PS3

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0.1 Problem set 3

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0.3 Link to your PS3 github repo: [https://github.com/IsabellaTan/Brown-DATA1030-HW3.git]

0.3.1 Problem 0

-2 points for every missing green OK sign.

Make sure you are in the DATA1030 environment.

[1]:
```
from __future__ import print_function
from packaging.version import parse as Version
from platform import python_version

OK = '\x1b[42m[ OK ]\x1b[0m'
FAIL = "\x1b[41m[FAIL]\x1b[0m"

try:
    import importlib
except ImportError:
    print(FAIL, "Python version 3.12.10 is required,"
                " but %s is installed." % sys.version)

def import_version(pkg, min_ver, fail_msg=""):
    mod = None
    try:
        mod = importlib.import_module(pkg)
        if pkg in {'PIL'}:
            ver = mod.VERSION
        else:
            ver = mod.__version__
        if Version(ver) == Version(min_ver):
            print(OK, "%s version %s is installed."
                  % (lib, min_ver))
        else:
            print(FAIL, "%s version %s is required, but %s installed."
                  % (lib, min_ver, ver))
```

```
    except ImportError:
        print(FAIL, '%s not installed. %s' % (pkg, fail_msg))
    return mod


# first check the python version
pyversion = Version(python_version())

if pyversion >= Version("3.12.10"):
    print(OK, "Python version is %s" % pyversion)
elif pyversion < Version("3.12.10"):
    print(FAIL, "Python version 3.12.10 is required,"
                " but %s is installed." % pyversion)
else:
    print(FAIL, "Unknown Python version: %s" % pyversion)


print()
requirements = {'numpy': "2.2.5", 'matplotlib': "3.10.1",'sklearn': "1.6.1",
                'pandas': "2.2.3",'xgboost': "3.0.0", 'shap': "0.47.2",
                'polars': "1.27.1", 'seaborn': "0.13.2"}

# now the dependencies
for lib, required_version in list(requirements.items()):
    import_version(lib, required_version)
```

```
[ OK ] Python version is 3.12.10
```

```
[ OK ] numpy version 2.2.5 is installed.
[ OK ] matplotlib version 3.10.1 is installed.
[ OK ] sklearn version 1.6.1 is installed.
[ OK ] pandas version 2.2.3 is installed.
[ OK ] xgboost version 3.0.0 is installed.
[ OK ] shap version 0.47.2 is installed.
[ OK ] polars version 1.27.1 is installed.
[ OK ] seaborn version 0.13.2 is installed.
```

0.4 Problem 1: EDA and visualizations

0.4.1 Problem 1a: EDA (5 points)

One of the datasets we will be working with this semester is the kaggle house price dataset. The goal of PS3 is to use this dataset to practice dataframe manipulations and perform EDA. The dataset, and its description, are located in the `data` folder.

Carefully read the dataset description. Whenever you work with a dataset, it is highly recommended that you prepare a similar description if it is not readily available. Specific things to note:

- each feature is described in full detail,

- the meaning of continuous features is explained and their unit is provided (e.g., lot size is measured in square feet),
- each category in a categorical or ordinal feature is spelled out and explained.

Answer the following EDA-related questions.

The sequence of questions here are typical things to ask when you perform EDA on a new dataset. First, you always want to know how many data points and features you have, and whether they are continuous, ordinal, or categorical. You should then take a closer look at the target variable. We will study the properties of the features and the relationships between the features and the target variable in 1b.

Q0 First, read the data into a data frame and display the columns of the data frame below. You might encounter error messages and other issues along the way. Please diagnose and resolve them.

[ ]:
```
# your code here

import pandas as pd
df = pd.read_excel('C:/Users/DELL/Desktop/zy/OneDrive/Brown/DATA1030/
 ↪assignment3/Brown-DATA1030-HW3/data/train.xlsx', sheet_name='data')
print(df.columns)
```

```
Index(['MSSubClass', 'MSZoning', 'LotFrontage', 'LotArea', 'Street', 'Alley',
       'LotShape', 'LandContour', 'Utilities', 'LotConfig', 'LandSlope',
       'Neighborhood', 'Condition1', 'Condition2', 'BldgType', 'HouseStyle',
       'OverallQual', 'OverallCond', 'YearBuilt', 'YearRemodAdd', 'RoofStyle',
       'RoofMatl', 'Exterior1st', 'Exterior2nd', 'MasVnrType', 'MasVnrArea',
       'ExterQual', 'ExterCond', 'Foundation', 'BsmtQual', 'BsmtCond',
       'BsmtExposure', 'BsmtFinType1', 'BsmtFinSF1', 'BsmtFinType2',
       'BsmtFinSF2', 'BsmtUnfSF', 'TotalBsmtSF', 'Heating', 'HeatingQC',
       'CentralAir', 'Electrical', '1stFlrSF', '2ndFlrSF', 'LowQualFinSF',
       'GrLivArea', 'BsmtFullBath', 'BsmtHalfBath', 'FullBath', 'HalfBath',
       'BedroomAbvGr', 'KitchenAbvGr', 'KitchenQual', 'TotRmsAbvGrd',
       'Functional', 'Fireplaces', 'FireplaceQu', 'GarageType', 'GarageYrBlt',
       'GarageFinish', 'GarageCars', 'GarageArea', 'GarageQual', 'GarageCond',
       'PavedDrive', 'WoodDeckSF', 'OpenPorchSF', 'EnclosedPorch', '3SsnPorch',
       'ScreenPorch', 'PoolArea', 'PoolQC', 'Fence', 'MiscFeature', 'MiscVal',
       'MoSold', 'YrSold', 'SaleType', 'SaleCondition', 'SalePrice'],
      dtype='object')
```

Q1 How many rows and columns do we have in the dataframe?

[ ]:
```
# your code here

print("The number of row is " + str(df.shape[0]))
print("The number of columb is " + str(df.shape[1]))
```

```
The number of row is 1460
The number of columb is 80
```

Q2 What are the data types of the columns? Make sure that the output is not truncated and you

see the type of each column.

[ ]:
```
# your code here

# Create a for loop to iterate through each column and print its name and data type
for col, dtype in df.dtypes.items():
    print(f"{col}: {dtype}")
```

```
MSSubClass: int64
MSZoning: object
LotFrontage: float64
LotArea: int64
Street: object
Alley: object
LotShape: object
LandContour: object
Utilities: object
LotConfig: object
LandSlope: object
Neighborhood: object
Condition1: object
Condition2: object
BldgType: object
HouseStyle: object
OverallQual: int64
OverallCond: int64
YearBuilt: int64
YearRemodAdd: int64
RoofStyle: object
RoofMatl: object
Exterior1st: object
Exterior2nd: object
MasVnrType: object
MasVnrArea: float64
ExterQual: object
ExterCond: object
Foundation: object
BsmtQual: object
BsmtCond: object
BsmtExposure: object
BsmtFinType1: object
BsmtFinSF1: int64
BsmtFinType2: object
BsmtFinSF2: int64
BsmtUnfSF: int64
TotalBsmtSF: int64
Heating: object
```

```
HeatingQC: object
CentralAir: object
Electrical: object
1stFlrSF: int64
2ndFlrSF: int64
LowQualFinSF: int64
GrLivArea: int64
BsmtFullBath: int64
BsmtHalfBath: int64
FullBath: int64
HalfBath: int64
BedroomAbvGr: int64
KitchenAbvGr: int64
KitchenQual: object
TotRmsAbvGrd: int64
Functional: object
Fireplaces: int64
FireplaceQu: object
GarageType: object
GarageYrBlt: float64
GarageFinish: object
GarageCars: int64
GarageArea: int64
GarageQual: object
GarageCond: object
PavedDrive: object
WoodDeckSF: int64
OpenPorchSF: int64
EnclosedPorch: int64
3SsnPorch: int64
ScreenPorch: int64
PoolArea: int64
PoolQC: object
Fence: object
MiscFeature: object
MiscVal: int64
MoSold: int64
YrSold: int64
SaleType: object
SaleCondition: object
SalePrice: int64
```

Q3 The ML target variable in this dataset is the sale price. We will develop ML pipelines to predict this variable based on the other features.

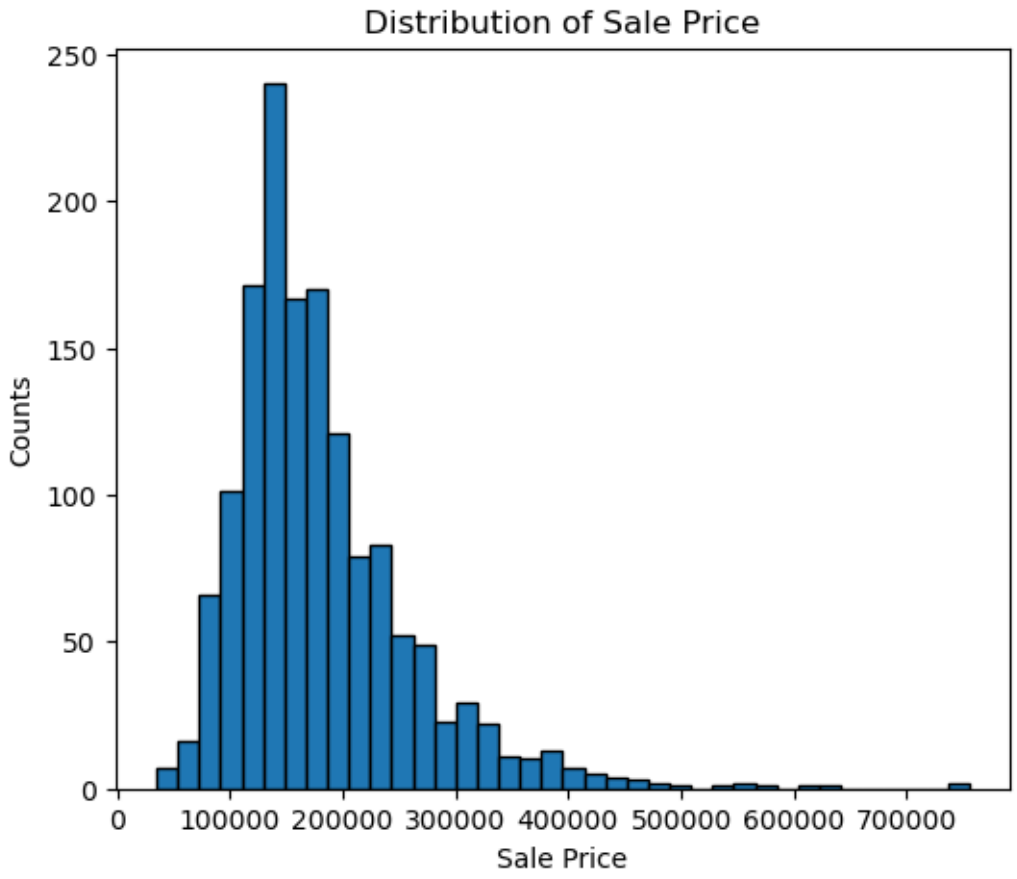
Is this column continuous or categorical? Please use .describe or .value_counts to take a quick look at this feature.

[ ]:
```
# your code here

print(df["SalePrice"].describe())
# 'SalePrice' is countinuous variable
```

```
count      1460.000000
mean     180921.195890
std       79442.502883
min       34900.000000
25%      129975.000000
50%      163000.000000
75%      214000.000000
max      755000.000000
Name: SalePrice, dtype: float64
```

Q4 Visualize the target variable. Don't forget the axis labels and graph title. Make sure to use appropriate arguments to best display the data.

[ ]:
```
# your code here

import matplotlib
from matplotlib import pylab as plt
import numpy as np
# Set the figure size
plt.figure(figsize=(6,5))
# Create the histogram
df['SalePrice'].plot.hist(
    bins = int(np.sqrt(df.shape[0])), # Let bins be the square root of the␣
 ↪number of rows
    edgecolor='black', # Color of the edge of the bars
    linewidth=1 # Width of the edge of the bars
    )
# Add labels and title
plt.xlabel('Sale Price')
plt.ylabel('Counts')
plt.title('Distribution of Sale Price')

plt.show()
```



0.4.2 Problem 1b: visualization (10 points)

Find one continuous, one ordinal, and one categorical feature that strongly correlates with the sale price. Create figures that illustrate your selected features and the sale price.

Don't forget to add axis labels and titles, and find apropriate arguments. Write figure captions to explain what the figure shows.

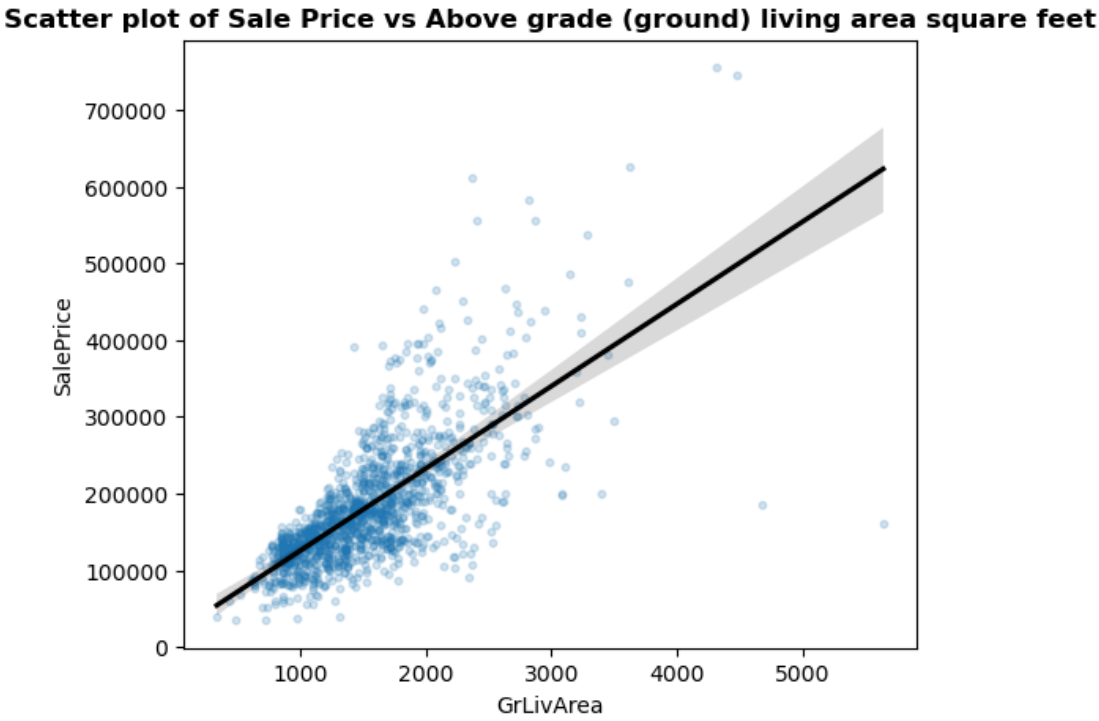
If you know how to quantitatively assess correlation strengths between variables, feel free to use those techniques. Qualitative/visual assessment also works for now.

[ ]:
```
# your code here
import matplotlib.pyplot as plt
import seaborn as sns

# Features that we choose:
# continuous feature : GrLivArea which is Above grade (ground) living area␣
 ↪square feet
# ordinal feature: OverallQual which is Overall material and finish of the house
# categorical feature: Alley which is Type of alley access to property
```

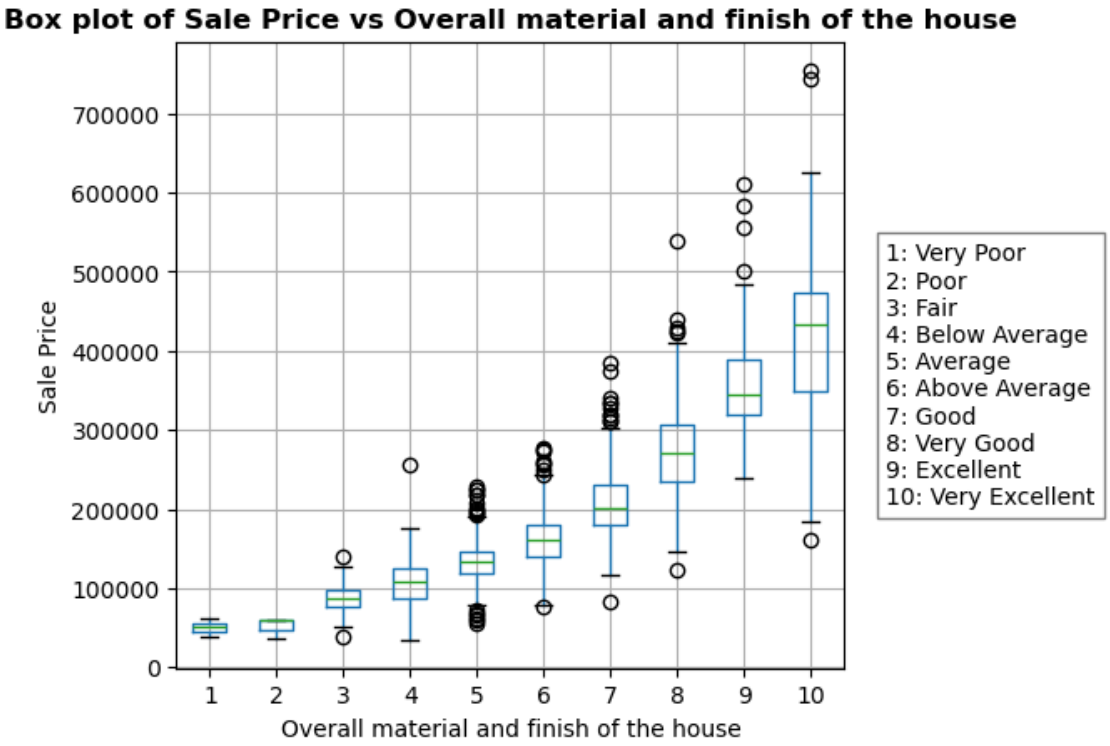
```
# Create a scatter plot for GrLivArea vs SalePrice
df.plot.scatter('GrLivArea','SalePrice',alpha=0.1,s=10, figsize=(6,5))
# Add labels and title
plt.xlabel('Above grade (ground) living area square feet')
plt.ylabel('Sale Price')
plt.title('Scatter plot of Sale Price vs Above grade (ground) living area␣
 ↪square feet',weight='bold')
# Add a regression line
sns.regplot(x='GrLivArea', y='SalePrice', data=df, scatter_kws={'alpha':0.1,␣
 ↪'s':10}, line_kws={'color':'black'})

plt.show()
# Calculate the Pearson correlation coefficient
corr1 = round(df['GrLivArea'].corr(df['SalePrice']),2)

print('The Pearson correlation coefficient between GrLivArea and SalePrice is␣
 ↪'+ str(corr1))
print('Based on the scatter plot and the correlation coefficient, there is a␣
 ↪strong positive linear relationship between GrLivArea and SalePrice. As the␣
 ↪above grade living area increases, the sale price tends to increase as well.
 ↪')
```

```
# Create a dictionary to map the ordinal values to their corresponding labels
cond_labels = {
    1: 'Very Poor',
    2: 'Poor',
    3: 'Fair',
    4: 'Below Average',
    5: 'Average',
    6: 'Above Average',
    7: 'Good',
    8: 'Very Good',
    9: 'Excellent',
    10: 'Very Excellent'}
# Create a box plot for OverallQual vs SalePrice
df[['OverallQual','SalePrice']].boxplot(by='OverallQual',figsize=(5,5))
# Add labels and title
plt.ylabel('Sale Price')
plt.xlabel('Overall material and finish of the house')
```

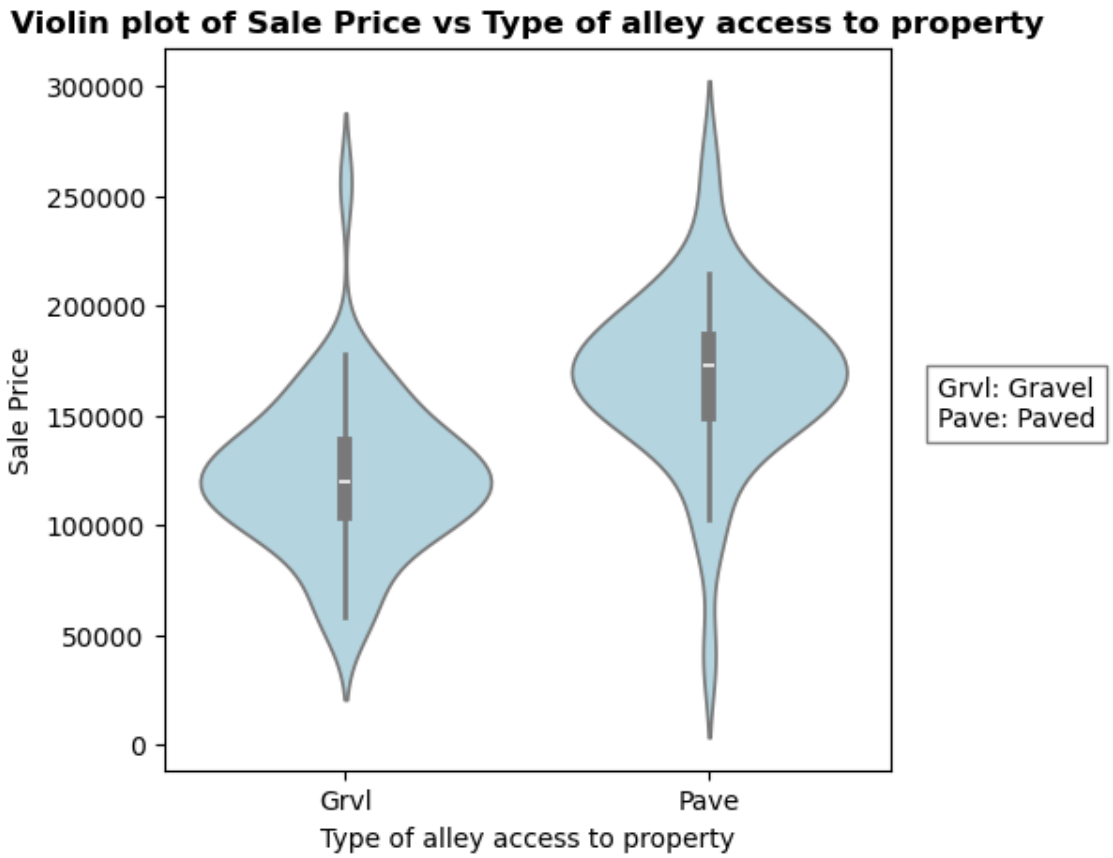
```
plt.title('Box plot of Sale Price vs Overall material and finish of the house',␣
 ↪weight='bold')
# Delete the automatic 'Boxplot grouped by group_by_column' title
plt.suptitle('')
# Add the mapping of ordinal values to their corresponding labels on the right␣
 ↪side of the plot
textstr = '\n'.join([f"{k}: {v}" for k,v in sorted(cond_labels.items())])
plt.gcf().text(0.95, 0.5, textstr, fontsize=10, va='center',␣
 ↪bbox=dict(facecolor='white', alpha=0.5))

plt.show()
# Calculate the Spearman correlation
corr2 = round(df['OverallQual'].corr(df['SalePrice'], method='spearman'),2)

print('The Spearman correlation coefficient between OverallQual and SalePrice␣
 ↪is ' + str(corr2))
print('Based on the box plot and the correlation coefficient, there is a strong␣
 ↪positive monotonic relationship between OverallQual and SalePrice. As the␣
 ↪overall quality of the house increases, the sale price tends to increase as␣
 ↪well.')



# Create a dictionary to map the categorical values to their corresponding␣
 ↪labels
alley_labels = {
    'Grvl':'Gravel',
    'Pave':'Paved'}
# Create a violin plot for Alley vs SalePrice
plt.figure(figsize=(5,5))
sns.violinplot(x='Alley', y='SalePrice', data=df, color='lightblue')
# Add labels and title
plt.ylabel('Sale Price')
plt.xlabel('Type of alley access to property')
plt.title('Violin plot of Sale Price vs Type of alley access to property',␣
 ↪weight='bold')
# Add the mapping of categorical values to their corresponding labels on the␣
 ↪right side of the plot
textstr2 = '\n'.join([f"{k}: {v}" for k,v in sorted(alley_labels.items())])
plt.gcf().text(0.95, 0.5, textstr2, fontsize=10, va='center',␣
 ↪bbox=dict(facecolor='white', alpha=0.5))
plt.show()
print('Based on the violin plot, houses with paved alley access tend to have␣
 ↪higher sale prices compared to those with gravel alley access. The type of␣
 ↪alley access appears to have an impact on the sale price of the house.')
```



The Pearson correlation coefficient between GrLivArea and SalePrice is 0.71
Based on the scatter plot and the correlation coefficient, there is a strong positive linear relationship between GrLivArea and SalePrice. As the above grade living area increases, the sale price tends to increase as well.



The Spearman correlation coefficient between OverallQual and SalePrice is 0.81 Based on the box plot and the correlation coefficient, there is a strong positive monotonic relationship between OverallQual and SalePrice. As the overall quality of the house increases, the sale price tends to increase as well.



Based on the violin plot, houses with paved alley access tend to have higher sale prices compared to those with gravel alley access. The type of alley access appears to have an impact on the sale price of the house.

0.5 Problem 2: basic splitting strategy (15 points)

Write a general function that performs basic splitting on a dataset, while also conducting integrity tests on both its inputs and outputs. The function is called basic_split, it is outlined in the cell below. It takes the following arguments as inputs: feature matrix (X), a target variable (y), train_size, val_size, test_size, and random_state. The output of the function should be: X_train, y_train, X_val, y_val, X_test, y_test, the three sets split according to the train, val, test sizes.

This function is general purpose, you'll be able to reuse it for any project if you want to perform basic split on your data.

[91]:
```
def basic_split(feature_matrix,target_variable,train_size = 0.6,val_size=0.
↪2,test_size=0.2,random_state=42):
    '''
    Split dataframes (feature matrix X and target variable y) into random␣
↪train, validation and test sets
```

```
    Parameters:
    -----------

    feature_matrix: a dataframe that contains your feature matrix
    target_variable: a series that contains your target variable
    train_size: a float between 0.0 and 1.0, it represents the proportion
        of the dataset to include in the training set
    val_size: a float between 0.0 and 1.0, it represents the proportion
        of the dataset to include in the validation set
    test_size: a float between 0.0 and 1.0, it represents the proportion
        of the dataset to include in the test set
    random_state: an int, it controls the shuffling applied to the data
        before applying the split

    NOTE: train_size+val_size+test_size must be equal to 1.

    Returns:
    --------
        a tuple containing the train, validation, and test sets

    Example:
    --------

    >>> import numpy as np
    >>> from sklearn.model_selection import train_test_split
    >>>
    >>> X, y = np.arange(10).reshape((5, 2)), range(5)
    >>>
    >>> X_train, y_train, X_val, y_val, X_test, y_test = basic_split(X,y)

    '''

    # ***************************
    # TODO: test the inputs first
    # ***************************
    # write an if statement to perform each of these checks
    # Important: raise a ValueError with a descriptive error message if␣
↪something is off
    # call basic_split with incorrect arguments to make sure all of the tests␣
↪work as intended!
    import pandas as pd
    import polars as pl

    # test 1: if feature_matrix is not a dataframe (pandas or polars), raise␣
↪ValueError
    if not isinstance(feature_matrix, (pd.DataFrame, pl.DataFrame)):
        raise ValueError("Feature_matrix is not a dataframe (pandas or polars)")
```

```
    # test 2: if the target-variable is not a series (pandas or polars), raise␣
↪ValueError
    if not isinstance(target_variable, (pd.Series, pl.Series)):
        raise ValueError("Target_variable is not a series (pandas or polars)")
    # test 3: if the number of rows in feature_matrix is not equal to the␣
↪length of target_variable, raise a ValueError
    if feature_matrix.shape[0] != len(target_variable):
        raise ValueError("The number of rows in feature_matrix is not equal to␣
↪the length of target_variable")
    # test 4: if train_size is less than 0.0 or larger than 1.0, raise␣
↪ValueError
    if train_size < 0.0 or train_size > 1.0:
        raise ValueError("train_size is less than 0.0 or larger than 1.0")
    # test 5: if val_size is less than 0.0 or larger than 1.0, raise ValueError
    if val_size < 0.0 or val_size > 1.0:
        raise ValueError("val_size is less than 0.0 or larger than 1.0")
    # test 6: if test_size is less than 0.0 or larger than 1.0, raise ValueError
    if test_size < 0.0 or test_size > 1.0:
        raise ValueError("test_size is less than 0.0 or larger than 1.0")
    # test 7: if train_size+val_size+test_size is not equal to 1.0, raise␣
↪ValueError
    if train_size + val_size + test_size != 1.0:
        raise ValueError("train_size+val_size+test_size is not equal to 1.0")
    # test 8: if random state is not an integer, raise ValueError
    if not isinstance(random_state, int):
        raise ValueError("random_state is not an integer")


    # ************************************
    # TODO: implement the splitting strategy
    # ************************************
    # as we discussed in class, use sklearn's train_test_split twice
    from sklearn.model_selection import train_test_split
    X_train, X_other, y_train, y_other = train_test_split(feature_matrix,␣
↪target_variable, train_size=train_size, random_state=random_state)
    X_val, X_test, y_val, y_test = train_test_split(X_other, y_other,␣
↪test_size=test_size/(test_size + val_size), random_state=random_state)


    # **********************
    # TODO: test the outputs
    # **********************
    # same as above, write an if statement to perform each of these checks
    # raise a ValueError with a descriptive error message if something is off.
```

```
    # test 1: the number of rows in X_train divided by the number of rows in X␣
 ↪should be close to train_size
    # think why we sometimes cannot achieve exact equality
    # and how you should express this as a condition in the if statement
    if not abs((X_train.shape[0] / feature_matrix.shape[0]) - train_size) < 0.
 ↪05:
        raise ValueError("The number of rows in X_train divided by the number␣
 ↪of rows in X is not close to train_size")
    # test 2: the number of rows in X_val divided by the number of rows in X␣
 ↪should be close to val_size
    if not abs((X_val.shape[0] / feature_matrix.shape[0]) - val_size) < 0.05:
        raise ValueError("The number of rows in X_val divided by the number of␣
 ↪rows in X is not close to val_size")
    # test 3: the number of rows in X_test divided by the number of rows in X␣
 ↪should be close to test_size
    if not abs((X_test.shape[0] / feature_matrix.shape[0]) - test_size) < 0.05:
        raise ValueError("The number of rows in X_test divided by the number of␣
 ↪rows in X is not close to test_size")
    # test 4: make sure that the length of y_train, y_val, y_test is equal to
    # the number of rows in X_train, X_val, X_test, respectively
    if not (len(y_train) == X_train.shape[0] and len(y_val) == X_val.shape[0]␣
 ↪and len(y_test) == X_test.shape[0]):
        raise ValueError("The length of y_train, y_val, y_test is not equal to␣
 ↪the number of rows in X_train, X_val, X_test, respectively")


    return X_train, y_train, X_val, y_val, X_test, y_test

# Call the function and preform tests here
# test 1: Apply the function to the house price dataset from problem 1 with␣
 ↪train_size = 0.6, val_size = 0.2, and test_size = 0.2.
X = df.drop(columns=['SalePrice'])
y = df['SalePrice']
X_train, y_train, X_val, y_val, X_test, y_test = basic_split(X,y)
# test 2: Print out the head of X_train, X_val, and X_test.
print("Train/Val/Test sizes:", len(X_train), len(X_val), len(X_test))
print("X_train head:\n", X_train.head())
print("X_val head:\n", X_val.head())
print("X_test head:\n", X_test.head())
# test 3: Make sure that you get the same points in each set every time you␣
 ↪rerun the cell (a.k.a., test for reproducability).
X_train1, y_train1, X_val1, y_val1, X_test1, y_test1 = basic_split(X, y)
X_train2, y_train2, X_val2, y_val2, X_test2, y_test2 = basic_split(X, y)
print('Checking reproducibility:')
print('If X_train is the same:', X_train1.equals(X_train2))
print('If y_train is the same:', y_train1.equals(y_train2))
```

```
print('If X_val is the same:', X_val1.equals(X_val2))
print('If y_val is the same:', y_val1.equals(y_val2))
print('If X_test is the same:', X_test1.equals(X_test2))
print('If y_test is the same:', y_test1.equals(y_test2))
# test 4: Try a couple of other train, val, test sizes here. make sure to test␣
 ↪the possible extreme values!
X_train_extrem, y_train_extrem, X_val_extrem, y_val_extrem, X_test_extrem,␣
 ↪y_test_extrem = basic_split(X, y, train_size = 0.8,val_size=0.1,test_size=0.
 ↪1)
X_train_extrem2, y_train_extrem2, X_val_extrem2, y_val_extrem2, X_test_extrem2,␣
 ↪y_test_extrem2 = basic_split(X, y, train_size = 0.9,val_size=0.
 ↪05,test_size=0.05)

# notice how most of the lines in basic_split are about testing the inputs and␣
 ↪outputs and
# testing the inputs ensures that the user correctly calls the function. if␣
 ↪they do not, a descriptive error message is returned.
# testing the outputs ensures that your code correctly performs the intended␣
 ↪operation anticipating edge cases and potential issues.
# this is pretty typical in software engineering and this is the key to writing␣
 ↪reusable code.
```

```
Train/Val/Test sizes: 876 292 292
X_train head:
     MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
314          70       RM         60.0     9600   Pave  Grvl      Reg
442          50       RM         52.0     6240   Pave   NaN      Reg
319          80       RL          NaN    14115   Pave   NaN      Reg
767          50       RL         75.0    12508   Pave   NaN      IR1
756          60       RL         68.0    10769   Pave   NaN      IR1

    LandContour Utilities LotConfig  … ScreenPorch PoolArea PoolQC Fence  \
314         Lvl    AllPub    Inside  …           0        0    NaN   NaN
442         Lvl    AllPub    Inside  …           0        0    NaN   NaN
319         Lvl    AllPub    Inside  …           0        0    NaN   NaN
767         Lvl    AllPub    Inside  …           0        0    NaN   NaN
756         Lvl    AllPub    Inside  …           0        0    NaN   NaN

    MiscFeature MiscVal  MoSold  YrSold  SaleType  SaleCondition
314         NaN       0       8    2006        WD         Normal
442         NaN       0       6    2008        WD         Normal
319         NaN       0       6    2009        WD         Normal
767        Shed    1300       7    2008        WD         Normal
756         NaN       0       4    2009        WD         Normal

[5 rows x 79 columns]
X_val head:
```

```
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
1336          90       RL         87.0     9246   Pave   NaN      IR1
178           20       RL         63.0    17423   Pave   NaN      IR1
619           60       RL         85.0    12244   Pave   NaN      Reg
548           20       RM         49.0     8235   Pave   NaN      IR1
1046          60       RL         85.0    16056   Pave   NaN      IR1

     LandContour Utilities LotConfig  … ScreenPorch PoolArea PoolQC  Fence  \
1336         Lvl    AllPub    Inside  …           0        0    NaN    NaN
178          Lvl    AllPub   CulDSac  …           0        0    NaN    NaN
619          Lvl    AllPub    Inside  …           0        0    NaN    NaN
548          HLS    AllPub    Inside  …           0        0    NaN  MnPrv
1046         Lvl    AllPub    Inside  …           0        0    NaN    NaN

     MiscFeature MiscVal  MoSold  YrSold  SaleType  SaleCondition
1336         NaN       0      11    2008        WD         Normal
178          NaN       0       7    2009       New        Partial
619          NaN       0       8    2008        WD         Normal
548          NaN       0       6    2008        WD         Normal
1046         NaN       0       7    2006       New        Partial

[5 rows x 79 columns]
X_test head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
1290          80       RL          NaN    14112   Pave   NaN      IR1
282          120       RL         34.0     5063   Pave   NaN      Reg
836           30       RM         90.0     8100   Pave  Pave      Reg
594           20       RL         88.0     7990   Pave   NaN      IR1
544           60       RL         58.0    17104   Pave   NaN      IR1

     LandContour Utilities LotConfig  … ScreenPorch PoolArea PoolQC  Fence  \
1290         Lvl    AllPub    Corner  …           0        0    NaN    NaN
282          Lvl    AllPub    Inside  …           0        0    NaN    NaN
836          Lvl    AllPub    Inside  …           0        0    NaN   GdWo
594          Lvl    AllPub    Inside  …           0        0    NaN  MnPrv
544          Lvl    AllPub    Inside  …           0        0    NaN    NaN

     MiscFeature MiscVal  MoSold  YrSold  SaleType  SaleCondition
1290         NaN       0       4    2010        WD         Normal
282          NaN       0       4    2009     ConLw         Normal
836          NaN       0       6    2007       COD         Normal
594          NaN       0       4    2008        WD         Normal
544          NaN       0       9    2006       New        Partial

[5 rows x 79 columns]
Checking reproducibility:
If X_train is the same: True
If y_train is the same: True
```

```
If X_val is the same: True
If y_val is the same: True
If X_test is the same: True
If y_test is the same: True
```

1 Problem 3: kfold splitting (20 points)

Write a function that performs kfold splitting. We provided the input arguments and the header of the function. You need test the inputs, implement the algorithm, and test the outputs.

[ ]:
```
def basic_kfold(feature_matrix,target_variable, k = 5, shuffle = True,␣
↪random_state = 42):
    '''
    Split dataframes (feature matrix X and target variable y) into `k` number␣
↪of equal size folds.
    One fold is used as the test set.
    Iterate over the remaining k-1 folds. Fold i is used as the validation set,
    the remaining folds are used as the training set.

    Parameters:
    -----------

    feature_matrix: a dataframe that contains your feature matrix
    target_variable: a series that contains your target variable
    k: an int, the number of folds
    shuffle: boolean variable. If True, the feature matrix and the target␣
↪variable are shuffled
        before the folds are created to randomize the sets
    random_state: an int, it controls the shuffling applied to the data

    Returns:
    --------
        one test set and a list with `k-1` elements containing tuples of the␣
↪train and validation sets

    >>> import numpy as np
    >>> from sklearn.model_selection import train_test_split
    >>>
    >>> X, y = np.arange(10).reshape((5, 2)), range(5)
    >>>
    >>> X_test, y_test, train_val_sets = basic_kfold(X,y)

    '''
    import pandas as pd
    import polars as pl
    import numpy as np
```

```
    # one of the outputs, it will contain the train and validation sets
    # k-1 train and val -> tuple1(train, val), tuple2(train, val), .....
    # train_val_sets = [(train1, val1) = ((x_train, y_train), (x_val, y_val))
    #                       .....
    #                   (traink-1, valk-1)]
    #
    train_val_sets = []

    # **********************
    # TODO: test the inputs!
    # **********************
    # test each of the input arguments. consider their types and what values␣
↪are possible as you come up with the tests
    # come up with at least 8 tests
    # among other things, consider what the smallest and largest k we can have

    # test 1: if feature_matrix is not a dataframe (pandas or polars), raise␣
↪ValueError
    if not isinstance(feature_matrix, (pd.DataFrame, pl.DataFrame)):
        raise ValueError("Feature_matrix is not a dataframe (pandas or polars)")
    # test 2: if the target-variable is not a series (pandas or polars), raise␣
↪ValueError
    if not isinstance(target_variable, (pd.Series, pl.Series)):
        raise ValueError("Target_variable is not a series (pandas or polars)")
    # test 3: if the number of rows in feature_matrix is not equal to the␣
↪length of target_variable, raise a ValueError
    if feature_matrix.shape[0] != len(target_variable):
        raise ValueError("The number of rows in feature_matrix is not equal to␣
↪the length of target_variable")
    # test 4: if k is not an integer, raise ValueError
    if not isinstance(k, int):
        raise ValueError("k is not an integer")
    # test 5: if shuffle is not a boolean, raise ValueError
    if not isinstance(shuffle, bool):
        raise ValueError("shuffle is not a boolean")
    # test 6: if random_state is not an integer, raise ValueError
    if not isinstance(random_state, int):
        raise ValueError("random_state is not an integer")
    # test 7: if k is less than 3 or larger than the number of rows in␣
↪feature_matrix, raise ValueError
    if k < 3 or k > feature_matrix.shape[0]:
        raise ValueError("k is less than 2 or larger than the number of rows in␣
↪feature_matrix")
    # test 8: if feature_matrix is empty, raise ValueError
    if feature_matrix.shape[0] == 0 or feature_matrix.shape[1] == 0:
        raise ValueError("feature_matrix is empty")
```

```
    # test 9: if target_variable is empty, raise ValueError
    if len(target_variable) == 0:
        raise ValueError("target_variable is empty")



    # ************************************
    # TODO: implement the splitting strategy
    # ************************************
    # you can use numpy, pandas or polars. do not use sklearn here!

    n_samples = len(feature_matrix)

    # Shuffle indices if needed
    indices = np.arange(n_samples)
    if shuffle:
        rng = np.random.default_rng(seed=random_state)
        rng.shuffle(indices)

    # Split indices into k folds
    fold_sizes = [n_samples // k] * k
    for i in range(n_samples % k):
        fold_sizes[i] += 1  # distribute remainder

    folds = []
    start = 0
    for size in fold_sizes:
        folds.append(indices[start:start + size])
        start += size

    # Pick first fold as test set
    test_idx = folds[0]
    X_test = feature_matrix.iloc[test_idx]
    y_test = target_variable.iloc[test_idx]

    # Remaining folds for train/validation
    train_val_folds = folds[1:]

    # Prepare train_val_sets
    train_val_sets = []
    for i, val_idx in enumerate(train_val_folds):
        # validation set
        X_val = feature_matrix.iloc[val_idx]
        y_val = target_variable.iloc[val_idx]
        # training set = all other folds
        other_idx = np.hstack([train_val_folds[j] for j in␣
↪range(len(train_val_folds)) if j != i])
```

```
        X_train = feature_matrix.iloc[other_idx]
        y_train = target_variable.iloc[other_idx]
        # append tuple ((X_train, y_train), (X_val, y_val))
        train_val_sets.append(((X_train, y_train), (X_val, y_val)))


    # **********************
    # TODO: test the outputs!
    # **********************
    # test 1: check whether each point is in exactly one set (no point is␣
↪duplicated and no point is left out)
    # All original sample indices
    all_indices = set(range(len(feature_matrix)))
    # Indices in the test set
    test_indices = set(X_test.index)
    # Indices in all train and validation sets
    train_val_indices = set()
    for train_set, val_set in train_val_sets:
        X_train, y_train = train_set # get train features and labels
        X_val, y_val = val_set # get validation features and labels
        train_val_indices.update(X_train.index) # add train indices
        train_val_indices.update(X_val.index) # add validation indices

    # Check the intersection between test and train/val
    if test_indices & train_val_indices:
        raise ValueError("Some points are duplicated between test and train/
↪validation sets!")

    # Check that all original samples are included
    if all_indices != test_indices.union(train_val_indices):
        raise ValueError("Some points are missing from the output sets!")



    # test 2: check whether you preserve the row-wise alignment between the␣
↪feature matrix and the target variable in each set
    # hint: for row-wise alignment, it may be useful to note that row indices␣
↪do not change when subsetting dfs.
    # i.e. if a row is index id 10 in dataframe 1, it is still given the index␣
↪id of 10 in a subsetted df.
    # Loop over each train/validation fold
    for i, (train_set, val_set) in enumerate(train_val_sets):
        X_train, y_train = train_set # get features and labels for train set
        X_val, y_val = val_set # # get features and labels for validation set
        # Check that row indices match between features and labels in train set
        if not X_train.index.equals(y_train.index):
            raise ValueError(f"Train set row alignment broken in fold {i+1}")
```

```
        # Check that row indices match between features and labels in␣
↪validation set
        if not X_val.index.equals(y_val.index):
            raise ValueError(f"Validation set row alignment broken in fold␣
↪{i+1}")
    # Check that row indices match between features and labels in test set
    if not X_test.index.equals(y_test.index):
        raise ValueError("Test set row alignment broken!")



    # test 3: check whether the order of the columns is the same in each set.
    # We don't check y because y only has 1 column
    # Check train and validation
    # Loop over each train/validation fold
    for i, (train_set, val_set) in enumerate(train_val_sets):
        X_train, _ = train_set # get feature matrix from train set
        X_val, _ = val_set # get feature matrix from validation set
        # Check if train columns match original feature matrix
        if not X_train.columns.equals(feature_matrix.columns):
            raise ValueError(f"Train set column order broken in fold {i+1}")
        # Check if validation columns match original feature matrix
        if not X_val.columns.equals(feature_matrix.columns):
            raise ValueError(f"Validation set column order broken in fold␣
↪{i+1}")

    # Check Test set
    if not X_test.columns.equals(feature_matrix.columns):
        raise ValueError("Test set column order broken!")



    # test 4: perform output tests similar to those in basic_split
    # Check if X_test is Dataframe
    if not isinstance (X_test, (pd.DataFrame,pl.DataFrame)):
        raise ValueError('The output X_test is not a Dataframe')
    # Check if y-test is Series
    if not isinstance(y_test, (pd.Series, pl.Series)):
        raise ValueError('The output y_test is not a Series')
    # Check if train_val_sets is List
    if not isinstance(train_val_sets, list):
        raise ValueError('The output train_val_sets is not a List')


    return X_test, y_test, train_val_sets
```

```
################################################
# TODO: call the function and preform tests here
################################################
# test 1: Apply the function to the house price dataset from problem 1 with 4␣
 ↪folds.
X = df.drop(columns=['SalePrice'])
y = df['SalePrice']
X_test, y_test, train_val_sets = basic_kfold(X,y,k = 4)

# test 2: Print out the head of the sets.
# print the head of test sets
print('Head of X_test:')
print(X_test.head())
print('Head of y_test')
print(y_test.head())
# make for loop to print the head of training and validation sets for every fold
for fold_idx, (train_set, val_set) in enumerate(train_val_sets):
    X_train, y_train = train_set
    X_val, y_val = val_set

    print(f"=== Fold {fold_idx+1} ===")

    print("X_train head:")
    print(X_train.head())

    print("y_train head:")
    print(y_train.head())

    print("X_val head:")
    print(X_val.head())

    print("y_val head:")
    print(y_val.head())

    print("\n")


# test 3: Make sure that you get the same points in each set every time you␣
 ↪rerun the cell (a.k.a., test for reproducability).
X_test1, y_test1, train_val_sets1 = basic_kfold(X, y)
X_test2, y_test2, train_val_sets2 = basic_kfold(X, y)

print('Checking reproducibility:')
print('If X_test is the same:', X_test1.equals(X_test2))
print('If y_test is the same:', y_test1.equals(y_test2))
```

```
# Loop over each fold in two separate runs of k-fold to check reproducibility
for i, ((train1, val1), (train2, val2)) in enumerate(zip(train_val_sets1,␣
 ↪train_val_sets2)):
    X_train1, y_train1 = train1
    X_val1, y_val1 = val1
    X_train2, y_train2 = train2
    X_val2, y_val2 = val2
    if not X_train1.index.equals(X_train2.index) or not y_train1.index.
 ↪equals(y_train2.index):
        raise AssertionError(f"Fold {i+1} train indices differ!")
    if not X_val1.index.equals(X_val2.index) or not y_val1.index.equals(y_val2.
 ↪index):
        raise AssertionError(f"Fold {i+1} validation indices differ!")
print("All train/validation fold indices are same.")


# test 4: Try a couple of other `k` values. test the extreme values!
X_test_extreme, y_test_extreme, train_val_sets_extreme = basic_kfold(X,y,k = 3)
X_test_extreme2, y_test_extreme2, train_val_sets_extreme2 = basic_kfold(X,y,k =␣
 ↪len(y))
```

```
Head of X_test:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
1257          30       RL         56.0     4060   Pave   NaN      Reg
612           60       RL          NaN    11885   Pave   NaN      Reg
1270          40       RL          NaN    23595   Pave   NaN      Reg
1061          30  C (all)        120.0    18000   Grvl   NaN      Reg
184           50       RL         92.0     7438   Pave   NaN      IR1

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
1257         Lvl    AllPub    Corner       Gtl      Edwards      Feedr
612          Lvl    AllPub    Inside       Gtl      CollgCr       Norm
1270         Low    AllPub    Inside       Sev      ClearCr       Norm
1061         Low    AllPub    Inside       Gtl       IDOTRR       Norm
184          Lvl    AllPub    Inside       Gtl      BrkSide       RRAn

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
1257       Norm     1Fam     1Story            5            8       1922
612        Norm     1Fam     2Story            8            5       2001
1270       Norm     1Fam     1Story            7            6       1979
1061       Norm     1Fam     1Story            3            4       1935
184       Feedr     1Fam     1.5Fin            5            8       1908

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
1257          1950     Gable  CompShg     Wd Sdng     Wd Sdng        NaN
612           2001     Gable  CompShg     VinylSd     VinylSd    BrkFace
```

```
1270          1979      Shed  WdShake     Plywood     Plywood        NaN
1061          1950     Gable  CompShg     MetalSd     MetalSd        NaN
184           1991     Gable  CompShg     AsbShng     Plywood        NaN

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
1257         0.0        TA        TA      PConc       Fa       TA
612        108.0        Gd        TA      PConc       Gd       TA
1270         0.0        Gd        TA      PConc       Gd       TA
1061         0.0        Fa        TA     CBlock       TA       TA
184          0.0        TA        TA      PConc       Fa       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
1257           No          Unf           0          Unf           0
612            Av          GLQ         990          Unf           0
1270           Gd          GLQ        1258          Unf           0
1061           No          Unf           0          Unf           0
184            No          Unf           0          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
1257        864          864    GasA        Ex          Y      SBrkr
612         309         1299    GasA        Ex          Y      SBrkr
1270         74         1332    GasA        TA          Y      SBrkr
1061        894          894    GasA        TA          Y      SBrkr
184         504          504    GasA        Gd          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
1257       864         0             0        864             0             0
612       1299       573             0       1872             1             0
1270      1332       192             0       1524             2             0
1061       894         0             0        894             0             0
184        936       316             0       1252             0             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
1257         1         0             2             1          TA
612          2         1             3             1          Ex
1270         0         1             0             1          Gd
1061         1         0             2             1          TA
184          1         0             3             1          TA

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
1257             4        Typ           0         NaN        NaN          NaN
612              7        Typ           1          TA    BuiltIn       2001.0
1270             4        Typ           1          TA     Attchd       1979.0
1061             6        Typ           0         NaN     Detchd       1994.0
184              5        Typ           0         NaN     Attchd       1986.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
1257          NaN           0           0        NaN        NaN          Y
```

```
612           RFn           2         531         TA         TA          Y
1270          Fin           2         586         TA         TA          Y
1061          RFn           3        1248         TA         TA          Y
184           Unf           2         576         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
1257           0           96              0          0            0
612          160          122              0          0            0
1270         268            0              0          0            0
1061           0           20              0          0            0
184          104            0              0          0            0

      PoolArea PoolQC  Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
1257         0    NaN    NaN         NaN        0       7    2009       WD
612          0    NaN    NaN         NaN        0      11    2009       WD
1270         0    NaN    NaN         NaN        0       4    2010       WD
1061         0    NaN    NaN        Shed      560       8    2008    ConLD
184          0    NaN  MnPrv         NaN        0       6    2006       WD

     SaleCondition
1257        Normal
612         Normal
1270        Normal
1061        Normal
184         Normal
Head of y_test
1257     99900
612     261500
1270    260000
1061     81000
184     127000
Name: SalePrice, dtype: int64
=== Fold 1 ===
X_train head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
541           60       RL          NaN    11000   Pave   NaN      Reg
341           20       RH         60.0     8400   Pave   NaN      Reg
1074          20       RL         74.0     8556   Pave   NaN      Reg
521           20       RL         90.0    11988   Pave   NaN      IR1
850          120       RM         36.0     4435   Pave   NaN      Reg

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
541          Lvl    AllPub       FR2       Gtl      NoRidge       Norm
341          Lvl    AllPub    Inside       Gtl      SawyerW      Feedr
1074         Lvl    AllPub    Inside       Gtl      CollgCr       Norm
521          Lvl    AllPub    Corner       Gtl        NAmes      Feedr
850          Lvl    AllPub    Inside       Gtl      CollgCr       Norm
```

```
     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
541        Norm     1Fam     2Story            8            5       2000
341        Norm     1Fam     1Story            4            4       1950
1074       Norm     1Fam     1Story            7            5       2006
521        Norm     1Fam     1Story            6            6       1957
850        Norm   TwnhsE     1Story            6            5       2003

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
541           2000     Gable  CompShg     VinylSd     VinylSd    BrkFace
341           1950     Gable  CompShg     Wd Sdng     AsbShng        NaN
1074          2006     Gable  CompShg     VinylSd     VinylSd        NaN
521           1957     Gable  CompShg     VinylSd     VinylSd        NaN
850           2003     Gable  CompShg     VinylSd     VinylSd    BrkFace

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
541         72.0        Gd        TA      PConc       Gd       TA
341          0.0        Fa        Fa     CBlock       TA       Fa
1074         0.0        Gd        TA      PConc       Gd       TA
521          0.0        TA        TA     CBlock       TA       TA
850        170.0        Gd        TA      PConc       Gd       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
541            No          Unf           0          Unf           0
341            No          Unf           0          Unf           0
1074           Av          Unf           0          Unf           0
521            No          Rec         777          Unf           0
850            Av          GLQ         659          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
541         969          969    GasA        Ex          Y      SBrkr
341         721          721    GasA        Gd          Y      SBrkr
1074       1240         1240    GasA        Ex          Y      SBrkr
521         467         1244    GasA        Ex          Y      FuseA
850         189          848    GasA        Ex          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
541        997      1288             0       2285             0             0
341        841         0             0        841             0             0
1074      1240         0             0       1240             0             0
521       1244         0             0       1244             0             0
850        848         0             0        848             1             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
541          2         1             4             1          Gd
341          1         0             2             1          TA
1074         2         0             2             1          Gd
521          1         1             3             1          TA
850          1         0             1             1          Gd
```

```
      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
541              8        Typ           1          TA    BuiltIn       2000.0
341              4        Typ           0         NaN    CarPort       1950.0
1074             5        Typ           0         NaN     Attchd       2006.0
521              6        Typ           2          Gd     Attchd       1957.0
850              3        Typ           0         NaN     Attchd       2003.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
541           Fin           3         648         TA         TA          Y
341           Unf           1         294         TA         TA          N
1074          RFn           3         826         TA         TA          Y
521           Unf           1         336         TA         TA          Y
850           Fin           2         420         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
541            0           56              0          0            0
341          250            0             24          0            0
1074         140           93              0          0            0
521            0           40              0          0            0
850          140            0              0          0            0

      PoolArea PoolQC Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
541          0    NaN   NaN         NaN        0       6    2007       WD
341          0    NaN   NaN         NaN        0       9    2009       WD
1074         0    NaN   NaN         NaN        0       5    2007       WD
521          0    NaN   NaN         NaN        0       5    2007       WD
850          0    NaN   NaN         NaN        0      11    2007       WD

     SaleCondition
541         Normal
341         Normal
1074        Normal
521         Normal
850         Normal
y_train head:
541     248000
341      82000
1074    194000
521     150000
850     131500
Name: SalePrice, dtype: int64
X_val head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
895           60       RL         71.0     7056   Pave   NaN      Reg
1414          50       RL         64.0    13053   Pave  Pave      Reg
25            20       RL        110.0    14230   Pave   NaN      Reg
0             60       RL         65.0     8450   Pave   NaN      Reg
```

```
959          160       FV         24.0     2572   Pave   NaN      Reg

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
895          Lvl    AllPub    Inside       Gtl        NAmes       Norm
1414         Bnk    AllPub    Inside       Gtl      BrkSide       Norm
25           Lvl    AllPub    Corner       Gtl      NridgHt       Norm
0            Lvl    AllPub    Inside       Gtl      CollgCr       Norm
959          Lvl    AllPub       FR2       Gtl      Somerst       Norm

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
895        Norm     1Fam     2Story            6            5       1963
1414       Norm     1Fam     1.5Fin            6            7       1923
25         Norm     1Fam     1Story            8            5       2007
0          Norm     1Fam     2Story            7            5       2003
959        Norm    Twnhs     2Story            7            5       1999

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
895           1963       Hip  CompShg     HdBoard     HdBoard    BrkFace
1414          2000   Gambrel  CompShg     Wd Sdng     Wd Sdng        NaN
25            2007     Gable  CompShg     VinylSd     VinylSd      Stone
0             2003     Gable  CompShg     VinylSd     VinylSd    BrkFace
959           1999       Hip  CompShg     MetalSd     MetalSd        NaN

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
895        415.0        TA        TA     CBlock       TA       TA
1414         0.0        TA        TA     BrkTil       TA       TA
25         640.0        Gd        TA      PConc       Gd       TA
0          196.0        Gd        TA      PConc       Gd       TA
959          0.0        Gd        TA      PConc       Gd       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
895            No          BLQ         400          Unf           0
1414           No          Unf           0          Unf           0
25             No          Unf           0          Unf           0
0              No          GLQ         706          Unf           0
959            No          ALQ         604          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
895         380          780    GasA        TA          Y      SBrkr
1414        833          833    GasA        Gd          Y      SBrkr
25         1566         1566    GasA        Ex          Y      SBrkr
0           150          856    GasA        Ex          Y      SBrkr
959          92          696    GasA        Ex          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
895        983       813             0       1796             1             0
1414      1053       795             0       1848             0             0
25        1600         0             0       1600             0             0
```

```
0          856       854             0       1710             1             0
959        696       720             0       1416             1             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
895          1         1             4             1          TA
1414         1         1             4             1          Gd
25           2         0             3             1          Gd
0            2         1             3             1          Gd
959          2         1             3             1          Gd

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
895              8        Typ           1          TA     Attchd       1963.0
1414             8        Typ           1          Gd     Detchd       1922.0
25               7        Typ           1          Gd     Attchd       2007.0
0                8        Typ           0         NaN     Attchd       2003.0
959              6        Typ           0         NaN     Detchd       1999.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
895           RFn           2         483         TA         TA          Y
1414          Unf           2         370         TA         TA          N
25            RFn           3         890         TA         TA          Y
0             RFn           2         548         TA         TA          Y
959           Unf           2         484         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
895            0           50              0          0            0
1414           0            0              0          0          220
25             0           56              0          0            0
0              0           61              0          0            0
959            0           44              0          0            0

      PoolArea PoolQC Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
895          0    NaN   NaN         NaN        0      10    2008       WD
1414         0    NaN   NaN         NaN        0       6    2008       WD
25           0    NaN   NaN         NaN        0       7    2009       WD
0            0    NaN   NaN         NaN        0       2    2008       WD
959          0    NaN   NaN         NaN        0       5    2010       WD

     SaleCondition
895         Normal
1414        Normal
25          Normal
0           Normal
959         Normal
y_val head:
895     140000
1414    207000
25      256300
```

```
0       208500
959     155000
Name: SalePrice, dtype: int64


=== Fold 2 ===
X_train head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
895           60       RL         71.0     7056   Pave   NaN      Reg
1414          50       RL         64.0    13053   Pave  Pave      Reg
25            20       RL        110.0    14230   Pave   NaN      Reg
0             60       RL         65.0     8450   Pave   NaN      Reg
959          160       FV         24.0     2572   Pave   NaN      Reg

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
895          Lvl    AllPub    Inside       Gtl        NAmes       Norm
1414         Bnk    AllPub    Inside       Gtl      BrkSide       Norm
25           Lvl    AllPub    Corner       Gtl      NridgHt       Norm
0            Lvl    AllPub    Inside       Gtl      CollgCr       Norm
959          Lvl    AllPub       FR2       Gtl      Somerst       Norm

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
895        Norm     1Fam     2Story            6            5       1963
1414       Norm     1Fam     1.5Fin            6            7       1923
25         Norm     1Fam     1Story            8            5       2007
0          Norm     1Fam     2Story            7            5       2003
959        Norm    Twnhs     2Story            7            5       1999

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
895           1963       Hip  CompShg     HdBoard     HdBoard    BrkFace
1414          2000   Gambrel  CompShg     Wd Sdng     Wd Sdng        NaN
25            2007     Gable  CompShg     VinylSd     VinylSd      Stone
0             2003     Gable  CompShg     VinylSd     VinylSd    BrkFace
959           1999       Hip  CompShg     MetalSd     MetalSd        NaN

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
895        415.0        TA        TA     CBlock       TA       TA
1414         0.0        TA        TA     BrkTil       TA       TA
25         640.0        Gd        TA      PConc       Gd       TA
0          196.0        Gd        TA      PConc       Gd       TA
959          0.0        Gd        TA      PConc       Gd       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
895            No          BLQ         400          Unf           0
1414           No          Unf           0          Unf           0
25             No          Unf           0          Unf           0
0              No          GLQ         706          Unf           0
959            No          ALQ         604          Unf           0
```

```
      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
895         380          780    GasA        TA          Y      SBrkr
1414        833          833    GasA        Gd          Y      SBrkr
25         1566         1566    GasA        Ex          Y      SBrkr
0           150          856    GasA        Ex          Y      SBrkr
959          92          696    GasA        Ex          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
895        983       813             0       1796             1             0
1414      1053       795             0       1848             0             0
25        1600         0             0       1600             0             0
0          856       854             0       1710             1             0
959        696       720             0       1416             1             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
895          1         1             4             1          TA
1414         1         1             4             1          Gd
25           2         0             3             1          Gd
0            2         1             3             1          Gd
959          2         1             3             1          Gd

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
895              8        Typ           1          TA     Attchd       1963.0
1414             8        Typ           1          Gd     Detchd       1922.0
25               7        Typ           1          Gd     Attchd       2007.0
0                8        Typ           0         NaN     Attchd       2003.0
959              6        Typ           0         NaN     Detchd       1999.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
895           RFn           2         483         TA         TA          Y
1414          Unf           2         370         TA         TA          N
25            RFn           3         890         TA         TA          Y
0             RFn           2         548         TA         TA          Y
959           Unf           2         484         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
895            0           50              0          0            0
1414           0            0              0          0          220
25             0           56              0          0            0
0              0           61              0          0            0
959            0           44              0          0            0

      PoolArea PoolQC Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
895          0    NaN   NaN         NaN        0      10    2008       WD
1414         0    NaN   NaN         NaN        0       6    2008       WD
25           0    NaN   NaN         NaN        0       7    2009       WD
0            0    NaN   NaN         NaN        0       2    2008       WD
```

```
959          0    NaN   NaN         NaN        0       5    2010       WD

     SaleCondition
895         Normal
1414        Normal
25          Normal
0           Normal
959         Normal
y_train head:
895     140000
1414    207000
25      256300
0       208500
959     155000
Name: SalePrice, dtype: int64
X_val head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
541           60       RL          NaN    11000   Pave   NaN      Reg
341           20       RH         60.0     8400   Pave   NaN      Reg
1074          20       RL         74.0     8556   Pave   NaN      Reg
521           20       RL         90.0    11988   Pave   NaN      IR1
850          120       RM         36.0     4435   Pave   NaN      Reg

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
541          Lvl    AllPub       FR2       Gtl      NoRidge       Norm
341          Lvl    AllPub    Inside       Gtl      SawyerW      Feedr
1074         Lvl    AllPub    Inside       Gtl      CollgCr       Norm
521          Lvl    AllPub    Corner       Gtl        NAmes      Feedr
850          Lvl    AllPub    Inside       Gtl      CollgCr       Norm

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
541        Norm     1Fam     2Story            8            5       2000
341        Norm     1Fam     1Story            4            4       1950
1074       Norm     1Fam     1Story            7            5       2006
521        Norm     1Fam     1Story            6            6       1957
850        Norm   TwnhsE     1Story            6            5       2003

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
541           2000     Gable  CompShg     VinylSd     VinylSd    BrkFace
341           1950     Gable  CompShg     Wd Sdng     AsbShng        NaN
1074          2006     Gable  CompShg     VinylSd     VinylSd        NaN
521           1957     Gable  CompShg     VinylSd     VinylSd        NaN
850           2003     Gable  CompShg     VinylSd     VinylSd    BrkFace

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
541         72.0        Gd        TA      PConc       Gd       TA
341          0.0        Fa        Fa     CBlock       TA       Fa
1074         0.0        Gd        TA      PConc       Gd       TA
```

```
521          0.0        TA        TA     CBlock       TA       TA
850        170.0        Gd        TA      PConc       Gd       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
541            No          Unf           0          Unf           0
341            No          Unf           0          Unf           0
1074           Av          Unf           0          Unf           0
521            No          Rec         777          Unf           0
850            Av          GLQ         659          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
541         969          969    GasA        Ex          Y      SBrkr
341         721          721    GasA        Gd          Y      SBrkr
1074       1240         1240    GasA        Ex          Y      SBrkr
521         467         1244    GasA        Ex          Y      FuseA
850         189          848    GasA        Ex          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
541        997      1288             0       2285             0             0
341        841         0             0        841             0             0
1074      1240         0             0       1240             0             0
521       1244         0             0       1244             0             0
850        848         0             0        848             1             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
541          2         1             4             1          Gd
341          1         0             2             1          TA
1074         2         0             2             1          Gd
521          1         1             3             1          TA
850          1         0             1             1          Gd

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
541              8        Typ           1          TA    BuiltIn       2000.0
341              4        Typ           0         NaN    CarPort       1950.0
1074             5        Typ           0         NaN     Attchd       2006.0
521              6        Typ           2          Gd     Attchd       1957.0
850              3        Typ           0         NaN     Attchd       2003.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
541           Fin           3         648         TA         TA          Y
341           Unf           1         294         TA         TA          N
1074          RFn           3         826         TA         TA          Y
521           Unf           1         336         TA         TA          Y
850           Fin           2         420         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
541            0           56              0          0            0
341          250            0             24          0            0
```

```
1074         140           93              0          0            0
521            0           40              0          0            0
850          140            0              0          0            0

      PoolArea PoolQC Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
541          0    NaN   NaN         NaN        0       6    2007       WD
341          0    NaN   NaN         NaN        0       9    2009       WD
1074         0    NaN   NaN         NaN        0       5    2007       WD
521          0    NaN   NaN         NaN        0       5    2007       WD
850          0    NaN   NaN         NaN        0      11    2007       WD

     SaleCondition
541         Normal
341         Normal
1074        Normal
521         Normal
850         Normal
y_val head:
541     248000
341      82000
1074    194000
521     150000
850     131500
Name: SalePrice, dtype: int64


=== Fold 3 ===
X_train head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
895           60       RL         71.0     7056   Pave   NaN      Reg
1414          50       RL         64.0    13053   Pave  Pave      Reg
25            20       RL        110.0    14230   Pave   NaN      Reg
0             60       RL         65.0     8450   Pave   NaN      Reg
959          160       FV         24.0     2572   Pave   NaN      Reg

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
895          Lvl    AllPub    Inside       Gtl        NAmes       Norm
1414         Bnk    AllPub    Inside       Gtl      BrkSide       Norm
25           Lvl    AllPub    Corner       Gtl      NridgHt       Norm
0            Lvl    AllPub    Inside       Gtl      CollgCr       Norm
959          Lvl    AllPub       FR2       Gtl      Somerst       Norm

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
895        Norm     1Fam     2Story            6            5       1963
1414       Norm     1Fam     1.5Fin            6            7       1923
25         Norm     1Fam     1Story            8            5       2007
0          Norm     1Fam     2Story            7            5       2003
959        Norm    Twnhs     2Story            7            5       1999
```

```
      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
895           1963       Hip  CompShg     HdBoard     HdBoard    BrkFace
1414          2000   Gambrel  CompShg     Wd Sdng     Wd Sdng        NaN
25            2007     Gable  CompShg     VinylSd     VinylSd      Stone
0             2003     Gable  CompShg     VinylSd     VinylSd    BrkFace
959           1999       Hip  CompShg     MetalSd     MetalSd        NaN

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
895        415.0        TA        TA     CBlock       TA       TA
1414         0.0        TA        TA     BrkTil       TA       TA
25         640.0        Gd        TA      PConc       Gd       TA
0          196.0        Gd        TA      PConc       Gd       TA
959          0.0        Gd        TA      PConc       Gd       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
895            No          BLQ         400          Unf           0
1414           No          Unf           0          Unf           0
25             No          Unf           0          Unf           0
0              No          GLQ         706          Unf           0
959            No          ALQ         604          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
895         380          780    GasA        TA          Y      SBrkr
1414        833          833    GasA        Gd          Y      SBrkr
25         1566         1566    GasA        Ex          Y      SBrkr
0           150          856    GasA        Ex          Y      SBrkr
959          92          696    GasA        Ex          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
895        983       813             0       1796             1             0
1414      1053       795             0       1848             0             0
25        1600         0             0       1600             0             0
0          856       854             0       1710             1             0
959        696       720             0       1416             1             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
895          1         1             4             1          TA
1414         1         1             4             1          Gd
25           2         0             3             1          Gd
0            2         1             3             1          Gd
959          2         1             3             1          Gd

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
895              8        Typ           1          TA     Attchd       1963.0
1414             8        Typ           1          Gd     Detchd       1922.0
25               7        Typ           1          Gd     Attchd       2007.0
0                8        Typ           0         NaN     Attchd       2003.0
```

```
959              6        Typ           0         NaN     Detchd       1999.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
895           RFn           2         483         TA         TA          Y
1414          Unf           2         370         TA         TA          N
25            RFn           3         890         TA         TA          Y
0             RFn           2         548         TA         TA          Y
959           Unf           2         484         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
895            0           50              0          0            0
1414           0            0              0          0          220
25             0           56              0          0            0
0              0           61              0          0            0
959            0           44              0          0            0

      PoolArea PoolQC Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
895          0    NaN   NaN         NaN        0      10    2008       WD
1414         0    NaN   NaN         NaN        0       6    2008       WD
25           0    NaN   NaN         NaN        0       7    2009       WD
0            0    NaN   NaN         NaN        0       2    2008       WD
959          0    NaN   NaN         NaN        0       5    2010       WD

     SaleCondition
895         Normal
1414        Normal
25          Normal
0           Normal
959         Normal
y_train head:
895     140000
1414    207000
25      256300
0       208500
959     155000
Name: SalePrice, dtype: int64
X_val head:
      MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
1441         120       RM          NaN     4426   Pave   NaN      Reg
1217          20       FV         72.0     8640   Pave   NaN      Reg
869           60       RL         80.0     9938   Pave   NaN      Reg
855           20       RL          NaN     6897   Pave   NaN      IR1
178           20       RL         63.0    17423   Pave   NaN      IR1

     LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
1441         Lvl    AllPub    Inside       Gtl      CollgCr       Norm
1217         Lvl    AllPub    Inside       Gtl      Somerst       Norm
869          Lvl    AllPub    Inside       Gtl      SawyerW       Norm
```

```
855          Lvl    AllPub    Corner       Gtl       Sawyer       Norm
178          Lvl    AllPub   CulDSac       Gtl      StoneBr       Norm

     Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
1441       Norm   TwnhsE     1Story            6            5       2004
1217       Norm     1Fam     1Story            8            5       2009
869        Norm     1Fam     2Story            7            5       1993
855        Norm     1Fam     1Story            5            8       1962
178        Norm     1Fam     1Story            9            5       2008

      YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
1441          2004     Gable  CompShg     VinylSd     VinylSd    BrkFace
1217          2009     Gable  CompShg     CemntBd     CmentBd      Stone
869           1994     Gable  CompShg     MetalSd     MetalSd    BrkFace
855           2010     Gable  CompShg     HdBoard     HdBoard        NaN
178           2009       Hip  CompShg     VinylSd     VinylSd      Stone

      MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond  \
1441       147.0        Gd        TA      PConc       Gd       TA
1217        72.0        Gd        TA      PConc       Gd       TA
869        246.0        Gd        TA      PConc       Gd       TA
855          0.0        TA        Gd     CBlock       TA       TA
178        748.0        Ex        TA      PConc       Ex       TA

     BsmtExposure BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  \
1441           Av          GLQ         697          Unf           0
1217           Mn          GLQ         936          Unf           0
869            No          GLQ         750          Unf           0
855            No          ALQ         659          Unf           0
178            No          GLQ        1904          Unf           0

      BsmtUnfSF  TotalBsmtSF Heating HeatingQC CentralAir Electrical  \
1441        151          848    GasA        Ex          Y      SBrkr
1217        364         1300    GasA        Ex          Y      SBrkr
869         300         1050    GasA        Ex          Y      SBrkr
855         381         1040    GasA        Ex          Y      SBrkr
178         312         2216    GasA        Ex          Y      SBrkr

      1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  BsmtHalfBath  \
1441       848         0             0        848             1             0
1217      1314         0             0       1314             1             0
869       1062       887             0       1949             1             0
855       1040         0             0       1040             1             0
178       2234         0             0       2234             1             0

      FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr KitchenQual  \
1441         1         0             1             1          Gd
1217         2         0             3             1          Gd
```

```
869          2         1             3             1          Gd
855          1         1             3             1          TA
178          2         0             1             1          Ex

      TotRmsAbvGrd Functional  Fireplaces FireplaceQu GarageType  GarageYrBlt  \
1441             3        Typ           1          TA     Attchd       2004.0
1217             6        Typ           0         NaN     Attchd       2009.0
869              8        Typ           1          TA     Attchd       1993.0
855              6        Typ           0         NaN     Detchd       1962.0
178              9        Typ           1          Gd     Attchd       2009.0

     GarageFinish  GarageCars  GarageArea GarageQual GarageCond PavedDrive  \
1441          RFn           2         420         TA         TA          Y
1217          RFn           2         552         TA         TA          Y
869           Fin           2         574         TA         TA          Y
855           Unf           1         260         TA         TA          Y
178           Fin           3        1166         TA         TA          Y

      WoodDeckSF  OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  \
1441         149            0              0          0            0
1217         135          112              0          0            0
869          156           90              0          0            0
855            0          104              0          0            0
178            0           60              0          0            0

      PoolArea PoolQC  Fence MiscFeature  MiscVal  MoSold  YrSold SaleType  \
1441         0    NaN    NaN         NaN        0       5    2008       WD
1217         0    NaN    NaN         NaN        0       9    2009      New
869          0    NaN  GdPrv         NaN        0       6    2010       WD
855          0    NaN    NaN         NaN        0       4    2010       WD
178          0    NaN    NaN         NaN        0       7    2009      New

     SaleCondition
1441        Normal
1217       Partial
869         Normal
855         Normal
178        Partial
y_val head:
1441    149300
1217    229456
869     236000
855     127000
178     501837
Name: SalePrice, dtype: int64


Checking reproducibility:
```

```
If X_test is the same: True
If y_test is the same: True
All train/validation fold indices are same.
```