Lecture 7
Encoding Categorical Variables as Quantitative

Dennis Sun
Stanford University

DATASCI 112

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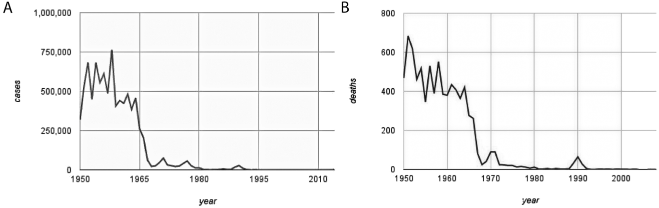
US measles cases (Panel A) and deaths (Panel B) since 1950



(Source: US Centers for Disease Control and Prevention)

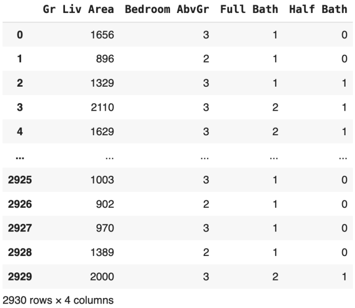
1. Motivation

2. Encoding Categorical Variables

3. Column Transformations in Scikit-Learn

Review

```
features = ["Gr Liv Area", "Bedroom AbvGr", "Full Bath", "Half Bath"]
df[features]
```



	Gr Liv Area	Bedroom AbvGr	Full Bath	Half Bath
0	1656	3	1	0
1	896	2	1	0
2	1329	3	1	1
3	2110	3	2	1
4	1629	3	2	1
...	...	...	...	...
2925	1003	3	1	0
2926	902	2	1	0
2927	970	3	1	0
2928	1389	2	1	0
2929	2000	3	2	1

2930 rows × 4 columns

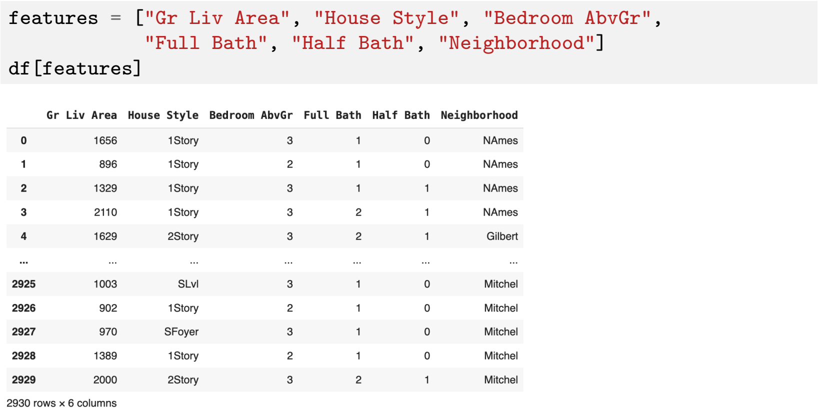
We might want to scale the variables first!

Last class, we discussed how to measure the distance between two observations $\mathbf{x}$ and $\mathbf{x}'$.

For example, we can calculate the Euclidean (ℓ_2) distance:

$$d(\mathbf{x}, \mathbf{x}') = \sqrt{\sum_{j=1}^{m} (x_j - x'_j)^2}.$$

What if there are categorical variables?



```python
features = ["Gr Liv Area", "House Style", "Bedroom AbvGr",
            "Full Bath", "Half Bath", "Neighborhood"]
df[features]
```

	Gr Liv Area	House Style	Bedroom AbvGr	Full Bath	Half Bath	Neighborhood
0	1656	1Story	3	1	0	NAmes
1	896	1Story	2	1	0	NAmes
2	1329	1Story	3	1	1	NAmes
3	2110	1Story	3	2	1	NAmes
4	1629	2Story	3	2	1	Gilbert
...	...	...	...	...	...	...
2925	1003	SLvl	3	1	0	Mitchel
2926	902	1Story	2	1	0	Mitchel
2927	970	SFoyer	3	1	0	Mitchel
2928	1389	1Story	2	1	0	Mitchel
2929	2000	2Story	3	2	1	Mitchel

2930 rows × 6 columns

If we want to calculate distances, we need to convert the categorical variables into quantitative variables first!

1. Motivation

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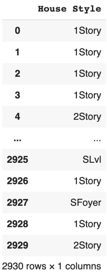
Encoding Categorical Variables as Quantitative

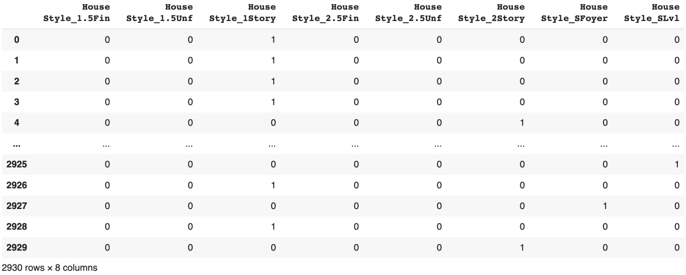
There is a standard way to encode a categorical variable as a quantitative variable: **dummy encoding** or **one-hot encoding**.



	House Style
0	1Story
1	1Story
2	1Story
3	1Story
4	2Story
...	...
2925	SLvl
2926	1Story
2927	SFoyer
2928	1Story
2929	2Story

2930 rows × 1 columns

$\Longrightarrow$



	House Style_1.5Fin	House Style_1.5Unf	House Style_1Story	House Style_2.5Fin	House Style_2.5Unf	House Style_2Story	House Style_SFoyer	House Style_SLvl
0	0	0	1	0	0	0	0	0
1	0	0	1	0	0	0	0	0
2	0	0	1	0	0	0	0	0
3	0	0	1	0	0	0	0	0
4	0	0	0	0	0	1	0	0
...	...	...	...	...	...	...	...	...
2925	0	0	0	0	0	0	0	1
2926	0	0	1	0	0	0	0	0
2927	0	0	0	0	0	0	1	0
2928	0	0	1	0	0	0	0	0
2929	0	0	0	0	0	1	0	0

2930 rows × 8 columns

- Each class gets its own column.
- Each column consists of 0s and 1s. A 1 indicates that the observation was in that class.

1. How many 1s are in each row?
2. How many 1s are in each column?

Dummy Encoding in Pandas

Let's go into Colab to learn how to do dummy encoding in Pandas.

1 Motivation

2 Encoding Categorical Variables

3 Column Transformations in Scikit-Learn

Dummy Encoding in Scikit-Learn

We can do dummy encoding in Scikit-Learn using `OneHotEncoder`.

```python
from sklearn.preprocessing import OneHotEncoder

# declare the encoder
enc = OneHotEncoder()

# fit the encoder to data
enc.fit(df[["House Style"]])

# transform the data
enc.transform(df[["House Style"]])
```

```
<2930x8 sparse matrix of type '<class 'numpy.float64'>'
        with 2930 stored elements in Compressed Sparse Row format>
```

Huh, what's a "sparse matrix"?

Dummy Encoding in Scikit-Learn

We can cast a sparse matrix to a “dense” one using `.todense()`…

…or specify that we don’t want a sparse matrix to begin with.

```
from sklearn.preprocessing import OneHotEncoder

# declare the encoder
enc = OneHotEncoder(sparse_output=False)

# fit the encoder to data
enc.fit(df[["House Style"]])

# transform the data
enc.transform(df[["House Style"]])
```

```
array([[0., 0., 1., ..., 0., 0., 0.],
       [0., 0., 1., ..., 0., 0., 0.],
       [0., 0., 1., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 1., ..., 0., 0., 0.],
       [0., 0., 0., ..., 1., 0., 0.]])
```

Mixed Variables in Scikit-Learn

What if we have a mix of quantitative and categorical variables, and we only want to dummy encode the categorical ones?

We make a `ColumnTransformer`.

```python
from sklearn.compose import make_column_transformer

transformer = make_column_transformer(
    (OneHotEncoder(), ["House Style", "Neighborhood"]),
    remainder="passthrough")
transformer.fit(df[features])
transformer.transform(df[features])
```

```
<2930x40 sparse matrix of type '<class 'numpy.float64'>'
        with 15717 stored elements in Compressed Sparse Row format>
```

Mixed Variables in Scikit-Learn

What if we have a mix of quantitative and categorical variables, and we only want to dummy encode the categorical ones?

We make a `ColumnTransformer`.

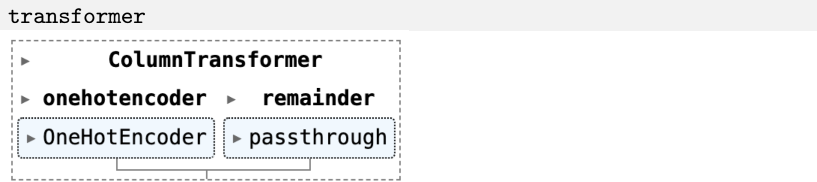
```
from sklearn.compose import make_column_transformer

transformer = make_column_transformer(
    (OneHotEncoder(sparse_output=False), ["House Style",
                                          "Neighborhood"]),
    remainder="passthrough")
transformer.fit(df[features])
transformer.transform(df[features])
```

```
array([[0., 0., 1., ..., 3., 1., 0.],
       [0., 0., 1., ..., 2., 1., 0.],
       [0., 0., 1., ..., 3., 1., 1.],
       ...,
       [0., 0., 0., ..., 3., 1., 0.],
       [0., 0., 1., ..., 2., 1., 0.],
       [0., 0., 0., ..., 3., 2., 1.]])
```

Visualizing a `ColumnTransformer`

Scikit-Learn provides a nice visualization of a `ColumnTransformer`.



```
transformer
```

Scaling and Encoding in Scikit-Learn

We can mix scalers and encoders with `ColumnTransformer`!

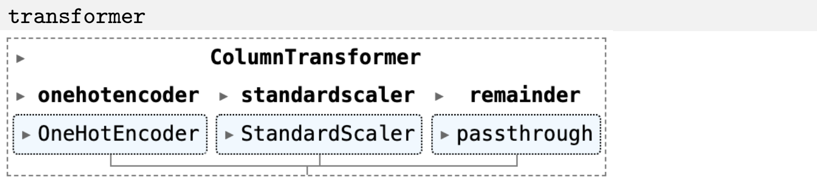
```
from sklearn.preprocessing import StandardScaler

transformer = make_column_transformer(
    (OneHotEncoder(sparse_output=False), ["House Style",
                                          "Neighborhood"]),
    (StandardScaler(), ["Gr Liv Area"]),
    remainder="passthrough")
transformer.fit(df[features])
transformer.transform(df[features])
```

```
array([[0., 0., 1., ..., 3., 1., 0.],
       [0., 0., 1., ..., 2., 1., 0.],
       [0., 0., 1., ..., 3., 1., 1.],
       ...,
       [0., 0., 0., ..., 3., 1., 0.],
       [0., 0., 1., ..., 2., 1., 0.],
       [0., 0., 0., ..., 3., 2., 1.]])
```

Scaling and Encoding in Scikit-Learn

Let's visualize this `ColumnTransformer` as well.



transformer

▸ ColumnTransformer

▸ onehotencoder ▸ standardscaler ▸ remainder

▸ OneHotEncoder ▸ StandardScaler ▸ passthrough

A Look Ahead

In section tomorrow, you will put all the pieces from the last two lectures together.

1. Convert categorical variables to quantitative variables.
2. Calculate distances on the transformed data to solve a real problem.