Assignment 2

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0.3 Course: DSCI-6601-001 (Pract Machine Learning 77223)

0.4 Assignment 2

0.4.1 Question 1

Import Libraries

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline

# Libraries to split data, create simple linaer regression
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn import metrics
from sklearn.metrics import mean_squared_error
```

Load the given EPA fuel economy data set into a pandas dataframe. Write code which removes the non-numeric columns from the data frame. Create a new column named "CityHighwayDiff" which is calculated by taking the difference of the "city08" column and "highway08" column. Plot a histogram of this column.

[2]:
```
# Code to load in the  EPA fuel economy data set and show the rows and columns
df = pd.read_csv('EPA fuel economy dataset.csv')
data = df                                          # duplicate dataframe
```

[3]:
```
data.head()
```

[3]:

	city08	cityA08	cylinders	fuelType	fuelType1	highway08	\
0	19	0	4	Regular	Regular Gasoline	25	
1	9	0	12	Regular	Regular Gasoline	14	
2	23	0	4	Regular	Regular Gasoline	33	
3	10	0	8	Regular	Regular Gasoline	12	
4	17	0	4	Premium	Premium Gasoline	23	

```
   highwayA08     id        make                 model mpgData  \
0           0      1  Alfa Romeo   Spider Veloce 2000       Y
1           0     10     Ferrari           Testarossa       N
2           0    100       Dodge              Charger       Y
3           0   1000       Dodge  B150/B250 Wagon 2WD       N
4           0  10000      Subaru     Legacy AWD Turbo       N

              trany  year  fuelType2
0     Manual 5-spd  1985        NaN
1     Manual 5-spd  1985        NaN
2     Manual 5-spd  1985        NaN
3  Automatic 3-spd  1985        NaN
4     Manual 5-spd  1993        NaN
```

[4]:
```
# Code to display the number of rows and columns
print(f"There are {data.shape[0]} rows and {data.shape[1]} columns.")
```

```
There are 6000 rows and 14 columns.
```

[5]:
```
# Display columns data type.
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6000 entries, 0 to 5999
Data columns (total 14 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   city08      6000 non-null   int64
 1   cityA08     6000 non-null   int64
 2   cylinders   6000 non-null   int64
 3   fuelType    6000 non-null   object
 4   fuelType1   6000 non-null   object
 5   highway08   6000 non-null   int64
 6   highwayA08  6000 non-null   int64
 7   id          6000 non-null   int64
 8   make        6000 non-null   object
 9   model       6000 non-null   object
 10  mpgData     6000 non-null   object
 11  trany       6000 non-null   object
 12  year        6000 non-null   int64
 13  fuelType2   0 non-null      float64
dtypes: float64(1), int64(7), object(6)
memory usage: 656.4+ KB
```

[6]:
```
# Dropping the non-numeric columns.
data = data.drop(['fuelType', 'fuelType1', 'make', 'model', 'mpgData',␣
 ↪'trany'], axis = 1)
```

[7]:
```
data.info()
print()
print('Confirmation that the non-numeric columns has been removed')
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6000 entries, 0 to 5999
Data columns (total 8 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   city08      6000 non-null   int64
 1   cityA08     6000 non-null   int64
 2   cylinders   6000 non-null   int64
 3   highway08   6000 non-null   int64
 4   highwayA08  6000 non-null   int64
 5   id          6000 non-null   int64
 6   year        6000 non-null   int64
 7   fuelType2   0 non-null      float64
dtypes: float64(1), int64(7)
memory usage: 375.1 KB

Confirmation that the non-numeric columns has been removed
```

[8]:
```
data.head()
```

[8]:

	city08	cityA08	cylinders	highway08	highwayA08	id	year	fuelType2
0	19	0	4	25	0	1	1985	NaN
1	9	0	12	14	0	10	1985	NaN
2	23	0	4	33	0	100	1985	NaN
3	10	0	8	12	0	1000	1985	NaN
4	17	0	4	23	0	10000	1993	NaN

[9]:
```
# Creaing the new column CityHighwayDiff.
data['CityHighwayDiff'] = data['highway08'] - data['city08']
```

[10]:
```
data.head()
```

[10]:

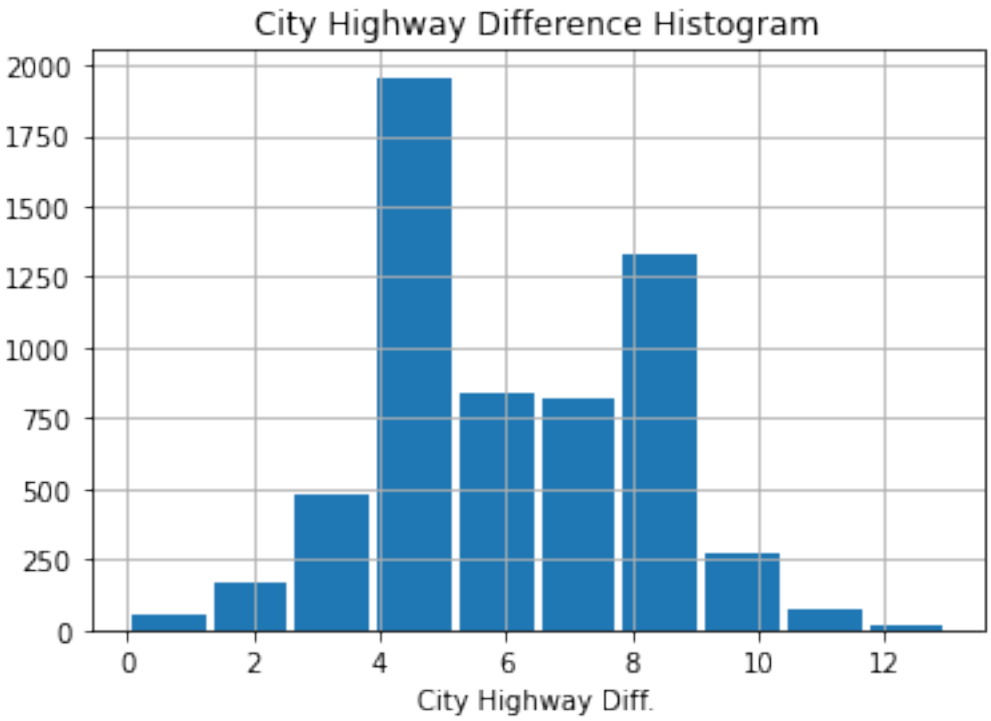
	city08	cityA08	cylinders	highway08	highwayA08	id	year	fuelType2	CityHighwayDiff
0	19	0	4	25	0	1	1985	NaN	6
1	9	0	12	14	0	10	1985	NaN	5
2	23	0	4	33	0	100	1985	NaN	10
3	10	0	8	12	0	1000	1985	NaN	
4	17	0	4	23	0	10000	1993	NaN	

```
3                 2
4                 6
```

New column created as shown in the above table

[11]:
```
# Plot a histogram of this column "CityHighwayDiff".
data.hist('CityHighwayDiff',bins= 10, rwidth=0.9)
plt.title('City Highway Difference Histogram')
plt.xlabel('City Highway Diff.')
```

[11]:
```
Text(0.5, 0, 'City Highway Diff.')
```



[12]:
```
data.isna().sum()
```

[12]:
```
city08              0
cityA08             0
cylinders           0
highway08           0
highwayA08          0
id                  0
year                0
fuelType2        6000
CityHighwayDiff     0
dtype: int64
```

The column labelled "fuelType2" has missing values (6000) in all the rows in the dataframe so it will be dropped.

[13]:
```
# Dropping the column labelled "fuelType2".
data = data.drop(['fuelType2'], axis=1)
```

[14]:
```
data.head()
```

[14]:

	city08	cityA08	cylinders	highway08	highwayA08	id	year	\
0	19	0	4	25	0	1	1985	
1	9	0	12	14	0	10	1985	
2	23	0	4	33	0	100	1985	
3	10	0	8	12	0	1000	1985	
4	17	0	4	23	0	10000	1993	

	CityHighwayDiff
0	6
1	5
2	10
3	2
4	6

0.4.2 Question 2

Using the EPA fuel economy data set. Consider the "year" column. Create a new column "Decade" from the year column which maps each year into a class based on its decade. Plot a histogram of the Decade column to visualize the occurrences in each of the decades. Remove any other non-numeric columns from the dataframe. With the columns remaining, create a linear classifier that predicts the decade of a particular car based on the rest of the columns. Train the classifier using the entire dataset. Calculate and print the training error of the resulting classifier.

[15]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

# Libraries to split data, create simple linaer regression
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import LogisticRegression
from sklearn import metrics
from sklearn.metrics import mean_squared_error
```

[16]:
```
# Code to load in the  EPA fuel economy data set and show the rows and columns
df1 = pd.read_csv('EPA fuel economy dataset.csv')
data2 = df1
```

[17]:
```
data2.head()
```

[17]:
```
   city08  cityA08  cylinders fuelType         fuelType1  highway08  \
0      19        0          4  Regular  Regular Gasoline         25
1       9        0         12  Regular  Regular Gasoline         14
2      23        0          4  Regular  Regular Gasoline         33
3      10        0          8  Regular  Regular Gasoline         12
4      17        0          4  Premium  Premium Gasoline         23

   highwayA08     id        make                model mpgData  \
0           0      1  Alfa Romeo   Spider Veloce 2000       Y
1           0     10     Ferrari           Testarossa       N
2           0    100       Dodge              Charger       Y
3           0   1000       Dodge  B150/B250 Wagon 2WD       N
4           0  10000      Subaru     Legacy AWD Turbo       N

             trany  year  fuelType2
0     Manual 5-spd  1985        NaN
1     Manual 5-spd  1985        NaN
2     Manual 5-spd  1985        NaN
3  Automatic 3-spd  1985        NaN
4     Manual 5-spd  1993        NaN
```

[18]:
```
#Creating a new column called "Decade".

data2["decade"]= [ int(np.floor(year/10) * 10) for year in data2["year"]]
```

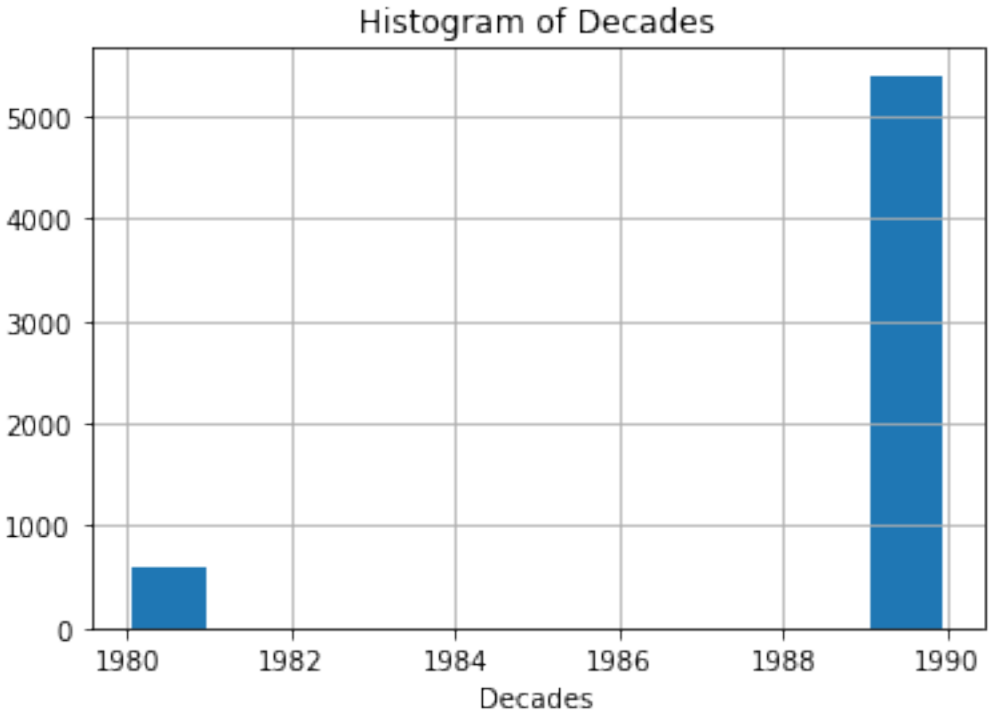
[19]:
```
data2.head()
```

[19]:
```
   city08  cityA08  cylinders fuelType         fuelType1  highway08  \
0      19        0          4  Regular  Regular Gasoline         25
1       9        0         12  Regular  Regular Gasoline         14
2      23        0          4  Regular  Regular Gasoline         33
3      10        0          8  Regular  Regular Gasoline         12
4      17        0          4  Premium  Premium Gasoline         23

   highwayA08     id        make                model mpgData  \
0           0      1  Alfa Romeo   Spider Veloce 2000       Y
1           0     10     Ferrari           Testarossa       N
2           0    100       Dodge              Charger       Y
3           0   1000       Dodge  B150/B250 Wagon 2WD       N
4           0  10000      Subaru     Legacy AWD Turbo       N

             trany  year  fuelType2  decade
0     Manual 5-spd  1985        NaN    1980
1     Manual 5-spd  1985        NaN    1980
2     Manual 5-spd  1985        NaN    1980
```

```
3  Automatic 3-spd  1985        NaN    1980
4     Manual 5-spd  1993        NaN    1990
```

[20]:
```
# Plot a histogram of the Decade column to visualize the occurrences in each of␣
 ↪the decades.
data2.hist('decade',bins= 10, rwidth=0.9)
plt.title('Histogram of Decades')
plt.xlabel('Decades')
```

[20]:
```
Text(0.5, 0, 'Decades')
```



[21]:
```
# Dropping the non-numeric columns.
data2 = data2.drop(['fuelType', 'fuelType1', 'make', 'model', 'mpgData',␣
 ↪'trany'], axis = 1)
data2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6000 entries, 0 to 5999
Data columns (total 9 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   city08      6000 non-null   int64
 1   cityA08     6000 non-null   int64
 2   cylinders   6000 non-null   int64
```

```
 3   highway08   6000 non-null   int64
 4   highwayA08  6000 non-null   int64
 5   id          6000 non-null   int64
 6   year        6000 non-null   int64
 7   fuelType2   0 non-null      float64
 8   decade      6000 non-null   int64
dtypes: float64(1), int64(8)
memory usage: 422.0 KB
```

Confirmation that the non-numeric columns has been removed.

[22]:
```
data2.head()
```

[22]:

	city08	cityA08	cylinders	highway08	highwayA08	id	year	fuelType2	\
0	19	0	4	25	0	1	1985	NaN	
1	9	0	12	14	0	10	1985	NaN	
2	23	0	4	33	0	100	1985	NaN	
3	10	0	8	12	0	1000	1985	NaN	
4	17	0	4	23	0	10000	1993	NaN	

	decade
0	1980
1	1980
2	1980
3	1980
4	1990

[23]:
```
data2.isna().sum()
```

[23]:
```
city08           0
cityA08          0
cylinders        0
highway08        0
highwayA08       0
id               0
year             0
fuelType2     6000
decade           0
dtype: int64
```

The column labelled “fuelType2” has missing values (6000) in all the rows in the dataframe so it will be dropped.

[24]:
```
# Dropping the column labelled "fuelType2".
data2 = data2.drop(['fuelType2'], axis=1)
```

[25]:
```
data2.head()
```

[25]:

	city08	cityA08	cylinders	highway08	highwayA08	id	year	decade
0	19	0	4	25	0	1	1985	1980
1	9	0	12	14	0	10	1985	1980
2	23	0	4	33	0	100	1985	1980
3	10	0	8	12	0	1000	1985	1980
4	17	0	4	23	0	10000	1993	1990

0.4.3 Design of linear classifier that predict the decade of a particular car

[26]:
```
# Divide the data into independent and dependent variables
X = data2.drop(["decade"], axis=1).values      # independent variables
Y = data2[["decade"]].values                   # dependent variables
```

[27]:
```
# Print new data
print(X)
print(Y)
```

```
[[   19     0     4 …     0     1  1985]
 [    9     0    12 …     0    10  1985]
 [   23     0     4 …     0   100  1985]
 …
 [   12     0     8 …     0 15397  1999]
 [   13     0     6 …     0 15398  1999]
 [   12     0     8 …     0 15399  1999]]
[[1980]
 [1980]
 [1980]
 …
 [1990]
 [1990]
 [1990]]
```

[28]:
```
# Linear regression to fit and predict. Using Logistic Regression to model
log_model = LogisticRegression(random_state=1)
clf = log_model.fit(X,Y)
clf.score(X,Y)
```

```
/Users/danielfiadjoe/anaconda3/lib/python3.8/site-
packages/sklearn/utils/validation.py:72: DataConversionWarning: A column-vector
y was passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
  return f(**kwargs)
```

[28]: 1.0

[29]:
```
# Calculate the training error
y_predict = log_model.predict(X)
```

```
print("The predicted decade of cars are:")
print(y_predict)
```

```
The predicted decade of cars are:
[1980 1980 1980 … 1990 1990 1990]
```

[30]:
```
# Print errors
print(mean_squared_error(Y, y_predict))
print(np.mean(np.square(np.array(y_predict)-np.array(Y))))
```

```
0.0
18.02666111111111
```

0.5 Question 3

Building on 2, split the training set used into a training and test set (split evenly 50:50). Re-fit the linear classifier developed above on the 50% training set and calculate and print the mean absolute error of the predictor using the 50% test set.

Split the data from question 2 into 50:50 and re-fit.

[31]:
```
# Spliting data into training (50%) and test data (50%) sets.
x_train, x_test, y_train, y_test = train_test_split(X, Y, test_size=0.5,␣
 ↪random_state=1)
```

[32]:
```
# Shape of the train and test sets
print("Number of rows in train data =", x_train.shape[0])
print("Number of rows in test data =", x_test.shape[0])
print("Number of rows in train data =", y_train.shape[0])
print("Number of rows in test data =", y_test.shape[0])
```

```
Number of rows in train data = 3000
Number of rows in test data = 3000
Number of rows in train data = 3000
Number of rows in test data = 3000
```

[33]:
```
# Fitting the linear regression model for the training (50%) and test data␣
 ↪(50%) sets
log_model1 = LogisticRegression(random_state=1)
clf1 = log_model1.fit(x_train,y_train)
clf1.score(x_train,y_train)
```

```
/Users/danielfiadjoe/anaconda3/lib/python3.8/site-
packages/sklearn/utils/validation.py:72: DataConversionWarning: A column-vector
y was passed when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
  return f(**kwargs)
```

[33]: 1.0

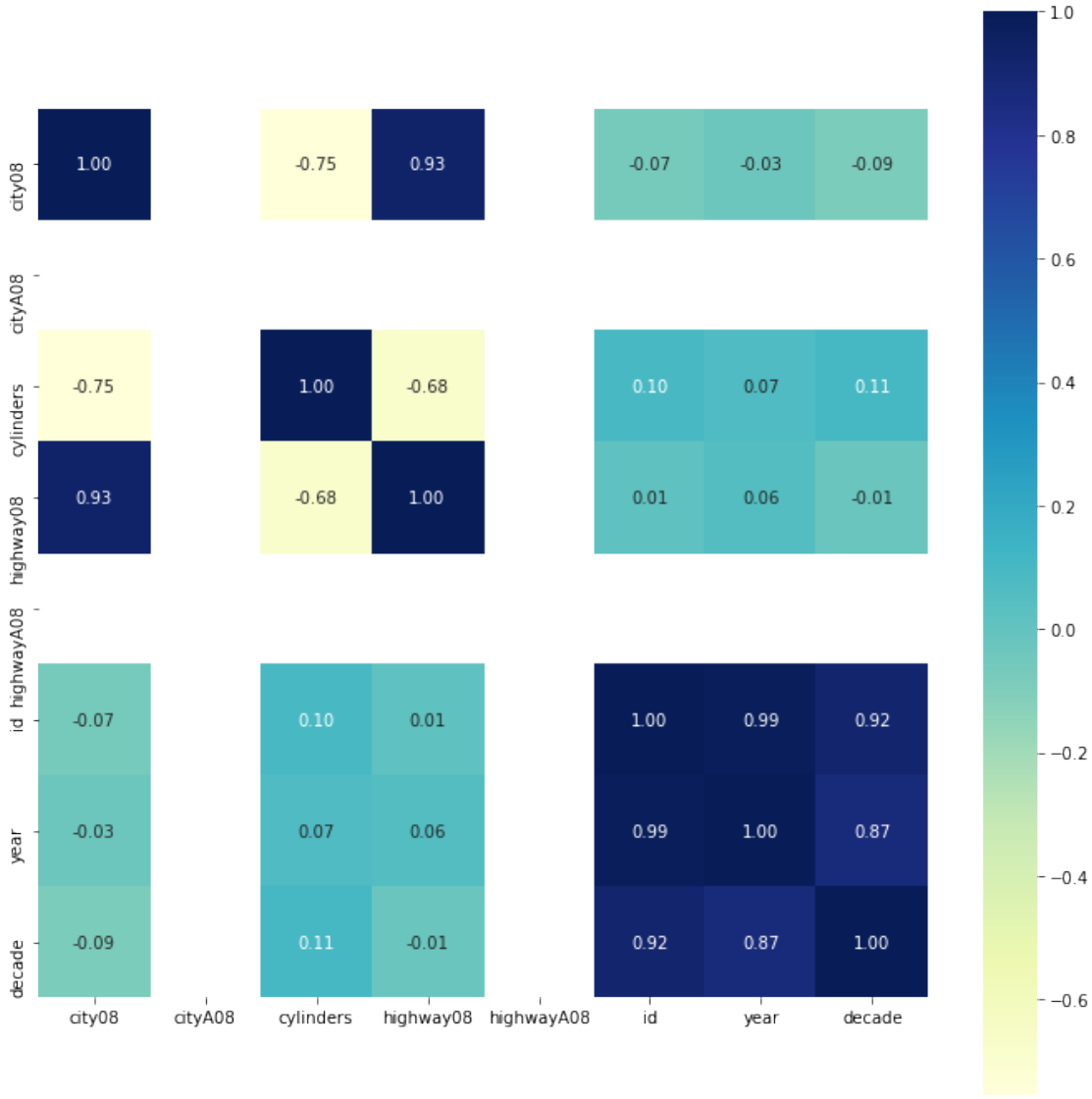
[34]:
```
y_predict2 = log_model1.predict(x_test)
print("List of predicted decades: ", y_predict2)
mean_ab_error = metrics.mean_absolute_error(y_test, y_predict2)
print()
print("The mean absolute error of the predictor using 50% of test set is: ",␣
 ↪mean_ab_error)
```

```
List of predicted decades:  [1990 1990 1990 … 1990 1990 1990]

The mean absolute error of the predictor using 50% of test set is:  0.0
```

0.6 Question 4

Pick 2 of the numeric columns of the dataframe to eliminate from the table. Re-train the classifier using this new dataset. Compare the testing and training error using the 50/50 split of the missing columns classifier with that containing the full set of columns.

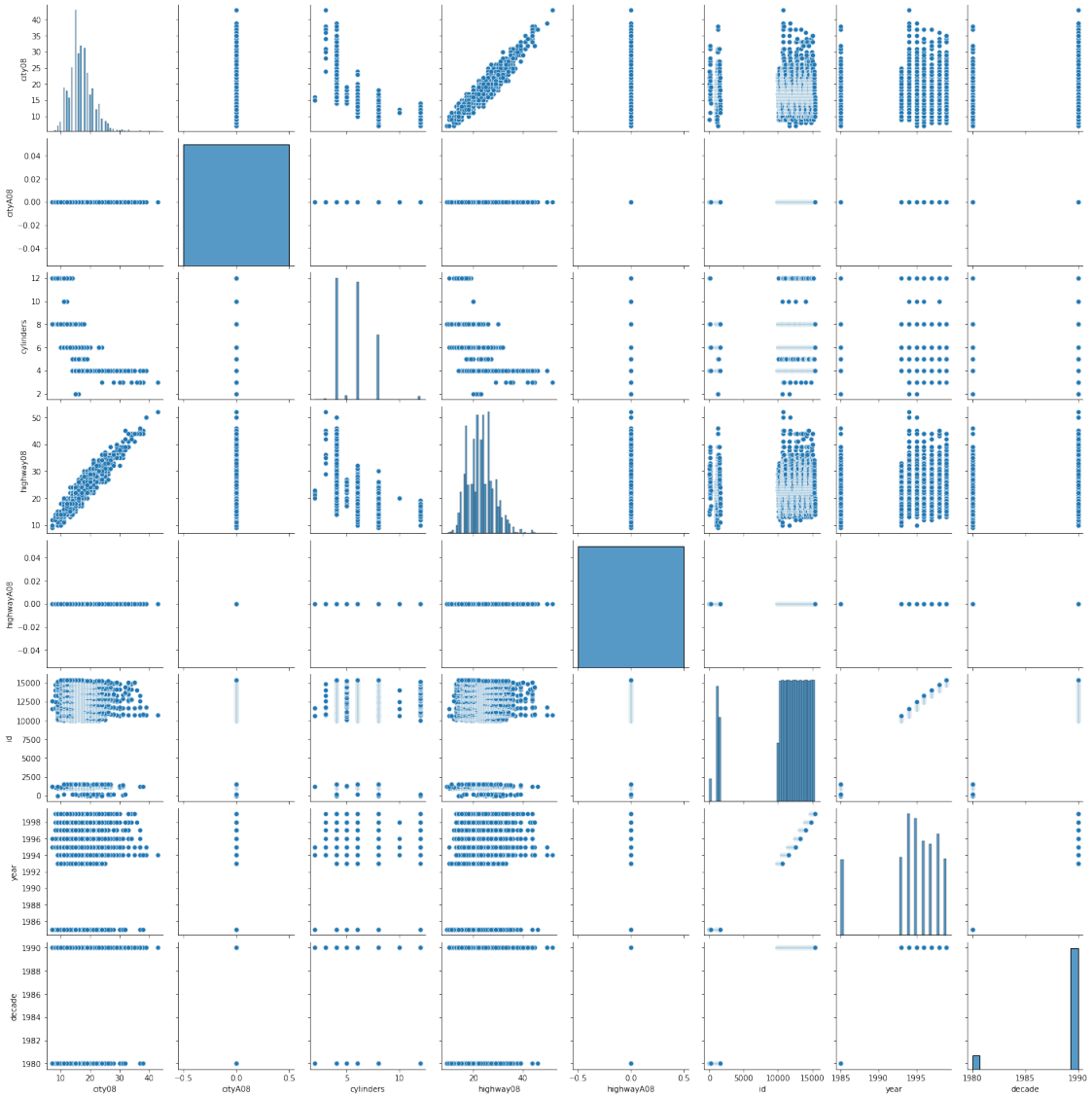
[35]:
```
#Let's Look at correlation values
corr=data2.corr()
fig,ax=plt.subplots(figsize=(12,12))
ax=sns.heatmap(corr,annot=True,square=True,fmt=".2f",cmap="YlGnBu")
```



From the above diagram, the 2 variables with no correlation can be removed because they have not impart on the data. The variables are "city08" and "highwayA08".

[36]:
```
sns.pairplot(data2)
```

[36]:
```
<seaborn.axisgrid.PairGrid at 0x7f7ea0ce3a00>
```



The pairplot above is also showing no reletionship between the 2 varibales which is shown as a single block in the diagram.

[37]:
```
data2.nunique().sort_values(ascending=True)
```

[37]:
```
cityA08          1
highwayA08       1
decade           2
cylinders        8
year             8
city08          34
highway08       40
id            6000
```

```
dtype: int64
```

Checking uniquiness of the variables also indicates that the 2 variables have value in them which is zero (0). Based on the 3 analyses above, the variables "city08" and "highwayA08" will be dropped as requested in the question.

[38]:
```
# Duplicating data used in question 3.
data3 = data2
```

[39]:
```
# Dropping the columns labelled "city08" and "highwayA08".
data3 = data3.drop(["cityA08", "highwayA08"], axis=1)
```

[40]:
```
data3.head()
```

[40]:

	city08	cylinders	highway08	id	year	decade
0	19	4	25	1	1985	1980
1	9	12	14	10	1985	1980
2	23	4	33	100	1985	1980
3	10	8	12	1000	1985	1980
4	17	4	23	10000	1993	1990

[41]:
```
# Divide the data into independent and dependent variables
X2 = data3.drop(["decade"], axis=1)                                    # independent␣
 ↪variables
Y2 = data3["decade"]                                                   # dependent␣
 ↪variables
```

[42]:
```
# Print new data
print(X2)
print(Y2)
```

```
      city08  cylinders  highway08     id  year
0         19          4         25      1  1985
1          9         12         14     10  1985
2         23          4         33    100  1985
3         10          8         12   1000  1985
4         17          4         23  10000  1993
…        …          …          …     …    …
5995      13          6         18  15395  1999
5996      13          8         16  15396  1999
5997      12          8         17  15397  1999
5998      13          6         15  15398  1999
5999      12          8         18  15399  1999

[6000 rows x 5 columns]
0       1980
1       1980
2       1980
```

```
3       1980
4       1990
        …
5995    1990
5996    1990
5997    1990
5998    1990
5999    1990
Name: decade, Length: 6000, dtype: int64
```

[43]:
```
# Spliting data into training (50%) and test data (50%) sets.
x2_train, x2_test, y2_train, y2_test = train_test_split(X2, Y2, test_size=0.5,␣
 ↪random_state=1)
```

[44]:
```
# Shape of the train and test sets
print("Number of rows in train data =", x2_train.shape[0])
print("Number of rows in test data =", x2_test.shape[0])
print("Number of rows in train data =", y2_train.shape[0])
print("Number of rows in test data =", y2_test.shape[0])
```

```
Number of rows in train data = 3000
Number of rows in test data = 3000
Number of rows in train data = 3000
Number of rows in test data = 3000
```

[45]:
```
# Fitting the linear regression model for the training (50%) and test data␣
 ↪(50%) sets
log_model2 = LogisticRegression(random_state=1)
clf2 = log_model2.fit(x2_train,y2_train)
clf2.score(x2_train,y2_train)
```

[45]: 1.0

[46]:
```
y2_predict3 = log_model2.predict(x2_test)
print("List of predicted decades: ", y2_predict3)
mean_ab_error2 = metrics.mean_absolute_error(y2_test, y2_predict3)
print()
print("The mean absolute error of the predictor using 50% of test set is: ",␣
 ↪mean_ab_error2)
training_error5 = np.mean(np.square(np.array(y2_predict3)-np.array(y2_train)))
print()
mse = mean_squared_error(y2_train, y2_predict3)
print("The mean squared error: ", mse)
print("The error:", training_error5)
```

```
List of predicted decades:  [1990 1990 1990 … 1990 1990 1990]

The mean absolute error of the predictor using 50% of test set is:  0.0
```

```
The mean squared error:  18.233333333333334
The error: 18.233333333333334
```

The test error is 0.0 and the training error is 18.2.

From the results above, it confirms that the 2 variables ("city08" and "highwayA08") that were dropped from data did not affect the model. There was no negative impact or positive impact on the model.