DSC550Week4

June 28, 2025

[164]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import sklearn as sk
import matplotlib.pyplot as plt
import sys

# No warnings about setting value on copy of slice
pd.options.mode.chained_assignment = None

# Matplotlib visualization
import matplotlib.pyplot as plt
%matplotlib inline

# Set default font size
plt.rcParams['font.size'] = 24

# Internal ipython tool for setting figure size
from IPython.core.pylabtools import figsize

# Seaborn for visualization
import seaborn as sns
sns.set(font_scale = 2)

# Splitting data into training and testing
from sklearn.model_selection import train_test_split
```

0.1 load and get information related to the data

[95]:
```
# Load the dataset
file_path = './auto-mpg.csv'
df = pd.read_csv(file_path, encoding='ascii')

# Display the first few rows of the dataframe
print('Dataframe shape:', df.shape)
df.head()
```

```
Dataframe shape: (398, 9)
```

[95]:

```
    mpg  cylinders  displacement horsepower  weight  acceleration  model year  \
0  18.0          8         307.0        130    3504          12.0          70
1  15.0          8         350.0        165    3693          11.5          70
2  18.0          8         318.0        150    3436          11.0          70
3  16.0          8         304.0        150    3433          12.0          70
4  17.0          8         302.0        140    3449          10.5          70

   origin                   car name
0       1  chevrolet chevelle malibu
1       1          buick skylark 320
2       1         plymouth satellite
3       1              amc rebel sst
4       1                ford torino
```

[97]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 398 entries, 0 to 397
Data columns (total 9 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   mpg           398 non-null    float64
 1   cylinders     398 non-null    int64
 2   displacement  398 non-null    float64
 3   horsepower    398 non-null    object
 4   weight        398 non-null    int64
 5   acceleration  398 non-null    float64
 6   model year    398 non-null    int64
 7   origin        398 non-null    int64
 8   car name      398 non-null    object
dtypes: float64(3), int64(4), object(2)
memory usage: 28.1+ KB
```

[99]:

```
# Check for missing values in the dataset
missing_values = df.isnull().sum()
print('Missing values in each column:')
print(missing_values)
```

```
Missing values in each column:
mpg             0
cylinders       0
displacement    0
horsepower      0
weight          0
acceleration    0
model year      0
origin          0
car name        0
```

```
dtype: int64
```

[101]:
```python
try:
    df.horsepower =df.horsepower.astype('float')
except:
    print("an error occured")
```

```
an error occured
```

An error occured while trying to convert "horsepower" . It may be something related to the values of the variable. Let's have a look at the distinct values of our variable

[104]:
```python
df.horsepower.unique()
```

[104]:
```
array(['130', '165', '150', '140', '198', '220', '215', '225', '190',
       '170', '160', '95', '97', '85', '88', '46', '87', '90', '113',
       '200', '210', '193', '?', '100', '105', '175', '153', '180', '110',
       '72', '86', '70', '76', '65', '69', '60', '80', '54', '208', '155',
       '112', '92', '145', '137', '158', '167', '94', '107', '230', '49',
       '75', '91', '122', '67', '83', '78', '52', '61', '93', '148',
       '129', '96', '71', '98', '115', '53', '81', '79', '120', '152',
       '102', '108', '68', '58', '149', '89', '63', '48', '66', '139',
       '103', '125', '133', '138', '135', '142', '77', '62', '132', '84',
       '64', '74', '116', '82'], dtype=object)
```

In th third line of our output, we see that we have '?' as a value. Maybe the creators of the dataset used it as a way to indicate that there are missing values. We can either try to impute by using the median value of "horsepower", or delete the observations where "horsepower" has '?' as a value. Let's have a look at those observations:

[107]:
```python
df[df['horsepower']=='?']
```

[107]:
```
      mpg  cylinders  displacement horsepower  weight  acceleration  \
32   25.0          4          98.0          ?    2046          19.0
126  21.0          6         200.0          ?    2875          17.0
330  40.9          4          85.0          ?    1835          17.3
336  23.6          4         140.0          ?    2905          14.3
354  34.5          4         100.0          ?    2320          15.8
374  23.0          4         151.0          ?    3035          20.5

     model year  origin                car name
32           71       1             ford pinto
126          74       1          ford maverick
330          80       2  renault lecar deluxe
336          80       1     ford mustang cobra
354          81       2            renault 18i
374          82       1         amc concord dl
```

[109]:
```python
# Since there aren't many, I chose to delete them
```

```
df = df[df.horsepower != '?']
```

[111]:
```
df.horsepower =df.horsepower.astype('float')
df.cylinders =df.cylinders.astype('float')
```

0.2 Summary Statistics

[114]:
```
df.describe()
```

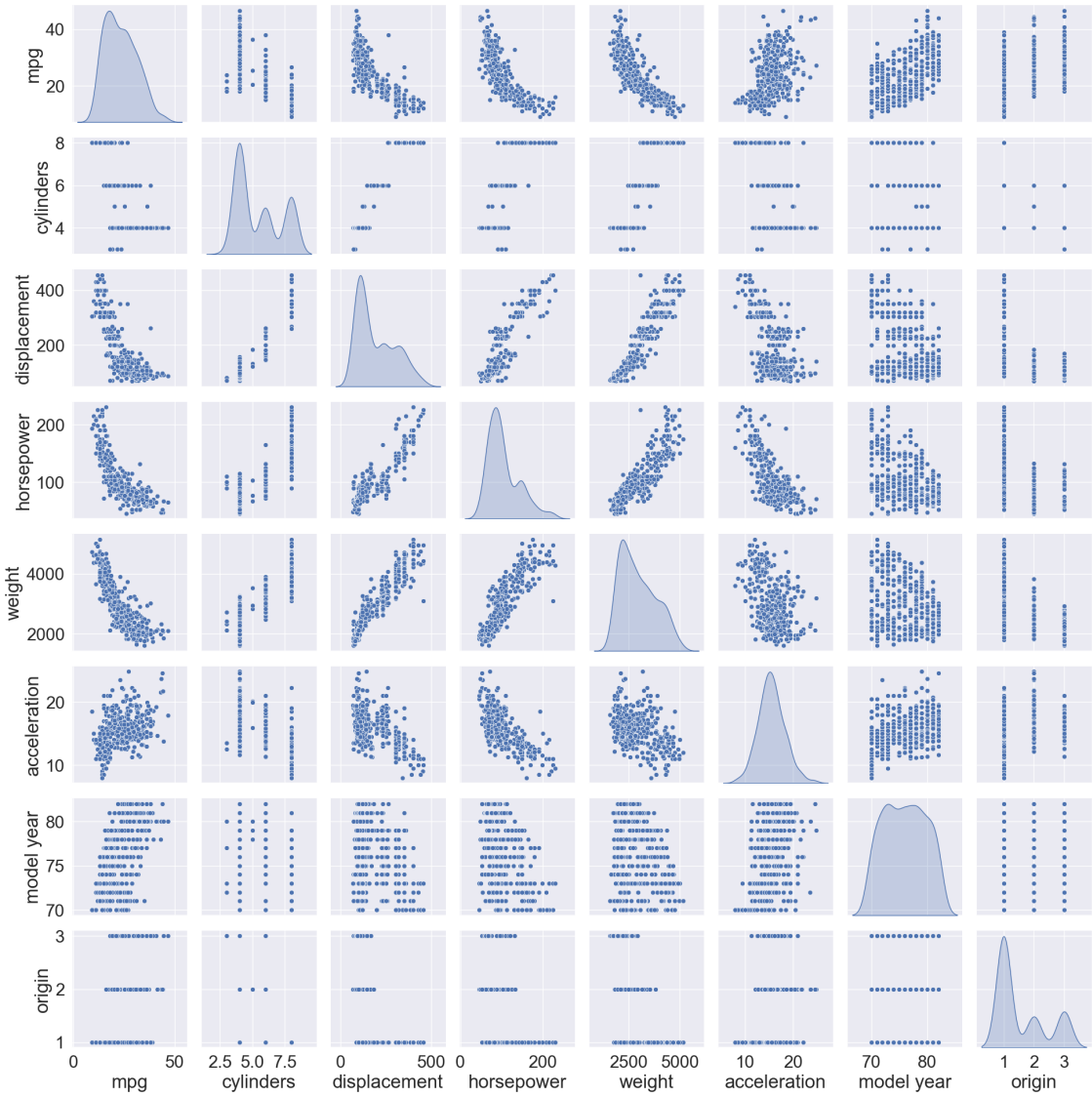
[114]:
```
              mpg   cylinders  displacement  horsepower       weight  \
count  392.000000  392.000000    392.000000  392.000000   392.000000
mean    23.445918    5.471939    194.411990  104.469388  2977.584184
std      7.805007    1.705783    104.644004   38.491160   849.402560
min      9.000000    3.000000     68.000000   46.000000  1613.000000
25%     17.000000    4.000000    105.000000   75.000000  2225.250000
50%     22.750000    4.000000    151.000000   93.500000  2803.500000
75%     29.000000    8.000000    275.750000  126.000000  3614.750000
max     46.600000    8.000000    455.000000  230.000000  5140.000000

       acceleration  model year      origin
count    392.000000  392.000000  392.000000
mean      15.541327   75.979592    1.576531
std        2.758864    3.683737    0.805518
min        8.000000   70.000000    1.000000
25%       13.775000   73.000000    1.000000
50%       15.500000   76.000000    1.000000
75%       17.025000   79.000000    2.000000
max       24.800000   82.000000    3.000000
```

The mean value for mpg is is 23.445918

50% of the vehicules in our sample have a mpg less than 22.75 (more than half of the cars are efficient)

1 Data vizualisation

[118]:
```
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
sns.pairplot(df, diag_kind='kde');
```



1.1 Dummy variables

[121]:
```
Y=df['mpg']
X=df.drop(['mpg','car name'],axis=1)
X=pd.get_dummies(X, columns=["origin"])
X.head()
```

[121]:

	cylinders	displacement	horsepower	weight	acceleration	model year	\
0	8.0	307.0	130.0	3504	12.0	70	
1	8.0	350.0	165.0	3693	11.5	70	
2	8.0	318.0	150.0	3436	11.0	70	
3	8.0	304.0	150.0	3433	12.0	70	
4	8.0	302.0	140.0	3449	10.5	70	

```
   origin_1  origin_2  origin_3
0      True     False     False
1      True     False     False
2      True     False     False
3      True     False     False
4      True     False     False
```

1.1.1 Correlation between our features and targets

To check the correlation we will use pearson correlation coefficient. the code below will show the correlation coefficient between the target and variables. This will only check correlation between integer and float values not categorical!

[125]:
```
df["car name"].value_counts()
```

[125]:
```
car name
amc matador            5
ford pinto             5
toyota corolla         5
toyota corona          4
amc hornet             4
                      ..
buick skyhawk          1
chevrolet monza 2+2    1
ford mustang ii        1
pontiac astro          1
chevy s-10             1
Name: count, Length: 301, dtype: int64
```

[127]:
```
model=[]
for x in df["car name"]:
    x = x.split()
    model.append(x[0])
```

[129]:
```
df["manufacturer"] = model
```

[131]:
```
df.head()
```

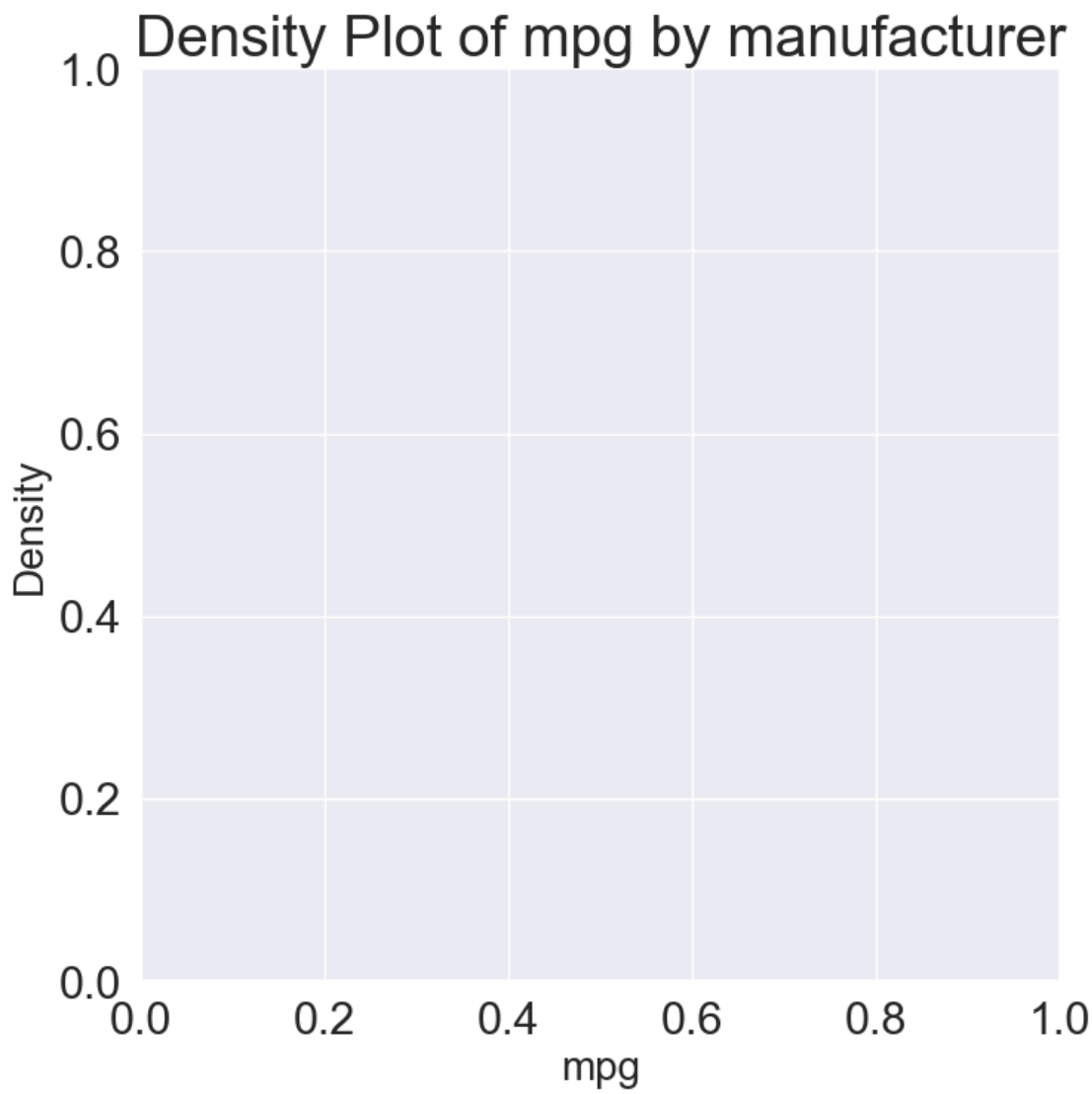
[131]:
```
    mpg  cylinders  displacement  horsepower  weight  acceleration  \
0  18.0        8.0         307.0       130.0    3504          12.0
1  15.0        8.0         350.0       165.0    3693          11.5
2  18.0        8.0         318.0       150.0    3436          11.0
3  16.0        8.0         304.0       150.0    3433          12.0
4  17.0        8.0         302.0       140.0    3449          10.5

   model year  origin                   car name manufacturer
0          70       1  chevrolet chevelle malibu    chevrolet
1          70       1          buick skylark 320        buick
```

```
2          70       1         plymouth satellite     plymouth
3          70       1              amc rebel sst          amc
4          70       1                ford torino         ford
```

[135]:
```python
df["manufacturer"].value_counts()
```

[135]:
```
manufacturer
ford             48
chevrolet        43
plymouth         31
dodge            28
amc              27
toyota           25
datsun           23
buick            17
pontiac          16
volkswagen       15
honda            13
mercury          11
mazda            10
oldsmobile       10
fiat              8
peugeot           8
audi              7
vw                6
chrysler          6
volvo             6
opel              4
saab              4
subaru            4
chevy             3
renault           3
maxda             2
cadillac          2
bmw               2
mercedes-benz     2
triumph           1
vokswagen         1
mercedes          1
hi                1
capri             1
chevroelt         1
toyouta           1
nissan            1
Name: count, dtype: int64
```

[142]:
```
brand = df.dropna(subset =["mpg"])
brand = df# Plot of distribution of mpg for manufacturer
figsize(8,8)

# Plot each manufacturer
for c_brand in brand:
    # Select the manufacturer
    subset = df[df['manufacturer'] == c_brand]

    # Density plot of mpg
    sns.kdeplot(subset['mpg'].dropna(),
                label = c_brand, shade = False, alpha = 0.8);

# label the plot
plt.xlabel('mpg', size = 20)
plt.ylabel('Density', size = 20)
plt.title('Density Plot of mpg by manufacturer', size = 28)
plt.show()['manufacturer'].value_counts()[:4]
brand =list(brand.index)
```




```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[142], line 18
     16 plt.ylabel('Density', size = 20)
     17 plt.title('Density Plot of mpg by manufacturer', size = 28)
---> 18 plt.show()['manufacturer'].value_counts()[:4]
     19 brand =list(brand.index)

TypeError: 'NoneType' object is not subscriptable
```

[146]:
```
# Select the numeric columns
numeric_subset = df.select_dtypes('number')
```

```python
# Create columns with square root and log of numeric columns
for col in numeric_subset.columns:
    # Skip the mpg column
    if col == 'mpg':
        next
    else:
        numeric_subset['sqrt_' + col] = np.sqrt(numeric_subset[col])
        numeric_subset['log_' + col] = np.log(numeric_subset[col])

# Select the categorical columns
categorical_subset = df['manufacturer']

# One hot encode
categorical_subset = pd.get_dummies(categorical_subset)

# Join the two dataframes using concat
# Make sure to use axis = 1 to perform a column bind
features = pd.concat([numeric_subset, categorical_subset], axis = 1)

# Drop cars without an mpg
features = features.dropna(subset = ['mpg'])

# Find correlations with the building
correlations = features.corr()['mpg'].dropna().sort_values()
```

[148]:
```python
correlations.head(10)
```

[148]:
```
log_weight          -0.844194
sqrt_weight         -0.840095
weight              -0.832244
log_displacement    -0.828453
sqrt_displacement   -0.821331
log_horsepower      -0.817517
displacement        -0.805127
sqrt_horsepower     -0.802311
horsepower          -0.778427
sqrt_cylinders      -0.778352
Name: mpg, dtype: float64
```

[150]:
```python
correlations.tail(10)
```

[150]:
```
acceleration         0.423329
sqrt_acceleration    0.430677
log_acceleration     0.435901
origin               0.565209
sqrt_origin          0.570802
```

```
log_origin           0.574276
log_model year       0.576519
sqrt_model year      0.578568
model year           0.580541
mpg                  1.000000
Name: mpg, dtype: float64
```

1.2 Feature Engineering and Selection

In this project we have decided to take the following steps:

Select only the numerical variables and two categorical variables (borough and property use type) Add in the log transformation of the numerical variables One-hot encode the categorical variables

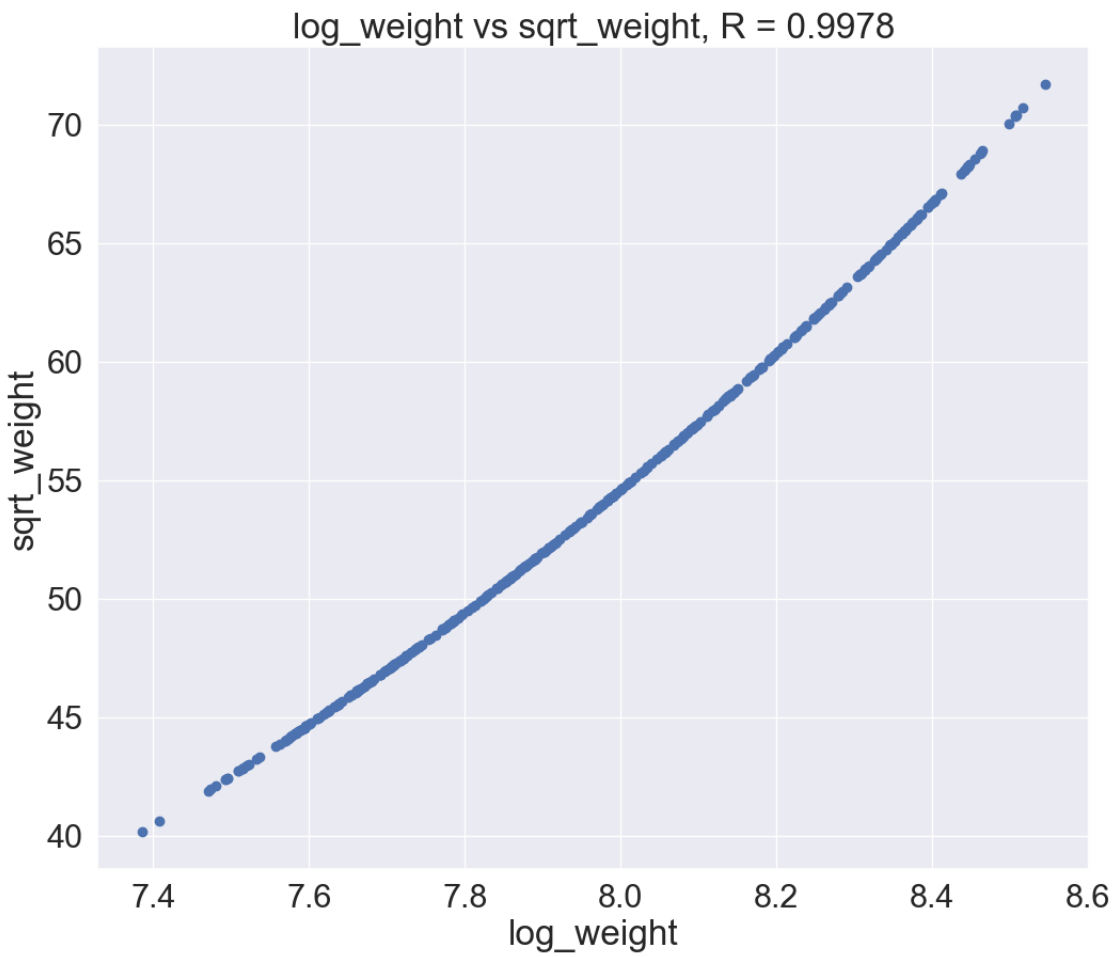
[174]:
```
# Copy the original data
features = df.copy()

# Select the numeric columns
numeric_subset = df.select_dtypes('number')

# Create columns with log of numeric columns
for col in numeric_subset.columns:
    # Skip the mpg column
    if col == 'mpg':
        next
    else:
        numeric_subset['sqrt_' + col] = np.sqrt(numeric_subset[col])
        numeric_subset['log_' + col] = np.log(numeric_subset[col])

# Select the categorical columns
categorical_subset = df["manufacturer"]

# One hot encode
categorical_subset = pd.get_dummies(categorical_subset)

# Join the two dataframes using concat
# Make sure to use axis = 1 to perform a column bind
features = pd.concat([numeric_subset, categorical_subset], axis = 1)

features.shape
```

[174]: (392, 59)

1.3 Remove colinear features

Highly colinear features describe the same thing so we only need one of them in our data set.

[182]:
```
plot_data = features[['log_weight', 'sqrt_weight']].dropna()

plt.plot(plot_data['log_weight'], plot_data['sqrt_weight'], 'bo')
plt.xlabel('log_weight'); plt.ylabel('sqrt_weight')
plt.title('log_weight vs sqrt_weight, R = %0.4f' % np.
 ↪corrcoef(features[['log_weight', 'sqrt_weight']].dropna(),␣
 ↪rowvar=False)[0][1]);
```



1.4 Split Into Training and Testing Sets

We are going to split our data set into training and testing sets

[186]:
```
#Extract the buildings with no score and the buildings with a score
no_mpg = features[features['mpg'].isna()]
mpg = features[features['mpg'].notnull()]

print(no_mpg.shape)
print(mpg.shape)
```

```
(0, 59)
(392, 59)
```

[188]:
```
# Separate out the features and targets
features = mpg.drop(columns='mpg')
targets = pd.DataFrame(mpg['mpg'])

# Replace the inf and -inf with nan (required for later imputation)
features = features.replace({np.inf: np.nan, -np.inf: np.nan})

# Split into 70% training and 30% testing set
X, X_test, y, y_test = train_test_split(features, targets, test_size = 0.3,␣
↪random_state = 42)

print(X.shape)
print(X_test.shape)
print(y.shape)
print(y_test.shape)
```

```
(274, 58)
(118, 58)
(274, 1)
(118, 1)
```

1.5 Establish a Baseline¶

Since it is import to establish a baseline(which is a naive guess). If our model cannot outperform a naive guess it is probably not good. our metric will be the mean absoliute error.

1.6 Mean absolute error

[192]:
```
# Function to calculate mean absolute error
def mae(y_true, y_pred):
    return np.mean(abs(y_true - y_pred))
```

[194]:
```
baseline_guess = np.median(y)

print('The baseline guess is a score of %0.2f' % baseline_guess)
print("Baseline Performance on the test set: MAE = %0.4f" % mae(y_test,␣
↪baseline_guess))
```

```
The baseline guess is a score of 23.00
Baseline Performance on the test set: MAE = 6.0585
```

[196]:
```
# Save the no scores, training, and testing data
# import os
# os.getcwd()
no_mpg.to_csv('\\Documents\\data science\\no_mpg.csv', index = False)
```

```
X.to_csv('\\Documents\\data science\\mpg_training_features.csv', index = False)
X_test.to_csv('\\Documents\\data science\\mpg_testing_features.csv', index =␣
 ↪False)
y.to_csv('\\Documents\\data science\\mpg_training_labels.csv', index = False)
y_test.to_csv('\\Documents\\data science\\mpg_testing_labels.csv', index =␣
 ↪False)
```

[198]:
```
from sklearn.preprocessing import MinMaxScaler
from sklearn.impute import SimpleImputer
imputer = SimpleImputer(strategy = "median")
imputer.fit(X,y)
X= imputer.transform(X)
X_test= imputer.transform(X_test)
```

[200]:
```
print(np.isnan(X).sum())
```

```
0
```

[202]:
```
print(np.isnan(X_test).sum())
```

```
0
```

[204]:
```
np.where(~np.isfinite(X))
```

[204]:
```
(array([], dtype=int64), array([], dtype=int64))
```

[206]:
```
np.where(~np.isfinite(X_test))
```

[206]:
```
(array([], dtype=int64), array([], dtype=int64))
```

[208]:
```
scaler = MinMaxScaler (feature_range=(0,1))
scaler.fit(X,y)
scaler.transform(X)
scaler.transform(X_test)
```

[208]:
```
array([[0.2       , 0.06753247, 0.11538462, …, 0.        , 0.        ,
        0.        ],
       [0.2       , 0.13246753, 0.36813187, …, 0.        , 0.        ,
        0.        ],
       [0.2       , 0.05454545, 0.06593407, …, 0.        , 0.        ,
        0.        ],
       …,
       [0.2       , 0.12727273, 0.28571429, …, 0.        , 0.        ,
        0.        ],
       [1.        , 0.64415584, 0.50549451, …, 0.        , 0.        ,
        0.        ],
       [0.6       , 0.46753247, 0.13186813, …, 0.        , 0.        ,
        0.        ]])
```

[210]:
```
y = np.array(y).reshape((-1,))
y_test = np.array(y_test).reshape((-1,))
```

[212]:
```
def rmse (y_true,y_pred):
    return np.sqrt(np.mean((y_true - y_pred)**2))
```

[214]:
```
def model_test(model):
    model.fit(X,y)
    predictions = model.predict(X_test)
    model_rsme = rmse(y_test,predictions)
    return model_rsme
```

[216]:
```
pip install xgboost
```

```
Collecting xgboost
  Downloading xgboost-3.0.2-py3-none-macosx_12_0_arm64.whl.metadata (2.1 kB)
Requirement already satisfied: numpy in /opt/anaconda3/lib/python3.12/site-
packages (from xgboost) (1.26.4)
Requirement already satisfied: scipy in /opt/anaconda3/lib/python3.12/site-
packages (from xgboost) (1.13.1)
Downloading xgboost-3.0.2-py3-none-macosx_12_0_arm64.whl (2.0 MB)
                         2.0/2.0 MB
14.8 MB/s eta 0:00:00a 0:00:01
Installing collected packages: xgboost
Successfully installed xgboost-3.0.2
Note: you may need to restart the kernel to use updated packages.
```

[218]:
```
from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.svm import SVR
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.ensemble import GradientBoostingRegressor
from sklearn.ensemble import AdaBoostRegressor
from xgboost import XGBRegressor
```

[220]:
```
lr = LinearRegression()
lr_rsme = model_test(lr)
print(" the root mean squared error for linear regression is:", lr_rsme)
```

```
 the root mean squared error for linear regression is: 2.8625006253099823
```

[222]:
```
knn = KNeighborsRegressor(n_neighbors=5)
knn_rsme = model_test(knn)
print(" the root mean squared error for K nearest neighbors is:", knn_rsme)
```

```
 the root mean squared error for K nearest neighbors is: 4.3192356511505015
```

[224]:
```
svm = SVR()
svm_rsme = model_test(svm)
print(" the root mean squared error for Support vector machine is:", svm_rsme)
```

```
the root mean squared error for Support vector machine is: 3.9446062808320677
```

[226]:
```
tree = DecisionTreeRegressor()
tree_rsme = model_test(tree)
print(" the root mean squared error for decision tree is:", tree_rsme)
```

```
the root mean squared error for decision tree is: 3.482060562757613
```

[228]:
```
xgb = XGBRegressor(objective='reg:squarederror')
xgb_rsme = model_test(xgb)
print(" the root mean squared error for XGB Regressor is:", xgb_rsme)
```

```
the root mean squared error for XGB Regressor is: 2.736867543530519
```

[230]:
```
rf = RandomForestRegressor(random_state=42)
gb = GradientBoostingRegressor(random_state=42)
rf_rsme = model_test(rf)
gb_rsme = model_test(gb)
```

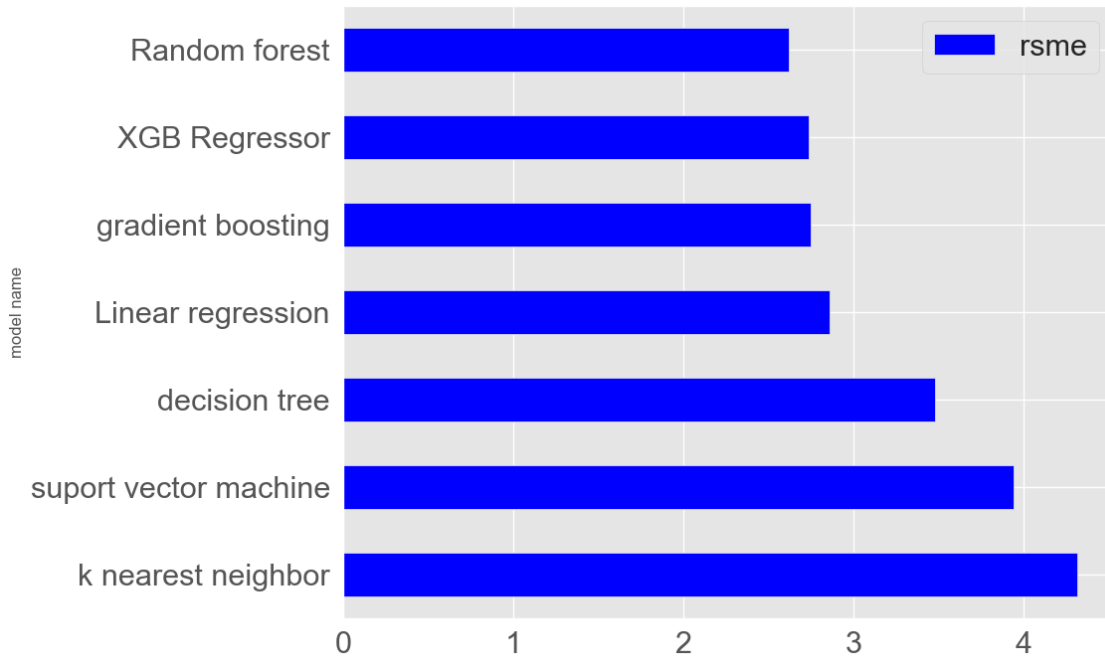
[232]:
```
print(" the root mean squared error for randoom forest is:", rf_rsme)
```

```
the root mean squared error for randoom forest is: 2.6189345550032015
```

[234]:
```
print(" the root mean squared error for gradient boosting is:", gb_rsme)
```

```
the root mean squared error for gradient boosting is: 2.74705035512234
```

[236]:
```
figsize(10,8)

plt.style.use("ggplot")
model_comparison = pd.DataFrame({"model name":["Linear regression", "k nearest␣
↪neighbor", "suport vector machine",
                                                "decision tree","XGB Regressor",␣
↪"Random forest", "gradient boosting"],
                                 "rsme":␣
↪[lr_rsme,knn_rsme,svm_rsme,tree_rsme,xgb_rsme,rf_rsme,gb_rsme]})
model_comparison = model_comparison.sort_values("rsme", ascending=False).
↪plot(x="model name", y="rsme", color="blue", kind="barh")
```



[238]:
```
booster=['gbtree','gblinear']
base_score=[0.25,0.5,0.75,1]
```

[242]:
```
## Hyper Parameter Optimization

n_estimators = [100, 500, 900, 1100, 1500]
max_depth = [2, 3, 5, 10, 15]
booster=['gbtree','gblinear']
learning_rate=[0.05,0.1,0.15,0.20]
min_child_weight=[1,2,3,4]

# Define the grid of hyperparameters to search
hyperparameter_grid = {
    'n_estimators': n_estimators,
    'max_depth':max_depth,
    'learning_rate':learning_rate,
    'min_child_weight':min_child_weight,
    'booster':booster,
    'base_score':base_score
    }
```

[244]:
```
from sklearn.model_selection import RandomizedSearchCV

# Set up the random search with 4-fold cross validation
random_cv = RandomizedSearchCV(estimator=xgb,
```

```
            param_distributions=hyperparameter_grid,
            cv=5, n_iter=50,
            scoring = 'neg_mean_absolute_error',n_jobs = 4,
            verbose = 5,
            return_train_score = True,
            random_state=42)
```

[246]:
```
random_cv.fit(X,y)
```

```
Fitting 5 folds for each of 50 candidates, totalling 250 fits

/opt/anaconda3/lib/python3.12/site-packages/xgboost/training.py:183:
UserWarning: [16:28:40] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:738:
Parameters: { "max_depth", "min_child_weight" } are not used.

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/opt/anaconda3/lib/python3.12/site-packages/xgboost/training.py:183:
UserWarning: [16:28:41] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:738:
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UserWarning: [16:28:42] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:738:
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UserWarning: [16:28:44] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:738:
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/opt/anaconda3/lib/python3.12/site-packages/xgboost/training.py:183:
UserWarning: [16:28:45] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:738:
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```

```
UserWarning: [16:28:46] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:738:
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```

[246]:
```
RandomizedSearchCV(cv=5,
                   estimator=XGBRegressor(base_score=None, booster=None,
                                          callbacks=None,
                                          colsample_bylevel=None,
                                          colsample_bynode=None,
                                          colsample_bytree=None, device=None,
                                          early_stopping_rounds=None,
                                          enable_categorical=False,
                                          eval_metric=None, feature_types=None,
                                          feature_weights=None, gamma=None,
                                          grow_policy=None,
                                          importance_type=None,
                                          interaction_constraint…
                                          n_estimators=None, n_jobs=None,
                                          num_parallel_tree=None, …),
                   n_iter=50, n_jobs=4,
                   param_distributions={'base_score': [0.25, 0.5, 0.75, 1],
                                        'booster': ['gbtree', 'gblinear'],
                                        'learning_rate': [0.05, 0.1, 0.15, 0.2],
                                        'max_depth': [2, 3, 5, 10, 15],
                                        'min_child_weight': [1, 2, 3, 4],
                                        'n_estimators': [100, 500, 900, 1100,
                                                         1500]},
                   random_state=42, return_train_score=True,
                   scoring='neg_mean_absolute_error', verbose=5)
```

[248]:
```
random_cv.best_estimator_
```

[248]:
```
XGBRegressor(base_score=0.75, booster='gbtree', callbacks=None,
             colsample_bylevel=None, colsample_bynode=None,
             colsample_bytree=None, device=None, early_stopping_rounds=None,
             enable_categorical=False, eval_metric=None, feature_types=None,
             feature_weights=None, gamma=None, grow_policy=None,
             importance_type=None, interaction_constraints=None,
             learning_rate=0.1, max_bin=None, max_cat_threshold=None,
             max_cat_to_onehot=None, max_delta_step=None, max_depth=5,
             max_leaves=None, min_child_weight=2, missing=nan,
             monotone_constraints=None, multi_strategy=None, n_estimators=1100,
             n_jobs=None, num_parallel_tree=None, …)
```

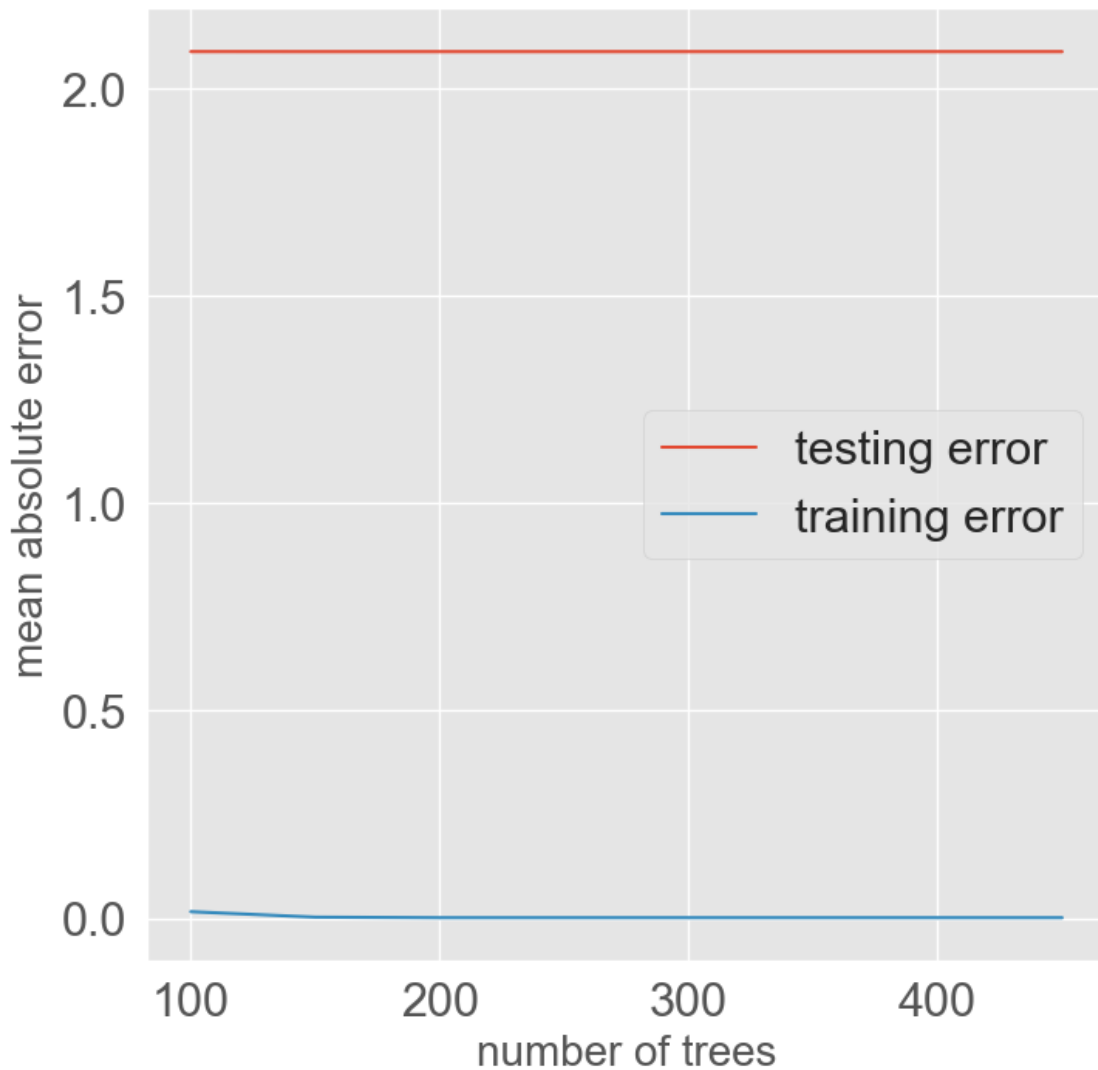
[250]:
```
from sklearn.model_selection import GridSearchCV


trees_grid = {"n_estimators":[100,150,200,250,300,350,400,450],
              }

grid_search = GridSearchCV(estimator=xgb,n_jobs=1,param_grid=trees_grid,
                           ␣
 ↪scoring="neg_mean_absolute_error",cv=10,verbose=1,return_train_score=True)
```

[252]:
```
grid_search.fit(X,y)
```

```
Fitting 10 folds for each of 8 candidates, totalling 80 fits
```

[252]:
```
GridSearchCV(cv=10,
             estimator=XGBRegressor(base_score=None, booster=None,
                                    callbacks=None, colsample_bylevel=None,
                                    colsample_bynode=None,
                                    colsample_bytree=None, device=None,
                                    early_stopping_rounds=None,
                                    enable_categorical=False, eval_metric=None,
                                    feature_types=None, feature_weights=None,
                                    gamma=None, grow_policy=None,
                                    importance_type=None,
                                    interaction_constraints=Non…
                                    max_cat_to_onehot=None, max_delta_step=None,
                                    max_depth=None, max_leaves=None,
                                    min_child_weight=None, missing=nan,
                                    monotone_constraints=None,
                                    multi_strategy=None, n_estimators=None,
                                    n_jobs=None, num_parallel_tree=None, …),
             n_jobs=1,
             param_grid={'n_estimators': [100, 150, 200, 250, 300, 350, 400,
                                          450]},
             return_train_score=True, scoring='neg_mean_absolute_error',
             verbose=1)
```

[254]:
```
results = pd.DataFrame(grid_search.cv_results_)
figsize(8,8)
plt.style.use("ggplot")
plt.plot(results["param_n_estimators"], -1*results["mean_test_score"],␣
↪label="testing error")
plt.plot(results["param_n_estimators"], -1*results["mean_train_score"],␣
↪label="training error")
plt.legend()
plt.ylabel("mean absolute error", size=20)
plt.xlabel("number of trees", size= 20)
plt.show()
```



[256]:
```
default_model = XGBRegressor(objective='reg:squarederror')
final_model = grid_search.best_estimator_
final_model
```

[256]:
```
XGBRegressor(base_score=None, booster=None, callbacks=None,
             colsample_bylevel=None, colsample_bynode=None,
             colsample_bytree=None, device=None, early_stopping_rounds=None,
             enable_categorical=False, eval_metric=None, feature_types=None,
             feature_weights=None, gamma=None, grow_policy=None,
             importance_type=None, interaction_constraints=None,
             learning_rate=None, max_bin=None, max_cat_threshold=None,
             max_cat_to_onehot=None, max_delta_step=None, max_depth=None,
             max_leaves=None, min_child_weight=None, missing=nan,
             monotone_constraints=None, multi_strategy=None, n_estimators=150,
             n_jobs=None, num_parallel_tree=None, …)
```

[258]:
```
%%timeit -n 1 -r 5
default_model.fit(X,y)
```

```
53.2 ms ± 16.9 ms per loop (mean ± std. dev. of 5 runs, 1 loop each)
```

[260]:
```
%%timeit -n 1 -r 5
final_model.fit(X,y)
```

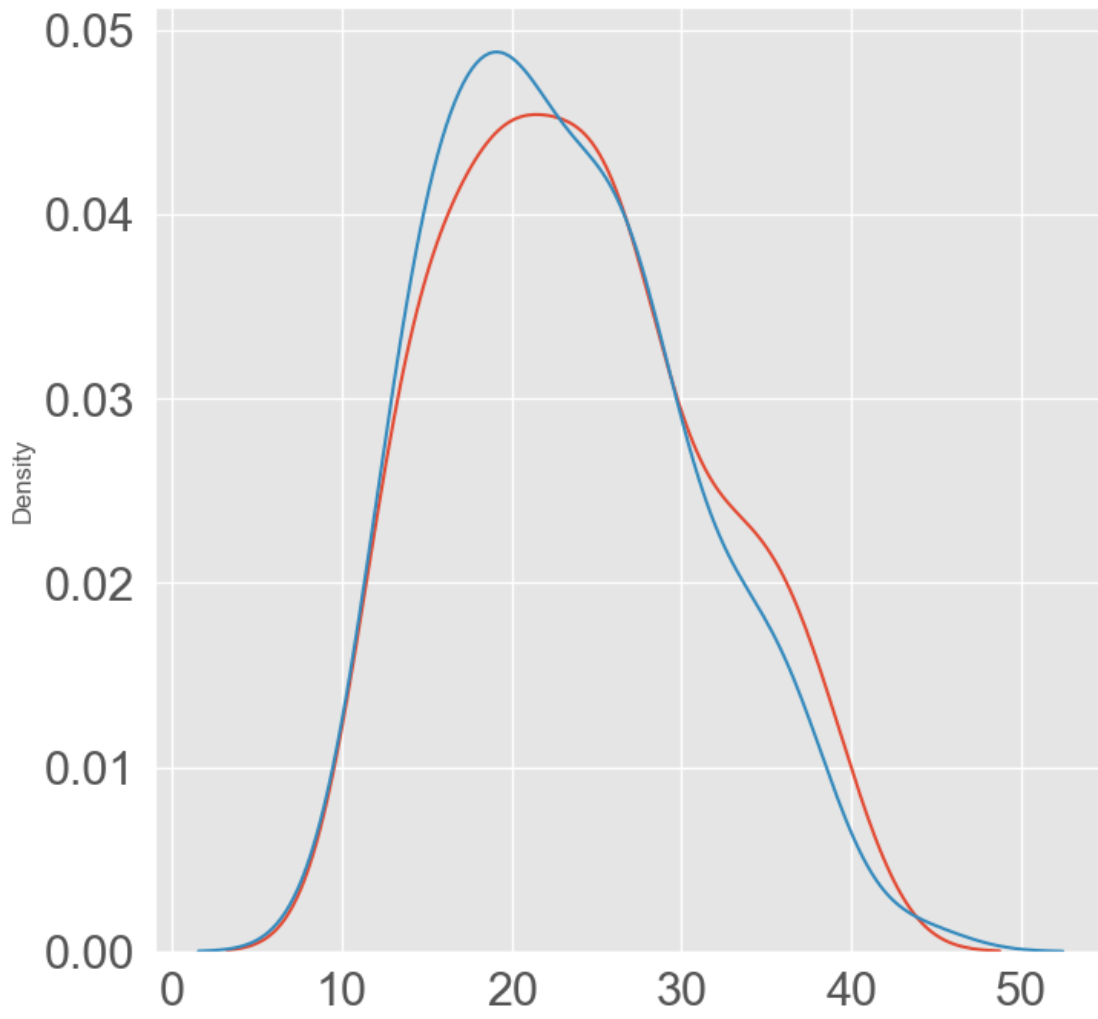
```
65.1 ms ± 21.3 ms per loop (mean ± std. dev. of 5 runs, 1 loop each)
```

[262]:
```
default_pred = default_model.predict(X_test)
final_pred = final_model.predict(X_test)
```

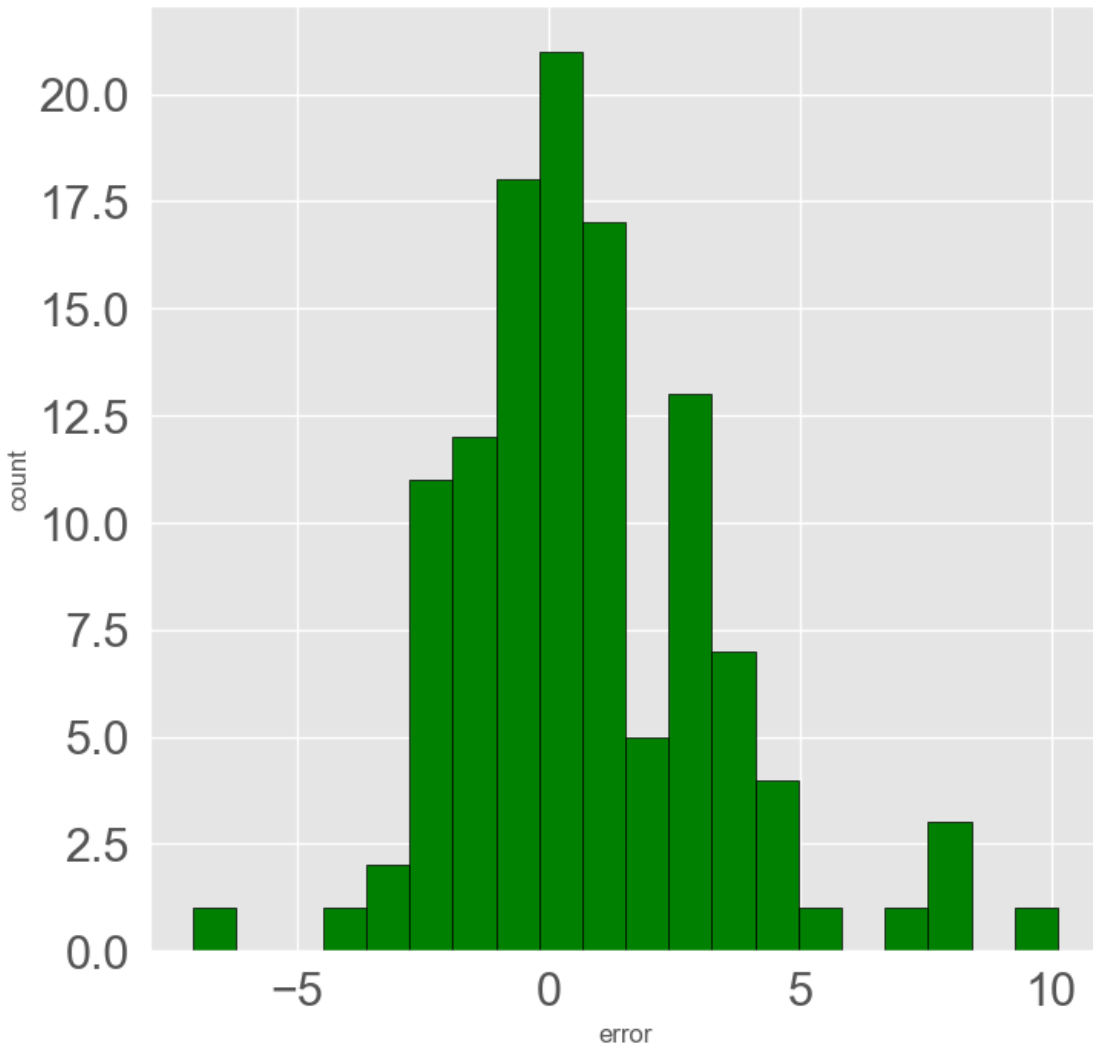
[264]:
```
print("the default model performance on the test set: rsme = %0.4f" ␣
 ↪%rmse(y_test,default_pred))
print("the final model performance on the test set: rsme = %0.4f"␣
 ↪%rmse(y_test,final_pred))
```

```
the default model performance on the test set: rsme = 2.7369
the final model performance on the test set: rsme = 2.7394
```

[266]:
```
figsize(8,8)
sns.kdeplot(final_pred, label="predictions")
sns.kdeplot(y_test, label="test values")
plt.show()
```



[268]:
```
figsize =(6,6)
residuals = final_pred - y_test

plt.hist(residuals, color = "green", bins=20, edgecolor="black")
plt.ylabel("count")
plt.xlabel("error")
plt.show()
```



[275]:
```
ann_pred = model.predict(X_test)
score = rmse(y_test,ann_pred)
```

```
4/4              0s 9ms/step
```

[277]:
```
score
```

[277]: 193.37023972635046

[ ]:
```

```