C | A | U Christian-Albrechts-Universität zu Kiel Technische Fakultät

Inf-KDDM: Knowledge Discovery and Data Mining

Winter Term 2020/21

Lecture 5: Classification

Lectures: Prof. Dr. Matthias Renz

Exercises: Steffen Strohm

Outline

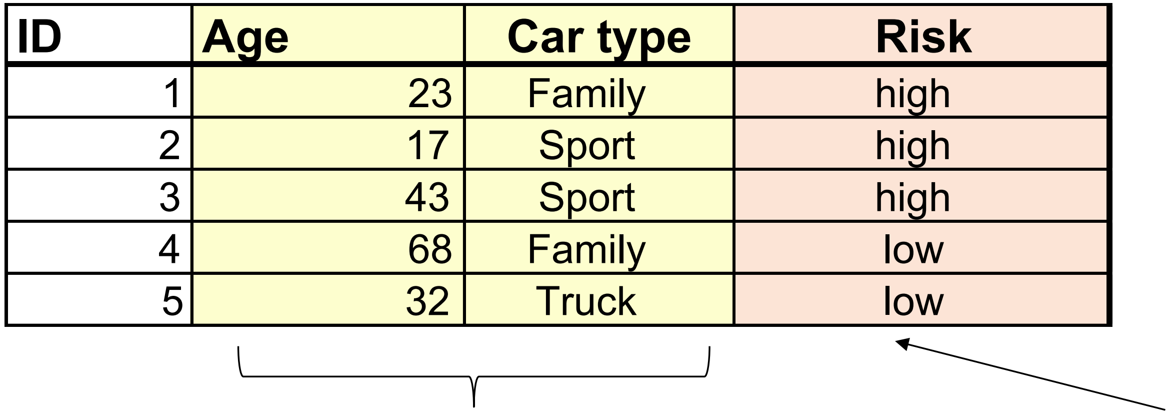
- Classification basics
- Decision tree classifiers
- Overfitting
- Lazy vs Eager Learners
- k-Nearest Neighbors (or learning from your neighbors)
- Evaluation of classifiers

The classification problem

- Given:
  - a dataset of instances $D=\{t_1,t_2,\ldots,t_n\}$ and
  - a set of classes $C=\{c_1,\ldots,c_k\}$

classification is the task of learning a *target function*/ mapping $f{:}D \rightarrow C$ that assigns each t_i to a c_j.

- The mapping or target function is known informally as a *classification model*.



ID	Age	Car type	Risk
1	23	Family	high
2	17	Sport	high
3	43	Sport	high
4	68	Family	low
5	32	Truck	low

Predictor attributes: Age, Car type

Class attribute: risk={high, low}

The classification problem

Classification vs Prediction

- Classification
  - predicts categorical (discrete, unordered) class labels
  - Constructs a model (classifier) based on a training set
  - Uses this model to predict the class label for new unknown-class instances

- Prediction
  - is similar, but may be viewed as having infinite number of classes (cf. Regression)

A simple classifier

ID	Age	Car type	Risk
1	23	Family	high
2	17	Sport	high
3	43	Sport	high
4	68	Family	low
5	32	Truck	low

A simple classifier:

- if Age > 50 then Risk= low;
- if Age $\leq$ 50 and Car type =Truck then Risk=low;
- if Age $\leq$ 50 and Car type $\neq$ Truck then Risk = high.

Applications

- Credit approval
  - Classify bank loan applications as e.g. safe or risky.
- Fraud detection
  - e.g., in credit cards
- Churn prediction
  - E.g., in telecommunication companies
- Target marketing
  - Is the customer a potential buyer for a new computer?
- Medical diagnosis
- Character recognition
- …

Classification techniques

- Typical classification approach:
  - Create specific model by evaluating training data (or using domain experts' knowledge).
    - Assess the quality of the model
  - Apply model developed to new data.
- Classes must be predefined!!!
- Many techniques
  - Decision trees
  - Naïve Bayes
  - kNN
  - Neural Networks
  - Support Vector Machines
  - ….

Classification technique (detailed)

- **Model construction:** describing a set of predetermined classes
  - The set of tuples used for model construction is the **training set**
  - Each tuple/sample is assumed to belong to a predefined class, as determined by the class label
  - The model is represented as classification rules, decision trees, or mathematical formula
- **Model evaluation:** estimate accuracy of the model
  - The set of tuples used for model evaluation is the **test set**
  - The class label of each tuple/sample in the test set is known in advance.
  - The known label of test sample is compared with the classified result from the model
    - Accuracy rate is the percentage of test set samples that are correctly classified by the model
  - Test set is independent of training set, otherwise over-fitting will occur
- **Model usage:** for classifying future or unknown objects
  - If the accuracy is acceptable, use the model to classify data tuples whose class labels are not known.

predefined class values

Class attribute: tenured={yes, no}

Training set

NAME	RANK	YEARS	TENURED
Mike	Assistant Prof	3	no
Mary	Assistant Prof	7	yes
Bill	Professor	2	yes
Jim	Associate Prof	7	yes
Dave	Assistant Prof	6	no
Anne	Associate Prof	3	no

known class label attribute

Test set

NAME	RANK	YEARS	TENURED	PREDICTED
Maria	Assistant Prof	3	no	no
John	Associate Prof	7	yes	no
Franz	Professor	3	yes	yes

known class label attribute

predicted class value by the model

NAME	RANK	YEARS	TENURED	PREDICTED
Jeff	Professor	4	?	yes
Patrick	Associate Prof	8	?	yes
Maria	Associate Prof	2	?	no

unknown class label attribute

predicted class value by the model

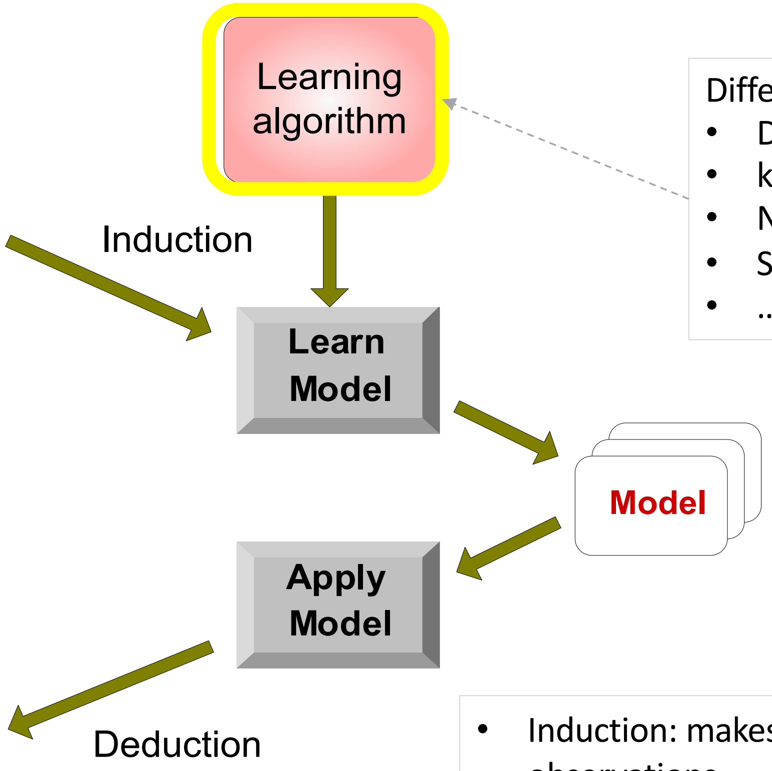
General approach for building a classification model

Tid	Attrib1	Attrib2	Attrib3	Class
1	Yes	Large	125K	No
2	No	Medium	100K	No
3	No	Small	70K	No
4	Yes	Medium	120K	No
5	No	Large	95K	Yes
6	No	Medium	60K	No
7	Yes	Large	220K	No
8	No	Small	85K	Yes
9	No	Medium	75K	No
10	No	Small	90K	Yes

Training Set

Tid	Attrib1	Attrib2	Attrib3	Class
11	No	Small	55K	?
12	Yes	Medium	80K	?
13	Yes	Large	110K	?
14	No	Small	95K	?
15	No	Large	67K	?

Test Set

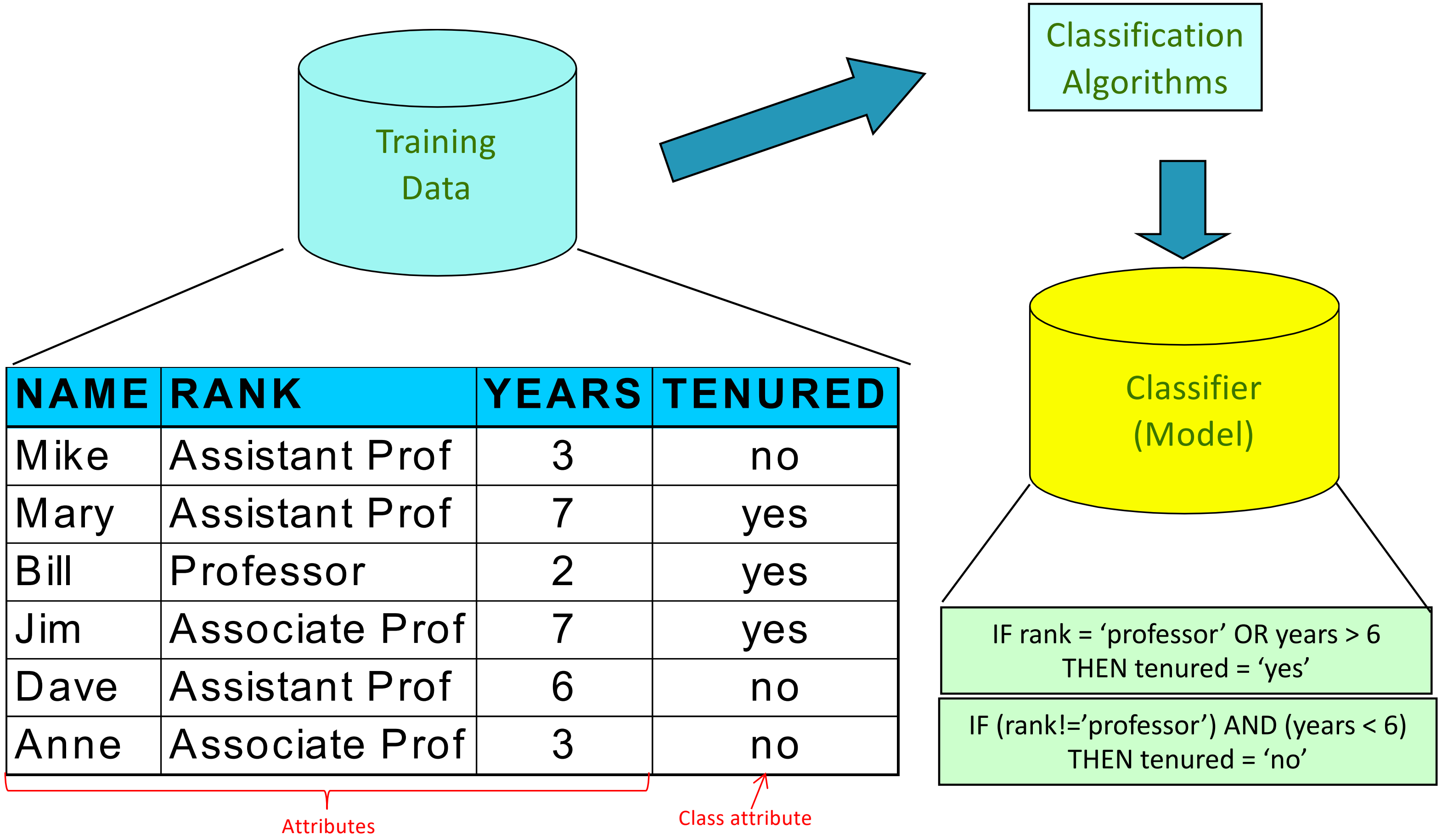


Different classification techniques (or classifiers)

- Decision trees
- kNN
- Neural networks
- SVMs
- …

- Induction: makes broad generalizations from specific observations
  - Generates new theory emerging from the data
- Deduction: from general to specific
  - Tests the theory

Model construction



Training Data

NAME	RANK	YEARS	TENURED
Mike	Assistant Prof	3	no
Mary	Assistant Prof	7	yes
Bill	Professor	2	yes
Jim	Associate Prof	7	yes
Dave	Assistant Prof	6	no
Anne	Associate Prof	3	no

Attributes

Class attribute

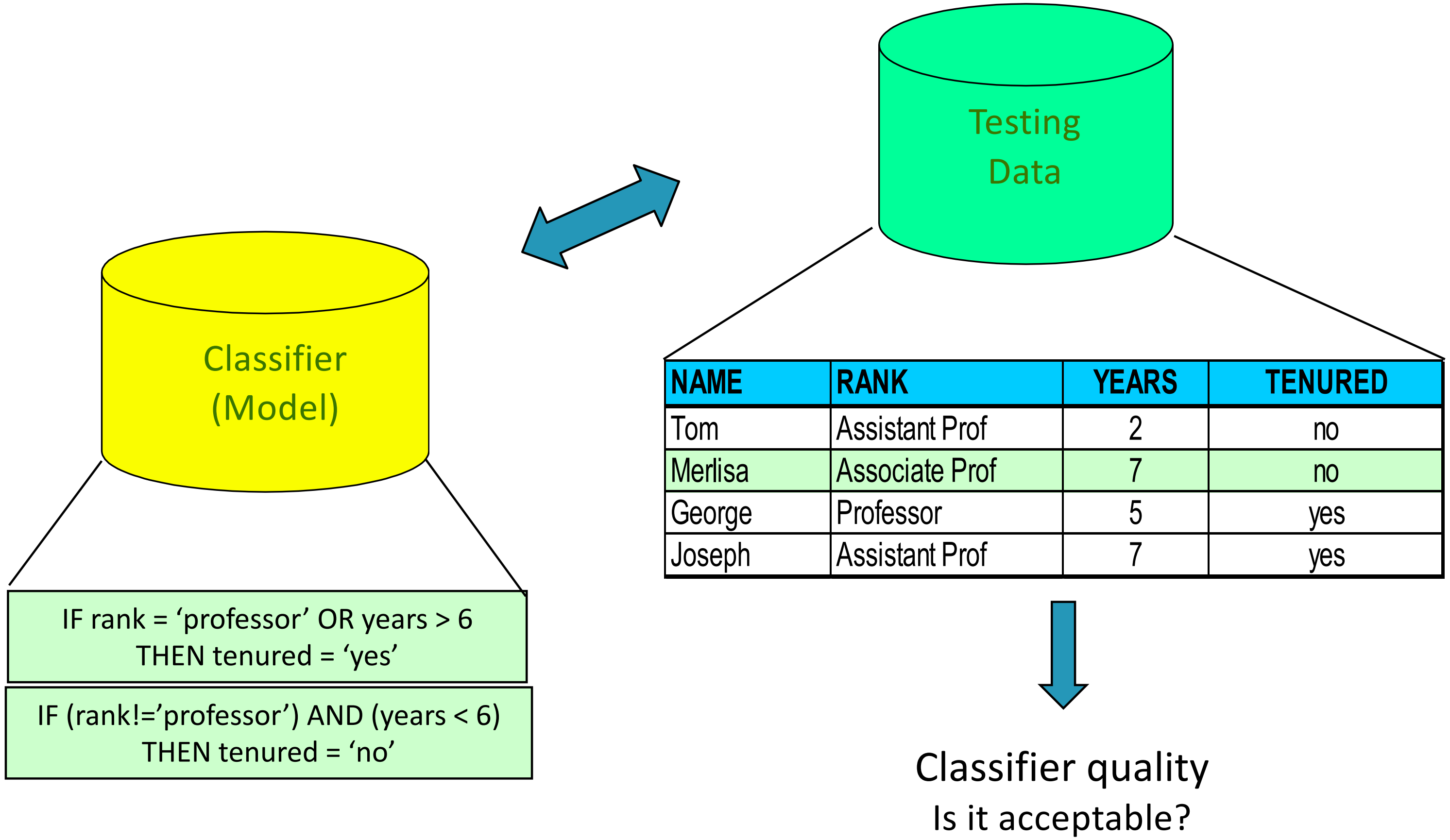
Classification Algorithms

Classifier (Model)

IF rank = ‘professor’ OR years > 6
THEN tenured = ‘yes’

IF (rank!=’professor’) AND (years < 6)
THEN tenured = ‘no’

Model evaluation



Testing Data

Classifier (Model)

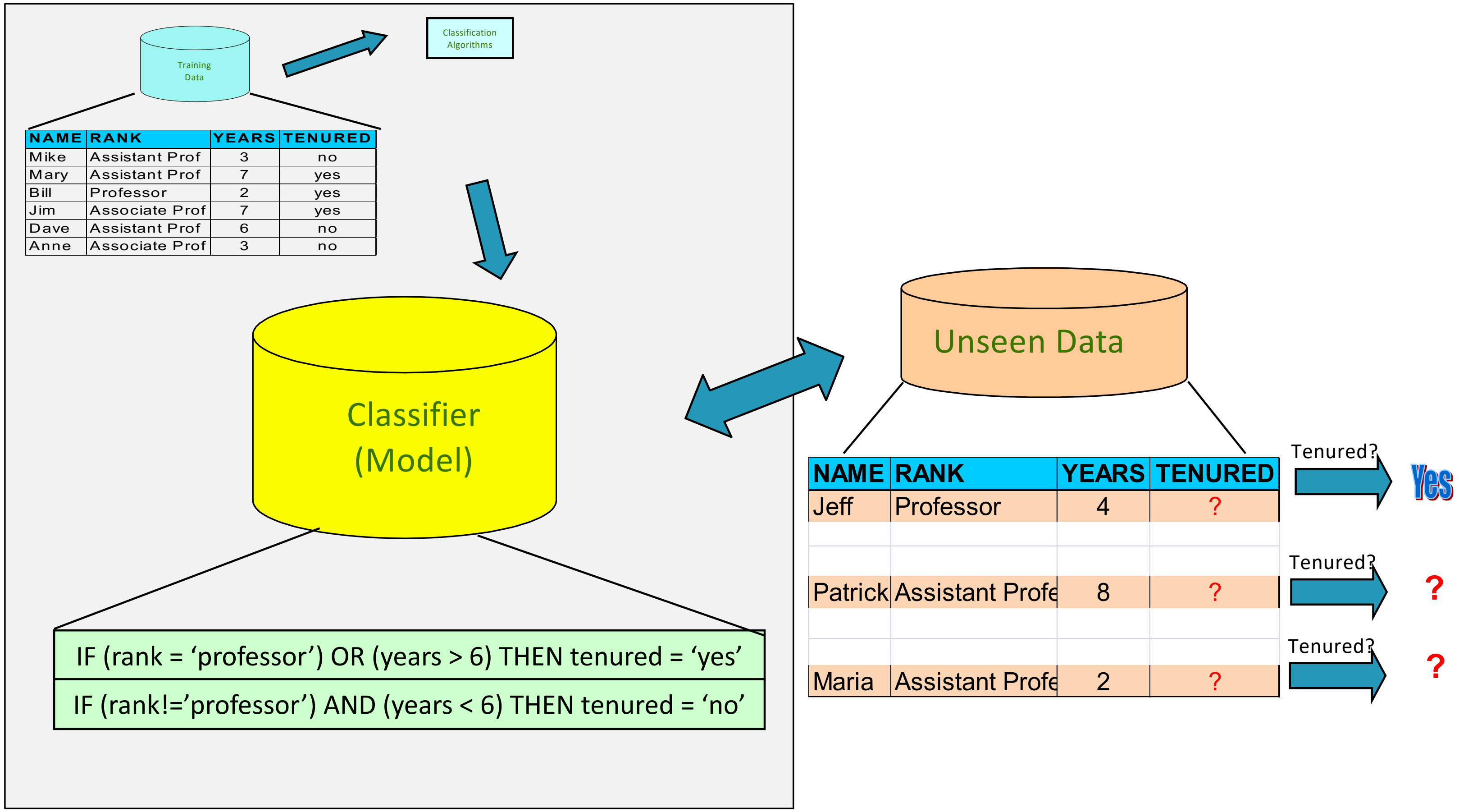
IF rank = ‘professor’ OR years > 6
THEN tenured = ‘yes’

IF (rank!=’professor’) AND (years < 6)
THEN tenured = ‘no’

NAME	RANK	YEARS	TENURED
Tom	Assistant Prof	2	no
Merlisa	Associate Prof	7	no
George	Professor	5	yes
Joseph	Assistant Prof	7	yes

Classifier quality
Is it acceptable?

Model usage for prediction



NAME	RANK	YEARS	TENURED
Mike	Assistant Prof	3	no
Mary	Assistant Prof	7	yes
Bill	Professor	2	yes
Jim	Associate Prof	7	yes
Dave	Assistant Prof	6	no
Anne	Associate Prof	3	no

IF (rank = 'professor') OR (years > 6) THEN tenured = 'yes'

IF (rank!='professor') AND (years < 6) THEN tenured = 'no'

NAME	RANK	YEARS	TENURED
Jeff	Professor	4	?
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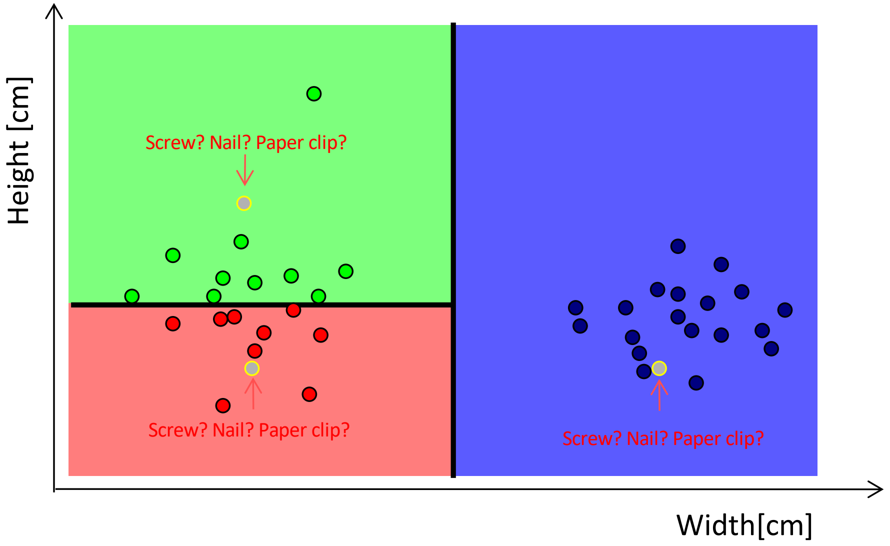
Maria	Assistant Profe	2	?

A supervised learning task

- Classification is a supervised learning task
  - Supervision: The training data (observations, measurements, etc.) are accompanied by *labels* indicating the *class* of the observations
  - New data is classified based on the training set

- Clustering is an unsupervised learning task
  - The class labels of training data is unknown
  - Given a set of measurements, observations, etc., the goal is to group the data into groups of similar data (clusters)

Supervised learning example



Classification model

● Screw

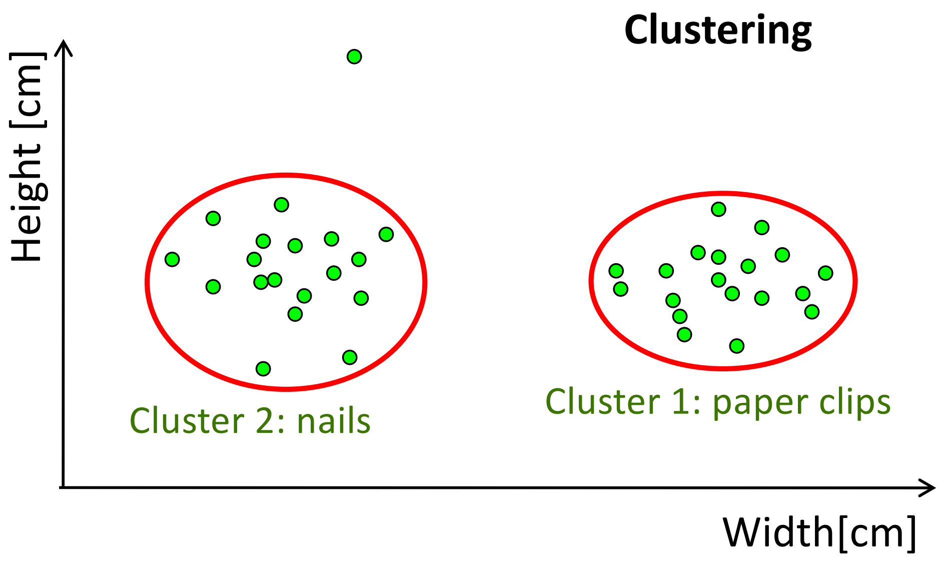
● Nails

● Paper clips

○ New object (unknown class)

<u>Question:</u>
What is the class of a new object???
Is it a screw, a nail or a paper clip?

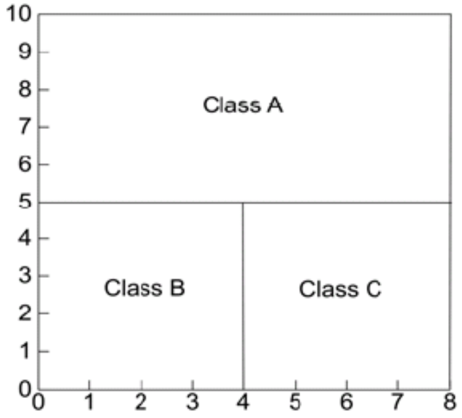
Unsupervised learning example

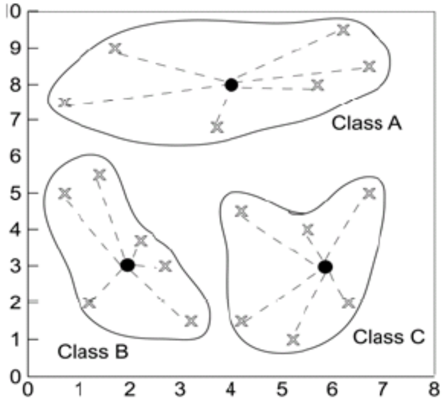


Question:
Is there any structure in data (based on their characteristics, i.e., width, height)?

Classification techniques

- Statistical methods
  - Bayesian classifiers etc
- Partitioning methods
  - Decision trees etc
- Similarity based methods
  - K-Nearest Neighbors etc





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