



Politecnico
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Data Science Lab

Scikit-learn
preprocessing

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- **Data preprocessing with scikit-learn**
- **Summary**
 - **Normalization**
 - **Feature extraction (examples)**
 - Handling nominal data
 - Computing TF-IDF
 - **Dimensionality reduction**
 - PCA



- Examples:
 - min-max normalization: `MinMaxScaler`
 - z-score normalization: `StandardScaler`

```
In [1]: from sklearn.preprocessing import MinMaxScaler
        from sklearn.preprocessing import StandardScaler

        minmax_s = MinMaxScaler()
        zscore_s = StandardScaler()
```



- Applying normalization to training and test set

```
In [1]: X_train = [[0, 10], [0, 20], [2, 10], [2, 20]]
X_test = [[1, 15]]

minmax_s.fit(X_train)
X_train_norm = minmax_s.transform(X_train)
X_test_norm = minmax_s.transform(X_test) # correct
X_test_wrong = minmax_s.fit_transform(X_test) # do not fit on test
print(X_test_norm)
print(X_test_wrong)
```

```
Out[1]: [[0.5 0.5]]
[[0, 0]]
```



- Necessary when a datasets presents samples that:
 - Are **not numerical vectors**
 - Example: nominal data, text, images
 - The **model** has a low capacity/can't extract enough knowledge from the row features
 - Example: extraction of polynomial features



- Nominal data
 - Two nominal values can only be compared with the equality operator (**cannot be ordered**)
 - For this reason it is **incorrect** to map them to integer features:
 - E.g. 'red', 'green', 'blue' \rightarrow [0, 1, 2]
 - Colors have no ordering
 - The model could infer ordering properties that do not describe correctly our data



- Nominal data
 - One of the simplest solutions is to use **one-hot encoding**:
 - Red → 0, 0, 1
 - Green → 0, 1, 0
 - Blue → 1, 0, 0
 - Pay attention: the **size of the output vector** is linear with the number of distinct values for the attribute
 - Some models (e.g. KNN, clustering) may have problems while working with high dimensional data



- Nominal data: 1-Hot vectors from dictionaries

```
In [1]: from sklearn.feature_extraction import DictVectorizer  
vect = DictVectorizer(sparse=False, dtype=int)
```

```
Out[1]: data = [{'model' : 'a', 'price' : 20000},  
{'model' : 'b', 'price' : 10000},  
{'model' : 'c', 'price' : 8000},  
{'model' : 'a', 'price' : 40000},  
{'model' : 'c', 'price' : 8500}]
```

```
print(vect.fit_transform(data))
```




- Nominal data: 1-Hot vectors from dictionaries

In [1]:

```
...  
print(vect.fit_transform(data))
```

```
data = [{'model' : 'a', 'price' : 20000},  
        {'model' : 'b', 'price' : 10000},  
        {'model' : 'c', 'price' : 8000},  
        {'model' : 'a', 'price' : 40000},  
        {'model' : 'c', 'price' : 8500}]
```

Out[1]:

```
[[ 1  0  0 20000]  
 [ 0  1  0 10000]  
 [ 0  0  1  8000]  
 [ 1  0  0 40000]  
 [ 0  0  1  8500]]
```

a b c



- Nominal data: 1-Hot vectors from dictionaries
 - If you have training and test data use fit and transform separately:

In [1]:

```
train = data[:3]
test = data[3:]

vect = DictVectorizer(sparse=False, dtype=int)
vect.fit(train) # Learn vocabulary from training set
test_transformed = vect.transform(test)
```



- 1-Hot encoding with *OneHotEncoder*
 - Allows passing data in tabular form (“feature matrix”)
 - Numerical values are also encoded – **beware!**
 - Some matrix manipulation is required to only encode categorical features

In [1]:

```
from sklearn.preprocessing import OneHotEncoder

X = np.array([
    ["a", 20000],
    ["b", 10000],
    ["c", 8000],
    ["a", 40000],
    ["c", 8500]
])

ohe = OneHotEncoder(sparse=False, dtype=int)
X_ohe = ohe.fit_transform(X[:, :1])

# same result as before
X_enc = np.hstack([ X_ohe, X[:, 1:].astype(int)])
```



- Textual data
 - Convert textual documents to count vectors
 - 1 feature for each word of the vocabulary that count the number of occurrences in the document
 - Example:
 - “My cat. My dog. My cat.”
 - “My dog. My house.”

cat	dog	house	my
2	1	0	3
0	1	1	1



- Textual data
 - Convert textual documents to count vectors
 - Drawback: frequent words have high scores for almost all documents
 - Solution: **TF-IDF** (Term Freq. Inverse Document Freq.)
 - Penalizes words that are common in all documents
 - Boosts words that are frequent in a document, but not in the others



■ Textual data: TF-IDF

```
In [1]: from sklearn.feature_extraction.text import TfidfVectorizer
vect = TfidfVectorizer(stop_words="english")

data = ["dog bites cat", "cat bites dog", "cat and dog house"]
print(vect.fit_transform(data).toarray())
```

convert to Numpy array

```
Out[1]: [[0.67325467 0.52284231 0.52284231 0.          ]
 [0.67325467 0.52284231 0.52284231 0.          ]
 [0.          0.45329466 0.45329466 0.76749457]]
```



■ Textual data: TF-IDF

In [1]:

```
...  
data = ["dog bites cat", "cat bites dog", "cat and dog house"]  
print(vect.fit_transform(data).toarray())  
# Print the learned vocabulary  
print(vect.vocabulary_)
```

Out[1]:

bites	cat	dog	house	
[0.67325467	0.52284231	0.52284231	0.] Doc 1
[0.67325467	0.52284231	0.52284231	0.] Doc 2
[0.	0.45329466	0.45329466	0.76749457]	Doc 3


```
{'dog': 2, 'bites': 0, 'cat': 1, 'house': 3}
```

stopword "and"
has been
removed

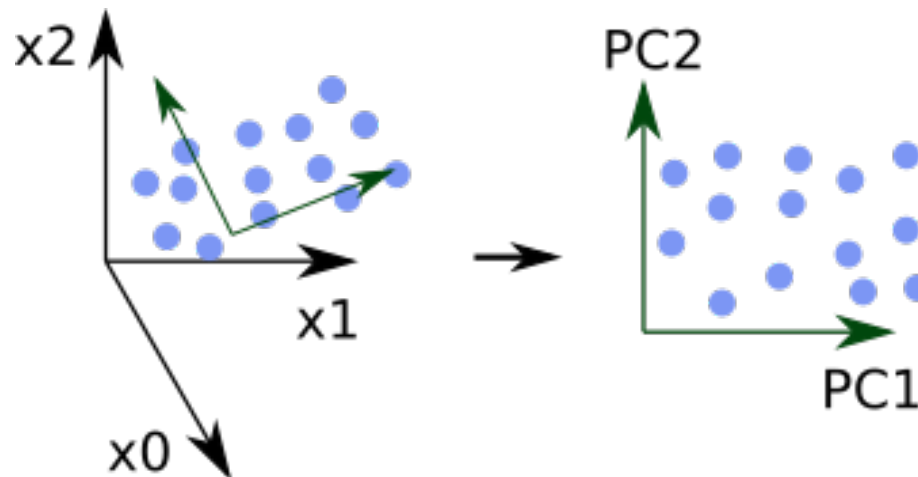
specific of this
document



- Useful when you want to reduce the number of features for high-dimensional data
 - For **graphical** representations
 - Before applying **classification** and **clustering** to give the features matrix a more **compact** representation



- Example: **PCA**
 - Reduces the dimensionality by finding the directions in the space where data has more variance





- PCA with Scikit-learn

```
from sklearn.decomposition import PCA

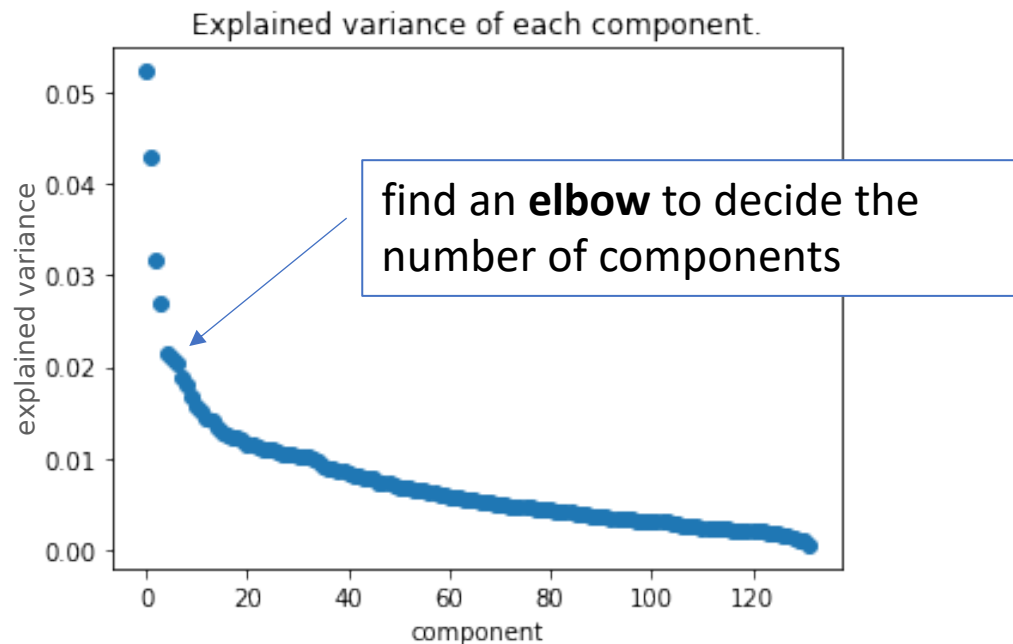
pca = PCA(n_components=5)
X_projection = pca.fit_transform(X)
```

- **n_components** specify the number of components that you want to keep after applying PCA
 - Should be \leq the number of initial features
- The result is a features matrix with the specified number of features



- Choosing the correct number of components

```
pca = PCA(n_components=130)  
X_projection = pca.fit_transform(X)  
plt.plot(pca.explained_variance_ratio_, marker='o', linestyle='')
```





- Applying the transformation and a classifier

```
pca = PCA(n_components=6)
X_projection = pca.fit_transform(X_train)
my_classifier.train(X_projection, y_train)

# PCA is already fit on training data: do not fit it on test set!
X_test_proj = pca.transform(X_test)
y_test_pred = my_classifier.predict(X_test_proj)
```



- **Other preprocessing methods**
 - <https://scikit-learn.org/stable/modules/classes.html#module-sklearn.preprocessing>