Application: Model

Case study: Houses for sale

In this tutorial, we will build a model with the Python `scikit-learn` module. Additionally, you will learn how to create a data preprocessing pipline.

Setup

In [1]:

```
%matplotlib inline

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

sns.set_theme(style="ticks", color_codes=True)
```

Data preparation

See notebook `10a-application-model-data-exploration.ipynb` for details about data preprocessing and data exploration.

In [2]:

```
ROOT = "https://raw.githubusercontent.com/kirenz/modern-statistics/main/data/"
DATA = "duke-forest.csv"
df = pd.read_csv(ROOT + DATA)

# Drop irrelevant features
df = df.drop(['url', 'address', 'type'], axis=1)

# Convert data types
df['heating'] = df['heating'].astype("category")
df['cooling'] = df['cooling'].astype("category")
df['parking'] = df['parking'].astype("category")

# drop column with too many missing values
df = df.drop(['hoa'], axis=1)

df.columns.tolist()
```

Out[2]:

```
['price',
 'bed',
 'bath',
 'area',
 'year_built',
 'heating',
 'cooling',
 'parking',
 'lot']
```

Creation of data preprocessing pipeline

In [3]:

```python
from sklearn.compose import ColumnTransformer
from sklearn.compose import make_column_selector as selector
from sklearn.pipeline import Pipeline
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler, OneHotEncoder

# Data preprocessing pipeline

# for numeric features
numeric_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='median')),
    ('scaler', StandardScaler())
    ])

# for categorical features
categorical_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='constant', fill_value='missing')),
    ('onehot', OneHotEncoder(handle_unknown='ignore'))
    ])

# Pipeline
preprocessor = ColumnTransformer(transformers=[
    ('num', numeric_transformer, selector(dtype_exclude="category")),
    ('cat', categorical_transformer, selector(dtype_include="category"))
        ])
```

Simple regression

In [4]:

```
# Select features for simple regression
features = ['area']
X = df[features]

X.info()
print("Missing values:",X.isnull().any(axis = 1).sum())

# Create response
y = df["price"]
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 98 entries, 0 to 97
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   area    98 non-null     int64
dtypes: int64(1)
memory usage: 912.0 bytes
Missing values: 0
```

Data splitting

In [5]:

```
from sklearn.model_selection import train_test_split

# Train Test Split
# Use random_state to make this notebook's output identical at every run
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

Modeling

In [6]:

```
from sklearn.linear_model import LinearRegression

# Create pipeline with model
lm_pipe = Pipeline(steps=[
    ('preprocessor', preprocessor),
    ('lm', LinearRegression())
                        ])
```

In [7]:

```
# Fit model
lm_pipe.fit(X_train, y_train)
```

Out[7]:

```
Pipeline(steps=[('preprocessor',
                 ColumnTransforme
rs=[('num',

Pipeline(steps=[('imputer',

SimpleImputer(strategy='median')),

('scaler',

StandardScaler())]),

<sklearn.compose._column_transformer.make_col
umn_selector object at 0x7fd0a0a09f40>),
('cat',

Pipeline(steps=[('imputer',

SimpleImputer(fill_value='missing',

strategy='constant')),

('onehot',

OneHotEncoder(handle_unknown='ignore'))]),

<sklearn.compose._column_transformer.make_col
umn_selector object at 0x7fd0a0a09dc0>)])),
               ('lm', LinearRegression())])
```

In [8]:

```
# Obtain model coefficients
lm_pipe.named_steps['lm'].coef_
```

Out[8]:

```
array([155120.6689059])
```

Evaluation with training data

In [9]:

```
y_pred = lm_pipe.predict(X_train)
```

In [10]:

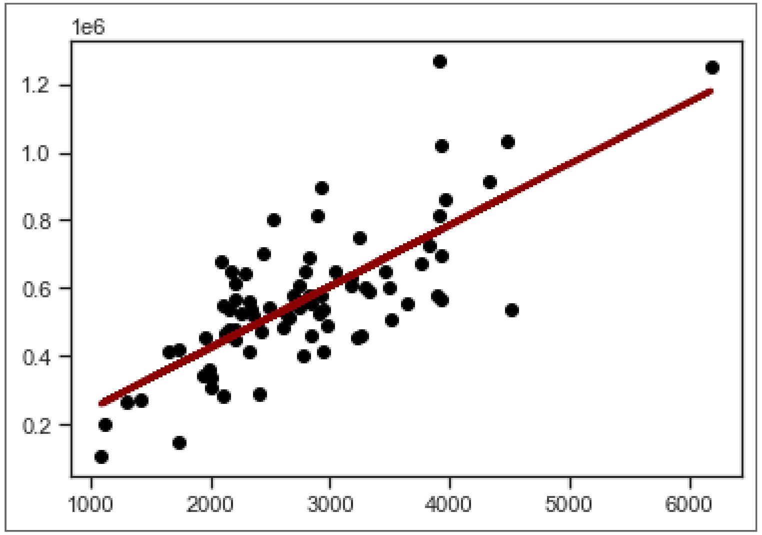
```
from sklearn.metrics import r2_score

r2_score(y_train, y_pred)
```

Out[10]:

```
0.5560009346032928
```

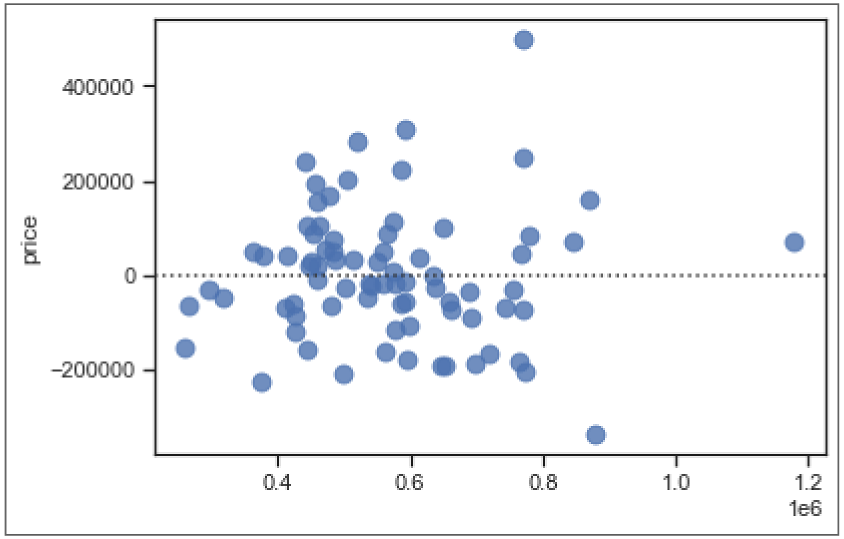
In [11]:

```
# Plot outputs
plt.scatter(X_train, y_train,  color='black')
plt.plot(X_train, y_pred, color='darkred', linewidth=3);
```



In [12]:

```
sns.residplot(x=y_pred, y=y_train, scatter_kws={"s": 80});
```



Multiple regression

In [13]:

```
# Select features for multiple regression
features= [
 'bed',
 'bath',
 'area',
 'year_built',
 'cooling',
 'lot'
  ]
X = df[features]

X.info()
print("Missing values:",X.isnull().any(axis = 1).sum())

# Create response
y = df["price"]
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 98 entries, 0 to 97
Data columns (total 6 columns):
 #   Column      Non-Null Count  Dtype  
---  ------      --------------  -----  
 0   bed         98 non-null     int64  
 1   bath        98 non-null     float64
 2   area        98 non-null     int64  
 3   year_built  98 non-null     int64
 4   cooling     98 non-null     category
 5   lot         97 non-null     float64
dtypes: category(1), float64(2), int64(3)
memory usage: 4.2 KB
Missing values: 1
```

In [14]:

```
# Data splitting
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

In [15]:

```
# Create pipeline with model
lm_pipe = Pipeline(steps=[
    ('preprocessor', preprocessor),
    ('lm', LinearRegression())
                   ])

# Fit model
lm_pipe.fit(X_train, y_train)
```

Out[15]:

```
Pipeline(steps=[('preprocessor',
                 ColumnTransformer(transforme
rs=[('num',

Pipeline(steps=[('imputer',

SimpleImputer(strategy='median')),

('scaler',

StandardScaler())]),
<sklearn.compose._column_transformer.make_col
umn_selector object at 0x7fd0a0a09f40>),

('cat',

Pipeline(steps=[('imputer',

SimpleImputer(fill_value='missing',

strategy='constant')),

('onehot',

OneHotEncoder(handle_unknown='ignore'))]),

<sklearn.compose._column_transformer.make_col
umn_selector object at 0x7fd0a0a09dc0>)])),
                ('lm', LinearRegression())])
```

In [16]:

```
# Obtain model coefficients
lm_pipe.named_steps['lm'].coef_
```

Out[16]:

```
array([  2447.57967471,  50670.93485383,  864
99.75206383,  20145.48540648,
        64856.29369518,  25401.84101108, -254
01.84101108])
```

In [17]:

```
y_pred = lm_pipe.predict(X_train)
```

In [18]:

```
r2_score(y_train, y_pred)
```

Out[18]:

```
0.693677282935018
```