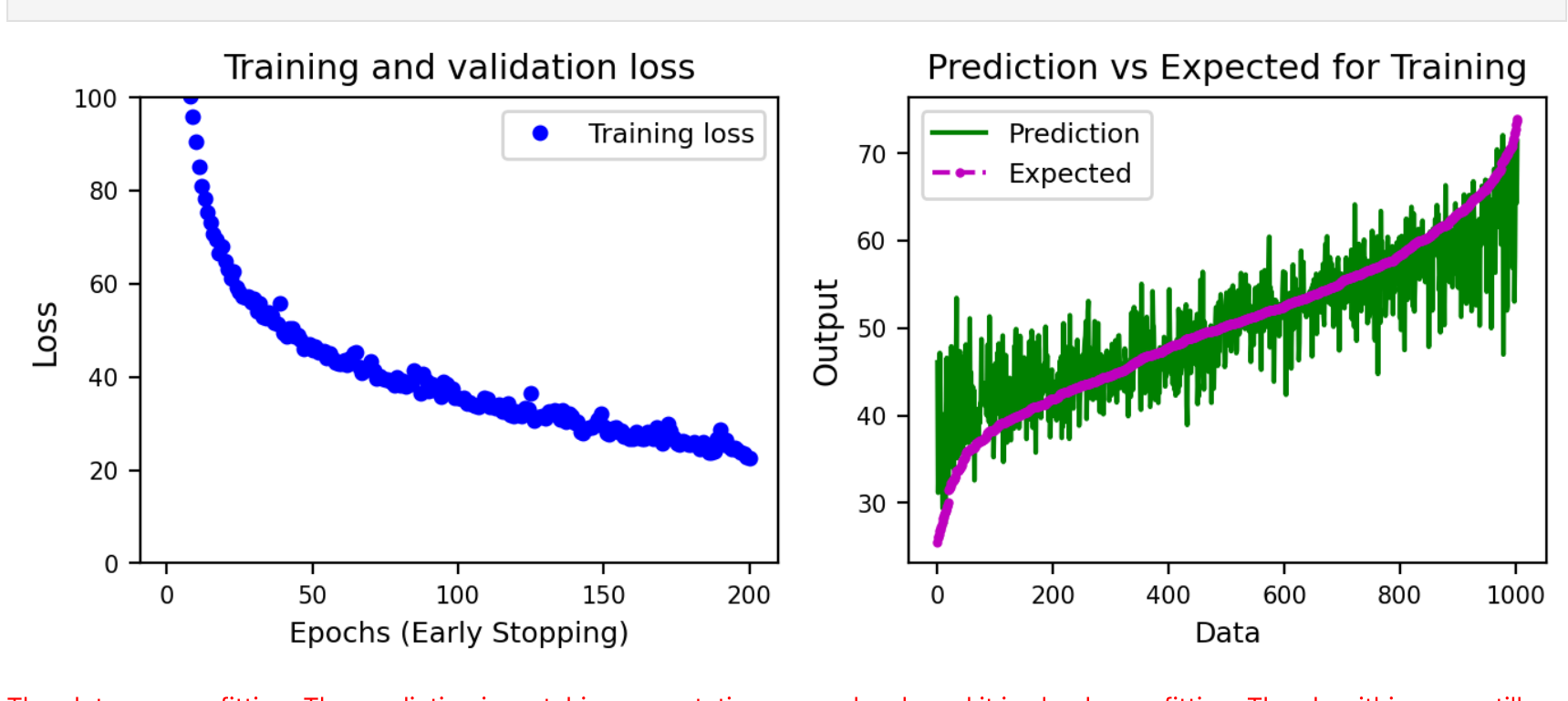
```
Using the above hyper-paramters in making the plot below.
```

In [163…

```
clf_no_early=ANN (input_dim=Smaller_Training.shape[1],neurons=150,dropout_rate= 0.2,activation= 'relu',
loss='mse',metrics=None,activation_out=None)

# Early stopping to avoid overfitting
#monitor= keras.callbacks.EarlyStopping(min_delta=1e-3,patience=5)
history=clf_no_early.fit(Smaller_Training,Smaller_Training_Target,batch_size=32,validation_data=
         (Validation,Validation_Target),callbacks=False,verbose=0,epochs=200)
```

In [164…

```
plot_NN(clf_no_early,history,Smaller_Training,Smaller_Training_Target)
```



The plots are overfitting. The prediction is matching expectations very closely and it is clearly overfitting. The algorithims runs till epoch 200 since no early stopping has been applied and leads to overfitting.

In [ ]:

PLOTTING THE PERFORMANCE OF ALL TRAINING DATASET

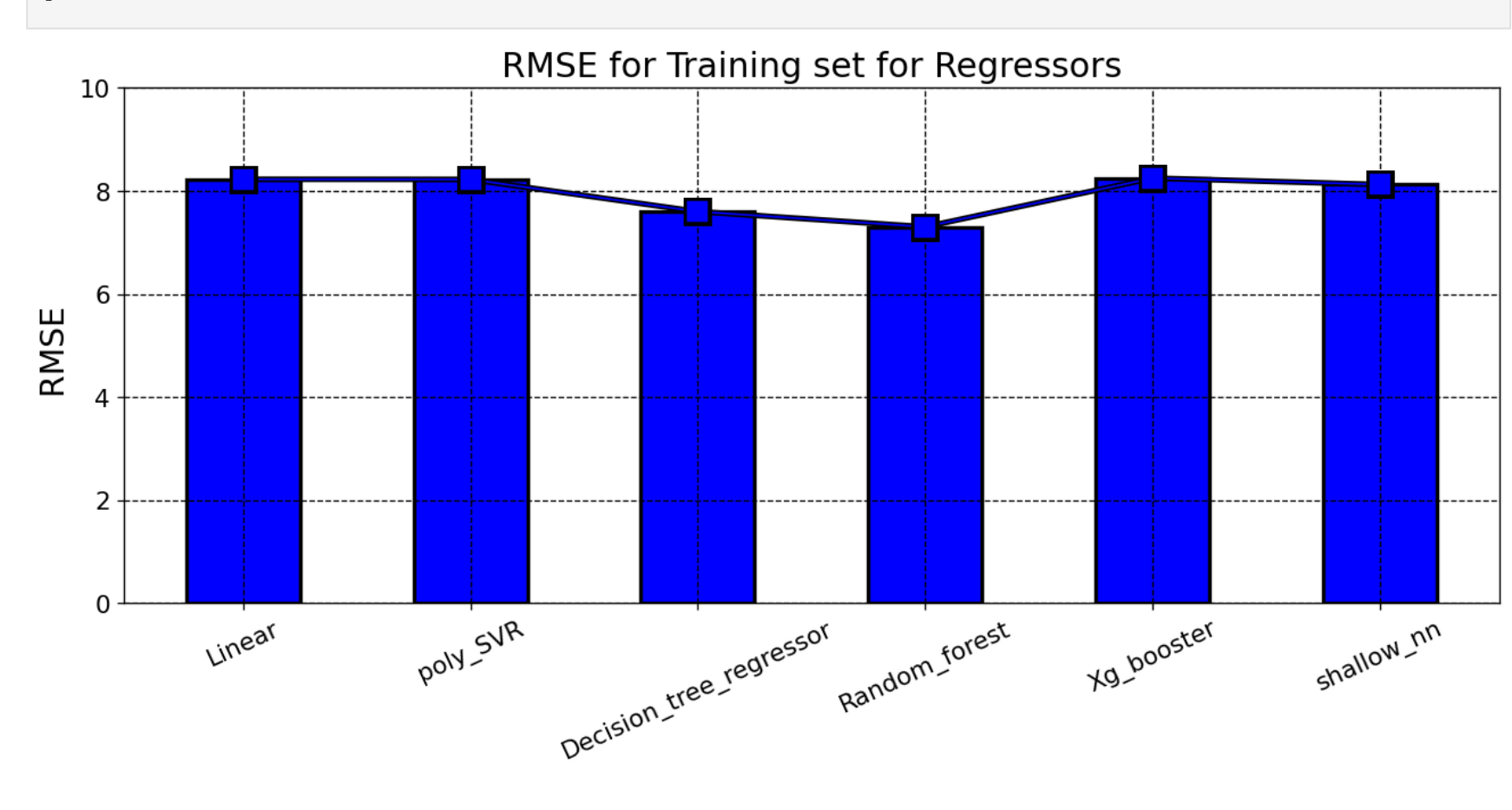
In [118…

```
clf_2=['Linear','poly_SVR','Decision_tree_regressor',
     'Random_forest', 'Xg_booster',
      'shallow_nn' ]

acc_all=[np.mean(linear_rmse_scores),  np.mean(svm_poly_scores) , np.mean(dt_rmse_scores) ,  np.mean(rf_rmse
 np.mean(xgb_rmse_scores),rmse_snn]

for i,clfier in enumerate(acc_all):
    print(clf_2[i], acc_all[i])
```

```
Linear 8.226802076502988
poly_SVR 8.224762598388708
Decision_tree_regressor 7.600048737727536
Random_forest 7.30416219410449
Xg_booster 8.249335407812195
shallow_nn 8.125924770839788
```

In [119…

```
import matplotlib
import pylab as plt
import matplotlib.patheffects as pe
font = {'size'   :13}
matplotlib.rc('font', **font)
fig, ax1 = plt.subplots(figsize=(13, 5), dpi= 120, facecolor='w', edgecolor='k')
plt.plot(clf_2,acc_all,'bs-',linewidth=1,path_effects=[pe.Stroke(linewidth=3, foreground='k'), pe.Normal()],
markersize=12,label='Accuracy',markeredgecolor='k')
ax1.bar(clf_2,acc_all,lw =2, align='center',width=0.5, alpha=1, ecolor='black', edgecolor='k',capsize=1
,color='b')
plt.ylim((0.0, 10.0))
ax1.set_xticklabels(clf_2, rotation=25)
ax1.xaxis.grid(color='k', linestyle='--', linewidth=0.8)
ax1.yaxis.grid(color='k', linestyle='--', linewidth=0.8)
plt.ylabel('RMSE ',fontsize='17')
plt.title('RMSE for Training set for Regressors',fontsize='18')
plt.show()
```



FINDING THE BEST ALGORITHIM ON TRAINING DATASET

The best algorithm on training data set is random forest.

In [ ]:

TESTING

In [120…

```
test_set_strat
```

Out[120…

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Abandoned (True/False)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Emission Rate (m3/day)
0	530.3	392.4	1405.9	19.987480	False	35.7	114.3	15566.5	0.0	30.224588
1	639.1	460.6	3857.8	9.318762	True	62.5	NaN	42082.8	0.0	50.859624
2	368.7	294.5	608.4	NaN	True	53.6	177.8	7662.5	215.2	39.581295
3	482.3	214.1	NaN	NaN	False	29.8	114.3	32784.4	0.0	34.881033
4	608.4	581.5	522.3	NaN	False	48.1	177.8	6.9	176.0	38.266446
...	...	...	...	...	...	...	...	...	...	...
291	427.2	332.0	3679.2	53.879711	True	35.7	139.7	192982.0	846.3	55.194368
292	635.1	289.1	NaN	NaN	False	35.7	114.3	393.9	0.0	35.697085
293	488.6	426.7	1609.4	64.273276	True	NaN	139.7	32683.5	0.0	57.997863
294	242.5	575.4	NaN	NaN	False	53.6	177.8	799.0	89.3	35.645165
295	388.0	813.3	NaN	NaN	False	25.3	114.3	3973.2	0.0	44.285067

296 rows × 10 columns

Removing target from test_set_strat

In [121…

```
# Remove target
X_test = test_set_strat.drop("Emission Rate (m3/day)", axis=1) # test_set_strat = ?
y_test = test_set_strat["Emission Rate (m3/day)"].copy()
```

In [122…

```
X_test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 296 entries, 0 to 295
Data columns (total 9 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   X Coordinate (km)            296 non-null    float64
 1   Y Coordinate (km)            296 non-null    float64
 2   Measured Depth (m)           199 non-null    float64
 3   Deviation (deg)              113 non-null    float64
 4   Abandoned (True/False)       296 non-null    bool
 5   Surface-Casing Weight (kg/m) 222 non-null    float64
 6   Production-Casing Size (mm)  274 non-null    float64
 7   Cumulative GAS Prod. (e3m3)  283 non-null    float64
 8   Month Well Spudded           296 non-null    float64
dtypes: bool(1), float64(8)
memory usage: 18.9 KB
```

IMPUTATION

In [123…

```
df3 = X_test.copy()
df3 = X_test.drop(["Abandoned (True/False)" ], axis=1)# for ordinal encoding
df3
```

Out[123…

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	530.3	392.4	1405.9	19.987480	35.7	114.3	15566.5	0.0
1	639.1	460.6	3857.8	9.318762	62.5	NaN	42082.8	0.0
2	368.7	294.5	608.4	NaN	53.6	177.8	7662.5	215.2
3	482.3	214.1	NaN	NaN	29.8	114.3	32784.4	0.0
4	608.4	581.5	522.3	NaN	48.1	177.8	6.9	176.0
...	...	...	...	...	...	...	...	...
291	427.2	332.0	3679.2	53.879711	35.7	139.7	192982.0	846.3
292	635.1	289.1	NaN	NaN	35.7	114.3	393.9	0.0
293	488.6	426.7	1609.4	64.273276	NaN	139.7	32683.5	0.0
294	242.5	575.4	NaN	NaN	53.6	177.8	799.0	89.3
295	388.0	813.3	NaN	NaN	25.3	114.3	3973.2	0.0

296 rows × 8 columns

In [ ]:

Column - Abandoned (True/False) has been removed from the df3 datatset.

We are replacing the df3 data with the median imputator from training data.

In [124…

```
im = imput_mdn.transform(df3)
```

In [125…

```
im
```

Out[125…

```
array([[  530.3,    392.4,  1405.9, ...,    114.3, 15566.5,      0. ],
       [  639.1,    460.6,  3857.8, ...,    139.7, 42082.8,      0. ],
       [  368.7,    294.5,   608.4, ...,    177.8,  7662.5,    215.2],
       ...,
       [  488.6,    426.7,  1609.4, ...,    139.7, 32683.5,      0. ],
       [  242.5,    575.4,  1104.9, ...,    177.8,   799. ,     89.3],
       [  388. ,    813.3,  1104.9, ...,    114.3,  3973.2,      0. ]])
```

In [126…

```
X_test_im = pd.DataFrame(im, columns=df3.columns)#numpy(nmerical data) to pd
#im is numerical dataframe,#Oil_Prod_num.columns -apply on all the column of the newly created data-oil_prod
#im numerical data frame and convert it to pandas
#pandas as before imputation
X_test_im
```

Out[126…

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	530.3	392.4	1405.9	19.987480	35.7	114.3	15566.5	0.0
1	639.1	460.6	3857.8	9.318762	62.5	139.7	42082.8	0.0
2	368.7	294.5	608.4	33.170044	53.6	177.8	7662.5	215.2
3	482.3	214.1	1104.9	33.170044	29.8	114.3	32784.4	0.0
4	608.4	581.5	522.3	33.170044	48.1	177.8	6.9	176.0
...	...	...	...	...	...	...	...	...
291	427.2	332.0	3679.2	53.879711	35.7	139.7	192982.0	846.3
292	635.1	289.1	1104.9	33.170044	35.7	114.3	393.9	0.0
293	488.6	426.7	1609.4	64.273276	35.7	139.7	32683.5	0.0
294	242.5	575.4	1104.9	33.170044	53.6	177.8	799.0	89.3
295	388.0	813.3	1104.9	33.170044	25.3	114.3	3973.2	0.0

296 rows × 8 columns

In [127…

```
X_test_im.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 296 entries, 0 to 295
Data columns (total 8 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   X Coordinate (km)            296 non-null    float64
 1   Y Coordinate (km)            296 non-null    float64
 2   Measured Depth (m)           296 non-null    float64
 3   Deviation (deg)              296 non-null    float64
 4   Surface-Casing Weight (kg/m) 296 non-null    float64
 5   Production-Casing Size (mm)  296 non-null    float64
 6   Cumulative GAS Prod. (e3m3)  296 non-null    float64
 7   Month Well Spudded           296 non-null    float64
dtypes: float64(8)
memory usage: 18.6 KB
```

CONCLUSION - All the values have been replaced with median of training data

ONE HOT ENCODING THE NUMBERICAL COLUMN - Abandoned (True/False)

In [128…

```
Oil_Prod_cat = X_test[["Abandoned (True/False)"]]
Oil_Prod_cat_2hot = cat_encoder.fit_transform(Oil_Prod_cat)#not using any statics
cat_hot_toarray_2=Oil_Prod_cat_2hot.toarray()
```

In [ ]:

STANDRADIZATION OF IMPUTED VARIABLES

In [129…

```
#from sklearn.preprocessing import StandardScaler
#scaler = StandardScaler()#call StandardScaler.
X_test_im_Std=scaler.transform(X_test_im)#fit transform
X_test_im_Std
```

Out[129…

```
array([[ 0.51005917, -0.44968879,  0.08968864, ..., -1.1634796 ,
        -0.19193026, -0.7320854 ],
       [ 1.13009763, -0.13559893,  3.13141524, ..., -0.13971303,
        -0.06583123, -0.7320854 ],
       [-0.41088029, -0.90055972, -0.89965716, ...,  1.39593683,
        -0.22951796,  0.13281071],
       ...,
       [ 0.27241576, -0.29172278,  0.34214239, ..., -0.13971303,
        -0.11052988, -0.7320854 ],
       [-1.1300793 ,  0.39310365, -0.28371962, ...,  1.39593683,
        -0.26215754, -0.37318567],
       [-0.30089185,  1.48873381, -0.28371962, ..., -1.1634796 ,
        -0.24706254, -0.7320854 ]])
```

In [130…

```
X_test_im_Std.mean()
```

Out[130…

```
0.008559681012234888
```

In [131…

```
X_test_im_Std.std()
```

Out[131…

```
1.0246366995249228
```

The mean is 0 and the standard deviation is 1 for the new X_train dataset. So, the X_train dataset is now stanrdardized.

In [132…

```
X_test_im_Std = pd.DataFrame(X_test_im_Std, columns=X_test_im.columns)#numpy(nmerical data) to pd
#im is numerical dataframe,#X_train_im.columns -use those column names for the newly created data
#im numerical data frame and convert it to pandas
X_test_im_Std
```

Out[132…

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded
0	0.510059	-0.449689	0.089689	-1.119683	-0.410919	-1.163480	-0.191930	-0.732085
1	1.130098	-0.135599	3.131415	-2.052404	1.973351	-0.139713	-0.065831	-0.732085
2	-0.410880	-0.900560	-0.899657	0.032812	1.181560	1.395937	-0.229518	0.132811
3	0.236513	-1.270836	-0.283720	0.032812	-0.935814	-1.163480	-0.110050	-0.732085
4	0.955142	0.421197	-1.006469	0.032812	0.692251	1.395937	-0.265924	-0.024735
...	...	...	...	...	...	...	...	...
291	-0.077496	-0.727856	2.909851	1.843371	-0.410919	-0.139713	0.651774	2.669223
292	1.107302	-0.925429	-0.283720	0.032812	-0.410919	-1.163480	-0.264084	-0.732085
293	0.272416	-0.291723	0.342142	2.752037	-0.410919	-0.139713	-0.110530	-0.732085
294	-1.130079	0.393104	-0.283720	0.032812	1.181560	1.395937	-0.262158	-0.373186
295	-0.300892	1.488734	-0.283720	0.032812	-1.336158	-1.163480	-0.247063	-0.732085

296 rows × 8 columns

CONCATANATION of STANRARDIZED DATA AND ONE-HOT ENCODNG column

In [133...
```python
concatenated_X_test=np.concatenate((X_test_im_Std, cat_hot_toarray_2), axis=1)# concanate columns together
#Oil_Prod_im_Std is just created above
concatenated_X_test[0:4]
```

Out[133...
```
array([[ 0.51005917, -0.44968879,  0.08968864, -1.11968349, -0.41091886,
        -1.1634796 , -0.19193026, -0.7320854 ,  1.        ,  0.        ],
       [ 1.13009763, -0.13559893,  3.13141524, -2.05240447,  1.97335136,
        -0.13971303, -0.06583123, -0.7320854 ,  0.        ,  1.        ],
       [-0.41088029, -0.90055972, -0.89965716,  0.03281248,  1.18156013,
         1.39593683, -0.22951796,  0.13281071,  0.        ,  1.        ],
       [ 0.2365128 , -1.27083574, -0.28371962,  0.03281248, -0.93581417,
        -1.1634796 , -0.11005004, -0.7320854 ,  1.        ,  0.        ]])
```

In [134...
```python
X_test_new = pd.DataFrame(concatenated_X_test)
X_test_new [0:10]
```

Out[134...

	0	1	2	3	4	5	6	7	8	9
0	0.510059	-0.449689	0.089689	-1.119683	-0.410919	-1.163480	-0.191930	-0.732085	1.0	0.0
1	1.130098	-0.135599	3.131415	-2.052404	1.973351	-0.139713	-0.065831	-0.732085	0.0	1.0
2	-0.410880	-0.900560	-0.899657	0.032812	1.181560	1.395937	-0.229518	0.132811	0.0	1.0
3	0.236513	-1.270836	-0.283720	0.032812	-0.935814	-1.163480	-0.110050	-0.732085	1.0	0.0
4	0.955142	0.421197	-1.006469	0.032812	0.692251	1.395937	-0.265924	-0.024735	1.0	0.0
5	-1.387099	0.242046	-1.157445	0.032812	-0.410919	-0.139713	-0.242154	-0.732085	1.0	0.0
6	0.569897	-1.587689	-0.575127	0.032812	-0.410919	-0.139713	-0.110530	-0.732085	1.0	0.0
7	0.427995	-0.150797	-0.283720	0.032812	-1.336158	-1.163480	-0.265544	-0.732085	0.0	1.0
8	0.815519	0.185860	-0.657748	-1.951699	1.181560	1.395937	-0.263484	0.353054	0.0	1.0
9	0.449651	-1.375379	0.545718	0.032812	-0.935814	-1.163480	-0.110530	0.939833	0.0	1.0

In [136...
```python
X_test_new = X_test_new.rename({0: 'X Coordinate (km)', 1: 'Y Coordinate (km)', 2: 'Measured Depth (m)', 3:

X_test_new
```

Out[136...

	X Coordinate (km)	Y Coordinate (km)	Measured Depth (m)	Deviation (deg)	Surface-Casing Weight (kg/m)	Production-Casing Size (mm)	Cumulative GAS Prod. (e3m3)	Month Well Spudded	Abandoned (False)	Abandoned (True
0	0.510059	-0.449689	0.089689	-1.119683	-0.410919	-1.163480	-0.191930	-0.732085	1.0	0.0
1	1.130098	-0.135599	3.131415	-2.052404	1.973351	-0.139713	-0.065831	-0.732085	0.0	1.0
2	-0.410880	-0.900560	-0.899657	0.032812	1.181560	1.395937	-0.229518	0.132811	0.0	1.0
3	0.236513	-1.270836	-0.283720	0.032812	-0.935814	-1.163480	-0.110050	-0.732085	1.0	0.0
4	0.955142	0.421197	-1.006469	0.032812	0.692251	1.395937	-0.265924	-0.024735	1.0	0.0
...	...	...	...	...	...	...	...	...	...	...
291	-0.077496	-0.727856	2.909851	1.843371	-0.410919	-0.139713	0.651774	2.669223	0.0	1.0
292	1.107302	-0.925429	-0.283720	0.032812	-0.410919	-1.163480	-0.264084	-0.732085	1.0	0.0
293	0.272416	-0.291723	0.342142	2.752037	-0.410919	-0.139713	-0.110530	-0.732085	0.0	1.0
294	-1.130079	0.393104	-0.283720	0.032812	1.181560	1.395937	-0.262158	-0.373186	1.0	0.0
295	-0.300892	1.488734	-0.283720	0.032812	-1.336158	-1.163480	-0.247063	-0.732085	1.0	0.0

296 rows × 10 columns

TESTING CHECK

In [139...
```python
from sklearn.metrics import mean_squared_error

Linear = LinearRegression()
Poly_SVR = SVR(kernel="poly", degree=1, coef0=1, C=8)
Decision_Tree = DecisionTreeRegressor(max_depth=4, min_samples_leaf=5, min_samples_split=5, random_state = 4

Random_Forest = RandomForestRegressor(bootstrap = True, max_depth=11, min_samples_split=8, n_estimators = 47


Gradient_Boosting = xgb.XGBRegressor(random_state=42,n_estimators=4, learning_rate=1, algorithm = 'SAMME.R')



clf=['Linear','Poly_SVR','Decision_Tree', 'Random_Forest',
     'Gradient_Boosting' ]
i=0
pre_acc=[]
for clfier in (Linear,Poly_SVR,Decision_Tree, Random_Forest,
               Gradient_Boosting):
    clfier.fit(X_test_new, y_test)
    y_pred = clfier.predict(X_test_new)
    mse = mean_squared_error(y_test, y_pred)
    rmse= np.sqrt(mse)
    pre_acc.append(rmse)
    print(clf[i], rmse)
    i+=1
```

```
Linear 7.905395666497231
Poly_SVR 7.956015604512923
Decision_Tree 6.412660348431807
Random_Forest 4.0179602140221
[09:37:53] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1593723618214/work/src/learner.cc:480:
Parameters: { algorithm } might not be used.

  This may not be accurate due to some parameters are only used in language bindings but
  passed down to XGBoost core.  Or some parameters are not used but slip through this
  verification. Please open an issue if you find above cases.


Gradient_Boosting 4.082089060864561
```

Testing on shallow neural network

In [140...
```python
pred=clf_early.predict(X_test_new)

mse= mean_squared_error(pred, y_test)
rmse_shallow= np.sqrt(mse)

print('rmse of shallow neural network on Test: ',rmse_shallow)
```

```
rmse of shallow neural network on Test:  7.936352956058528
```

The accuracy of shallow neural network is lower than its accuracy on each the training data.

FINDING THE BEST ALGORITHIM FOR REGRESSION ON TEST DATA

The best algorithims according to test data is random forest.

CONCLUSION

I would suggest using random forest for future data as it giving the best performance among all the algorithims on both test and training data set.