



SUPERVISED LEARNING WITH SCIKIT-LEARN

Supervised learning

What is machine learning?

- The art *and* science of:
 - Giving computers the ability to learn to make decisions from data
 - ... without being explicitly programmed!
- Examples:
 - Learning to predict whether an email is spam or not
 - Clustering wikipedia entries into different categories
- Supervised learning: Uses labeled data
- Unsupervised learning: Uses unlabeled data

Unsupervised learning

- Uncovering hidden patterns from unlabeled data
- Example:
 - Grouping customers into distinct categories (Clustering)



Reinforcement learning

- Software agents interact with an environment
 - Learn how to optimize their behavior
 - Given a system of rewards and punishments
 - Draws inspiration from behavioral psychology
- Applications
 - Economics
 - Genetics
 - Game playing
- AlphaGo: First computer to defeat the world champion in Go



Supervised learning

- Predictor variables/features and a target variable
- Aim: Predict the target variable, given the predictor variables
- Classification: Target variable consists of categories
- Regression: Target variable is continuous

Predictor variables

Target variable



	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
0	5.1	3.5	1.4	0.2
1	4.9	3.0	1.4	0.2
2	4.7	3.2	1.3	0.2
3	4.6	3.1	1.5	0.2
4	5.0	3.6	1.4	0.2

species
setosa
setosa
setosa
setosa
setosa

Naming conventions

- Features = predictor variables = independent variables
- Target variable = dependent variable = response variable



Supervised learning

- Automate time-consuming or expensive manual tasks
 - Example: Doctor's diagnosis
- Make predictions about the future
 - Example: Will a customer click on an ad or not?
- Need labeled data
 - Historical data with labels
 - Experiments to get labeled data
 - Crowd-sourcing labeled data



Supervised learning in Python

- We will use scikit-learn/sklearn
 - Integrates well with the SciPy stack
- Other libraries
 - TensorFlow
 - keras



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Let's practice!



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Exploratory data analysis



The Iris dataset

- Features:
 - Petal length
 - Petal width
 - Sepal length
 - Sepal width
- Target variable: Species
 - Versicolor
 - Virginica
 - Setosa





The Iris dataset in scikit-learn

```
In [1]: from sklearn import datasets
```

```
In [2]: import pandas as pd
```

```
In [3]: import numpy as np
```

```
In [4]: import matplotlib.pyplot as plt
```

```
In [5]: plt.style.use('ggplot')
```

```
In [6]: iris = datasets.load_iris()
```

```
In [7]: type(iris)
```

```
Out[7]: sklearn.datasets.base.Bunch
```

```
In [8]: print(iris.keys())
```

```
dict_keys(['data', 'target_names', 'DESCR', 'feature_names', 'target'])
```



The Iris dataset in scikit-learn

```
In [9]: type(iris.data), type(iris.target)
Out[9]: (numpy.ndarray, numpy.ndarray)
```

```
In [10]: iris.data.shape
Out[10]: (150, 4)
```

```
In [11]: iris.target_names
Out[11]: array(['setosa', 'versicolor', 'virginica'], dtype='<U10')
```



Exploratory data analysis (EDA)

```
In [12]: X = iris.data
```

```
In [13]: y = iris.target
```

```
In [14]: df = pd.DataFrame(X, columns=iris.feature_names)
```

```
In [15]: print(df.head())
```

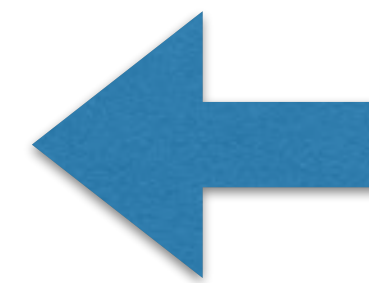
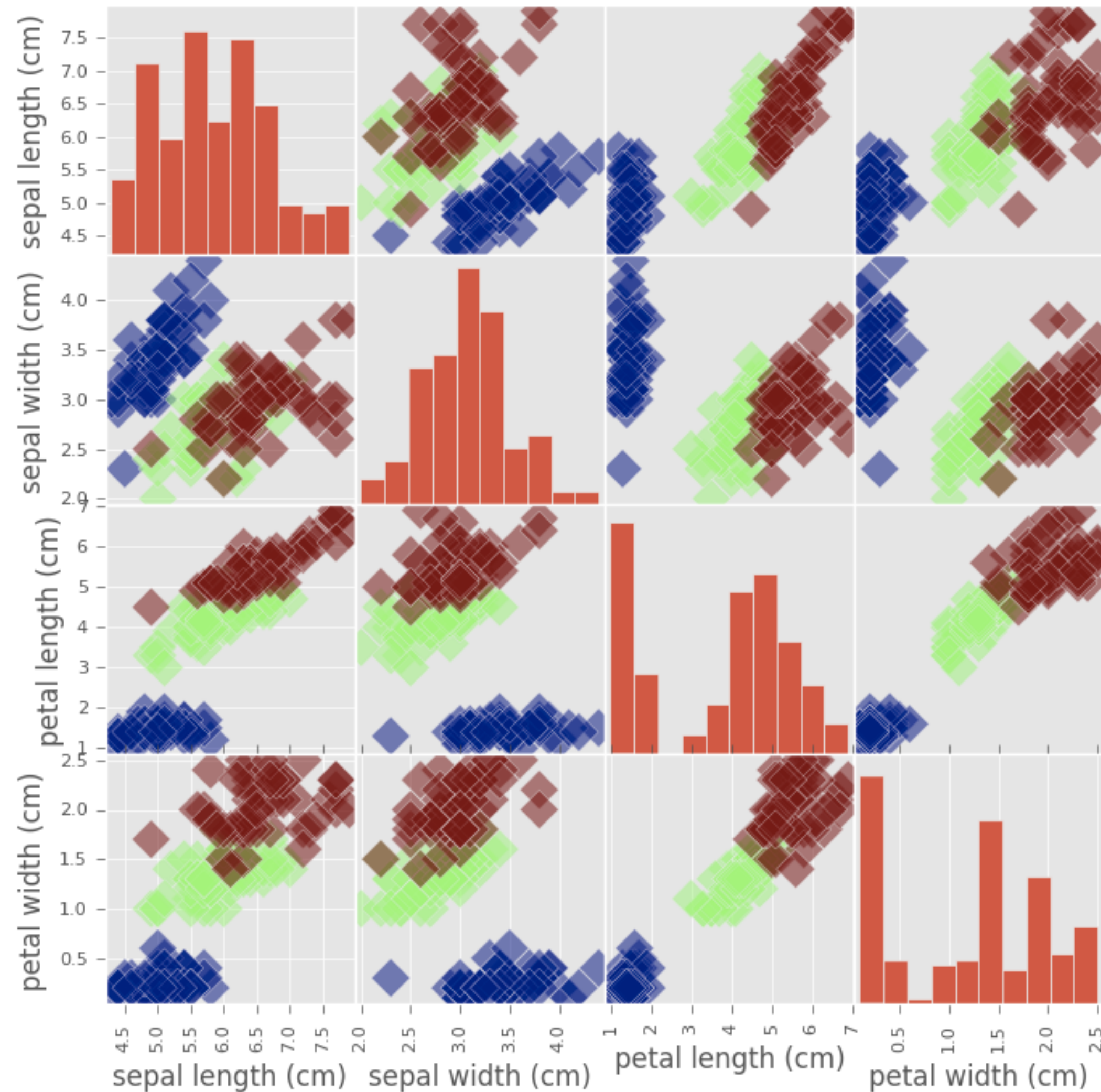
	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
0	5.1	3.5	1.4	0.2
1	4.9	3.0	1.4	0.2
2	4.7	3.2	1.3	0.2
3	4.6	3.1	1.5	0.2
4	5.0	3.6	1.4	0.2



Visual EDA

```
In [16]: _ = pd.scatter_matrix(df, c = y, figsize = [8, 8],  
    ....:                        s=150, marker = 'D')
```


Visual EDA





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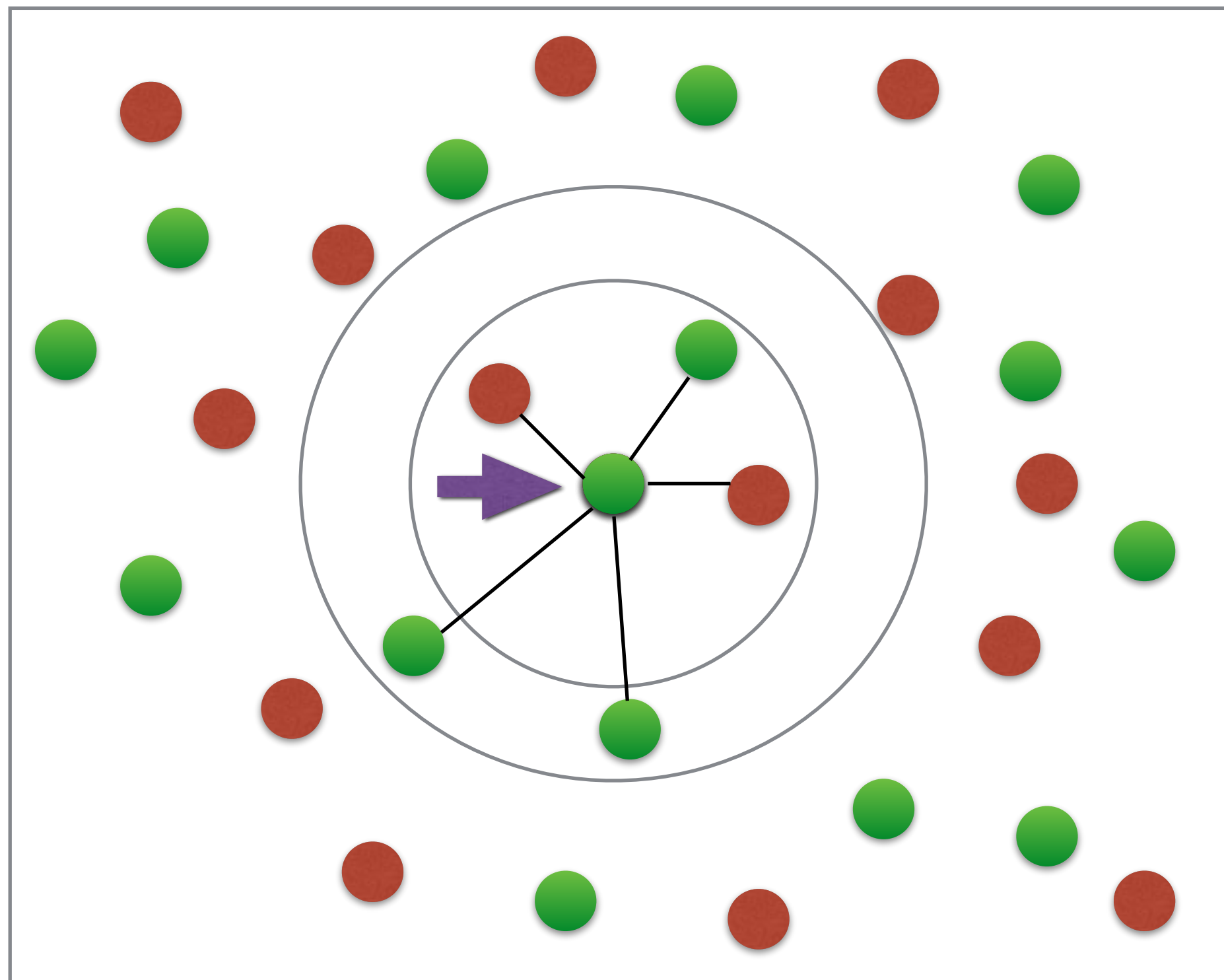
The classification challenge



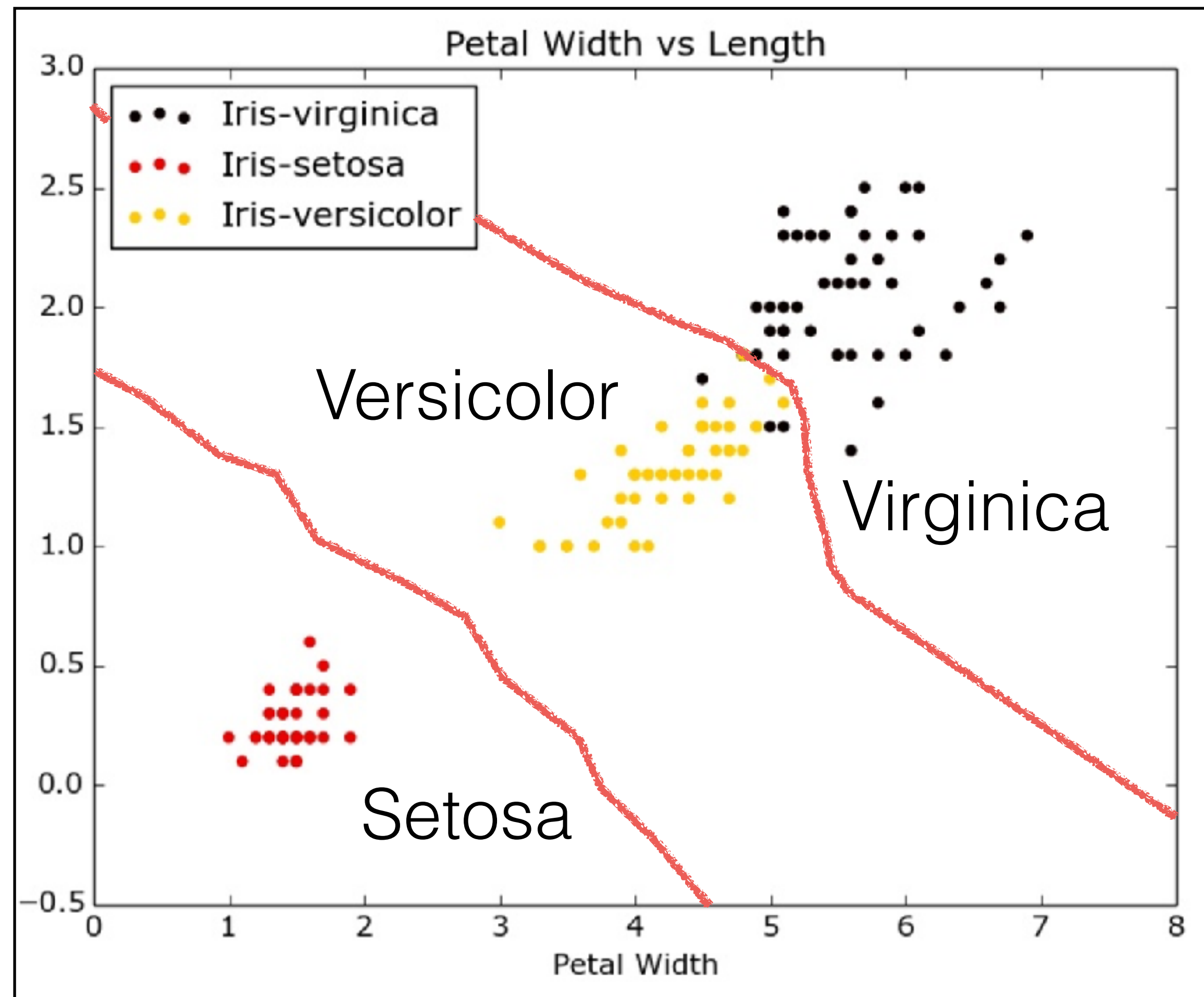
k-Nearest Neighbors

- Basic idea: Predict the label of a data point by
 - Looking at the 'k' closest labeled data points
 - Taking a majority vote

k-Nearest Neighbors



k-NN: Intuition





Scikit-learn fit and predict

- All machine learning models implemented as Python classes
 - They implement the algorithms for learning and predicting
 - Store the information learned from the data
- Training a model on the data = ‘fitting’ a model to the data
 - `.fit()` method
- To predict the labels of new data: `.predict()` method



Using scikit-learn to fit a classifier

```
In [1]: from sklearn.neighbors import KNeighborsClassifier
```

```
In [2]: knn = KNeighborsClassifier(n_neighbors=6)
```

```
In [3]: knn.fit(iris['data'], iris['target'])
```

```
Out[3]: KNeighborsClassifier(algorithm='auto', leaf_size=30,  
...: metric='minkowski', metric_params=None, n_jobs=1,  
...: n_neighbors=6, p=2, weights='uniform')
```

```
In [4]: iris['data'].shape
```

```
Out[4]: (150, 4)
```

```
In [5]: iris['target'].shape
```

```
Out[5]: (150,)
```

Predicting on unlabeled data

```
In [6]: prediction = knn.predict(X_new)

In [7]: X_new.shape
Out[7]: (3, 4)

In [8]: print('Prediction {}'.format(prediction))
Prediction: [1 1 0]
```




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Measuring model performance

Measuring model performance

- In classification, accuracy is a commonly used metric
- Accuracy = Fraction of correct predictions
- Which data should be used to compute accuracy?
- How well will the model perform on new data?



Measuring model performance

- Could compute accuracy on data used to fit classifier
 - NOT indicative of ability to generalize
- Split data into training and test set
 - Fit/train the classifier on the training set
 - Make predictions on test set
 - Compare predictions with the known labels



Train/test split

```
In [1]: from sklearn.model_selection import train_test_split
```

```
In [2]: X_train, X_test, y_train, y_test =  
...: train_test_split(X, y, test_size=0.3,  
...:                  random_state=21, stratify=y)
```

```
In [3]: knn = KNeighborsClassifier(n_neighbors=8)
```

```
In [4]: knn.fit(X_train, y_train)
```

```
In [5]: y_pred = knn.predict(X_test)
```

```
In [6]: print("Test set predictions:\n {}".format(y_pred))
```

Test set predictions:

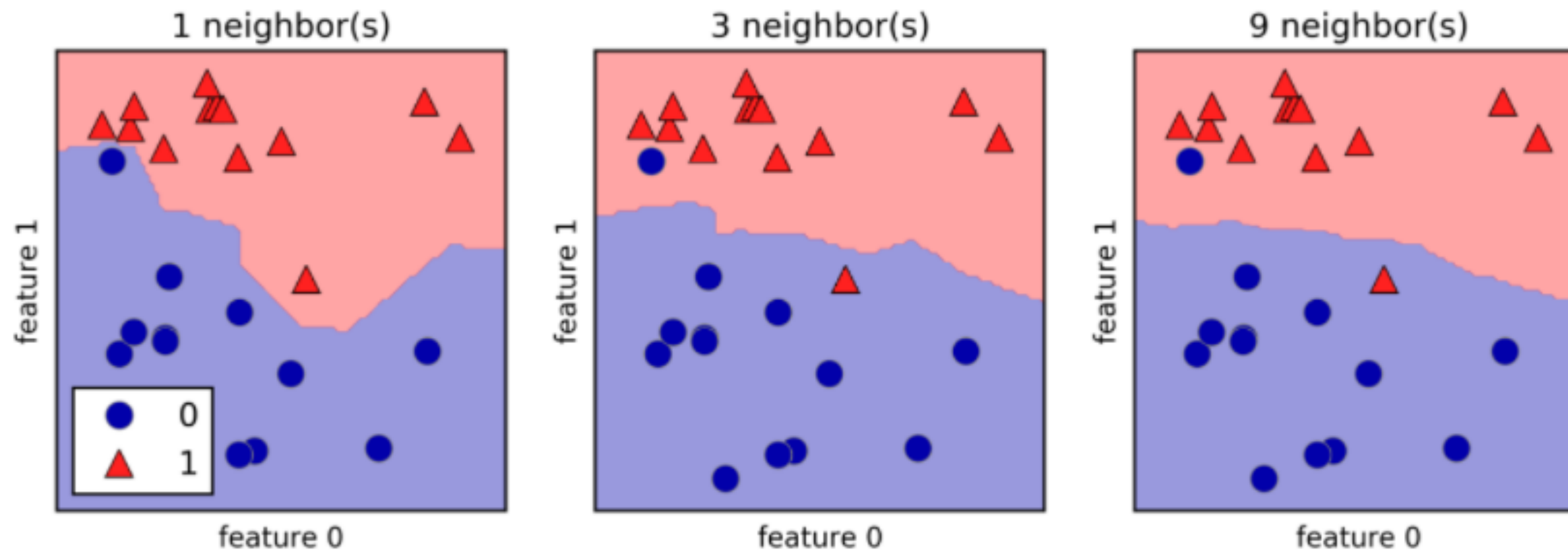
```
[2 1 2 2 1 0 1 0 0 1 0 2 0 2 2 0 0 0 1 0 2 2 2 0 1 1 1 0 0  
 1 2 2 0 0 2 2 1 1 2 1 1 0 2 1]
```

```
In [7]: knn.score(X_test, y_test)
```

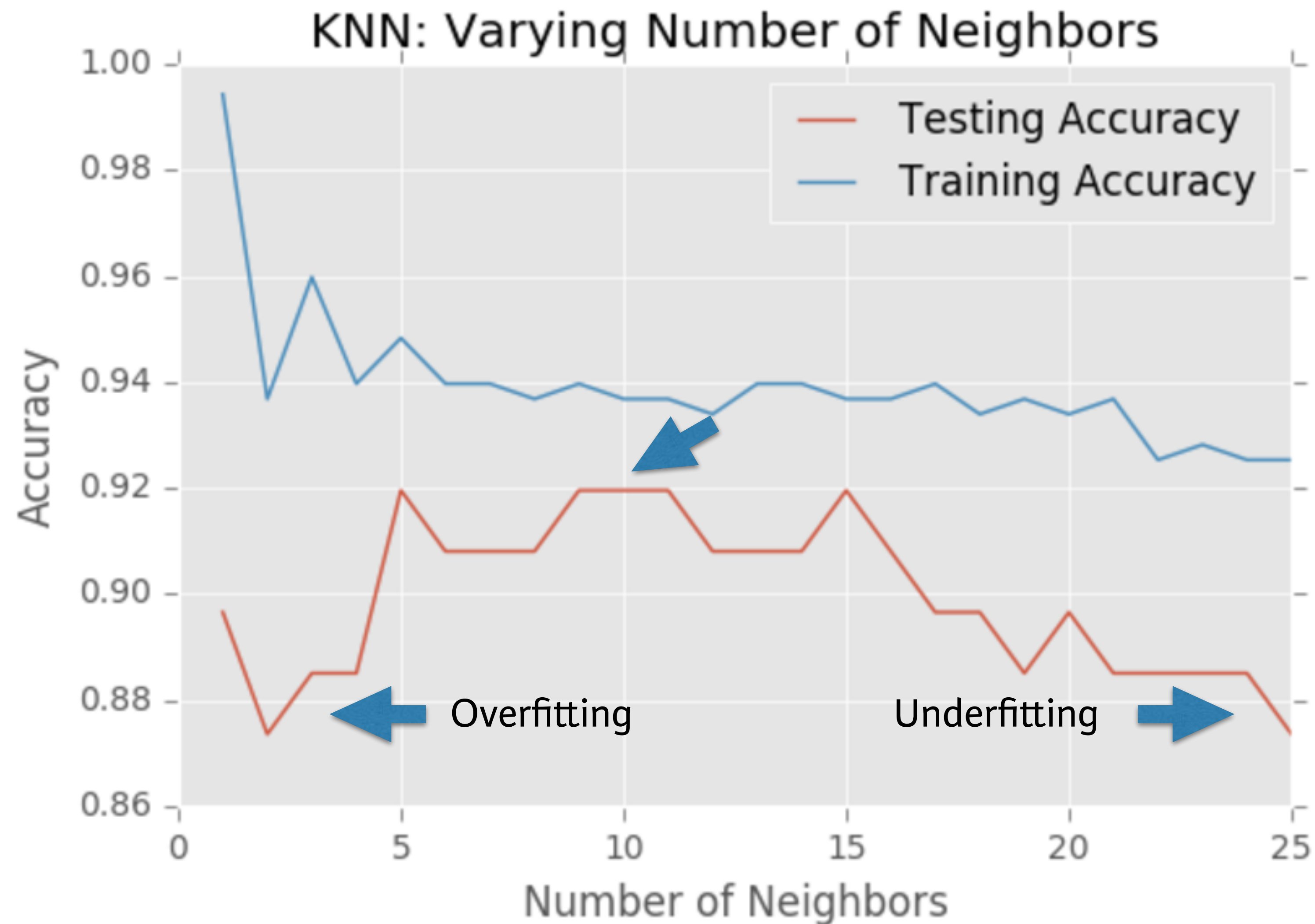
```
Out[7]: 0.9555555555555556
```

Model complexity

- Larger k = smoother decision boundary = less complex model
- Smaller k = more complex model = can lead to overfitting



Model complexity and over/underfitting





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