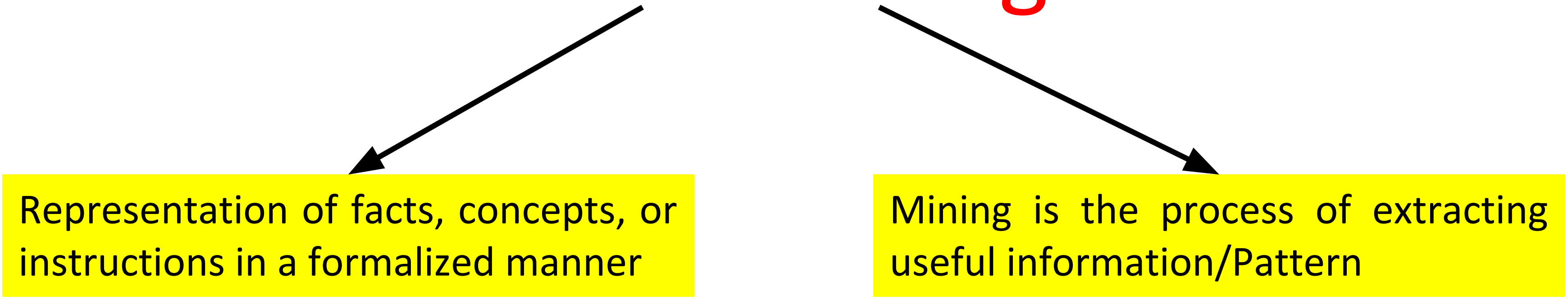
Data Mining



Representation of facts, concepts, or instructions in a formalized manner

Mining is the process of extracting useful information/Pattern

Introduction

- **Data is growing at a phenomenal rate**
- **Users expect more sophisticated information**
- **How?**
  - Find hidden information in a database
  - Fit data to a model

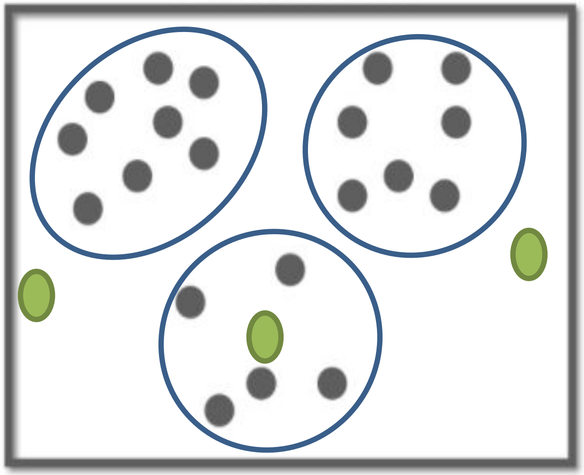
UNCOVER HIDDEN INFORMATION

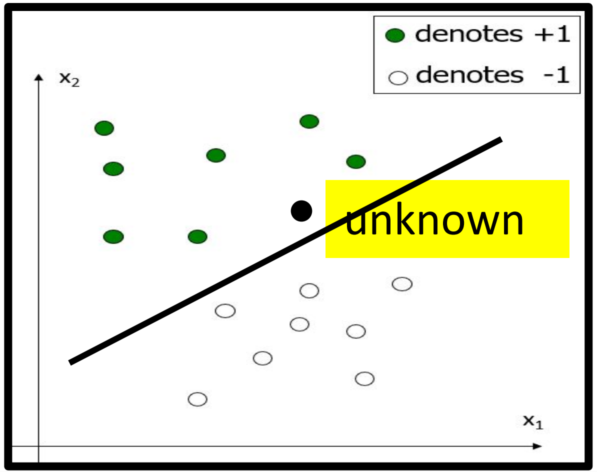
DATA MINING

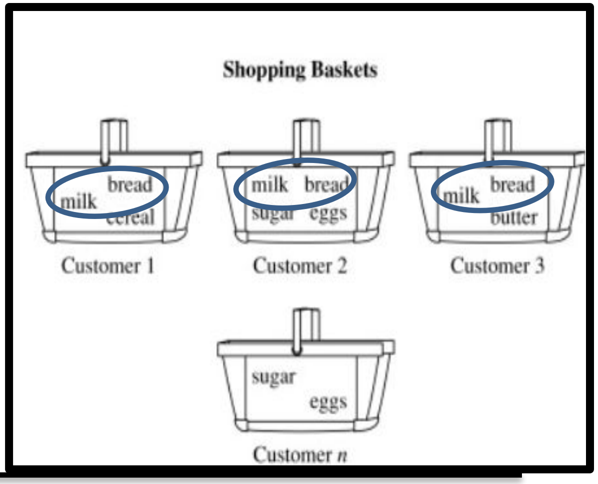
What is Data Mining?

- There are many definitions
- But most mean essentially the following.

Data mining is to discover interesting patterns from the large volumes of data.







What is a Pattern?

- **“A pattern is the opposite of chaos; it is an entity vaguely defined, that could be given a name.”**
- **e.g.,**
  - fingerprint image,
  - handwritten word,
  - human face,
  - speech signal,
  - . . .

What is (not) Data Mining?

- **What is not Data Mining?**
  - Look up phone number in phone directory
  - Query a Web search engine for information about “Amazon”

- **What is Data Mining?**
  - Certain names are more prevalent in certain Indian locations
  - Group together similar documents returned by search engine according to their context (e.g. Amazon rainforest, Amazon.com,)

Database Processing vs. Data Mining Processing

- **Query**
  - Well defined
  - SQL
- **Data**
  - Operational data
- **Output**
  - Precise
  - Subset of database

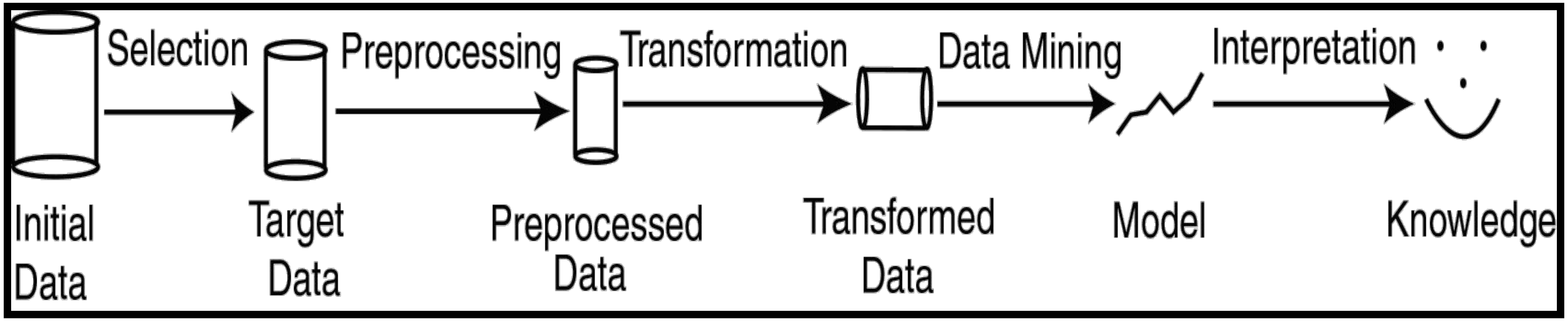
- **Query**
  - Poorly defined
  - No precise query language
- **Data**
  - Not operational data
- **Output**
  - Fuzzy
  - Not a subset of database

Query Examples

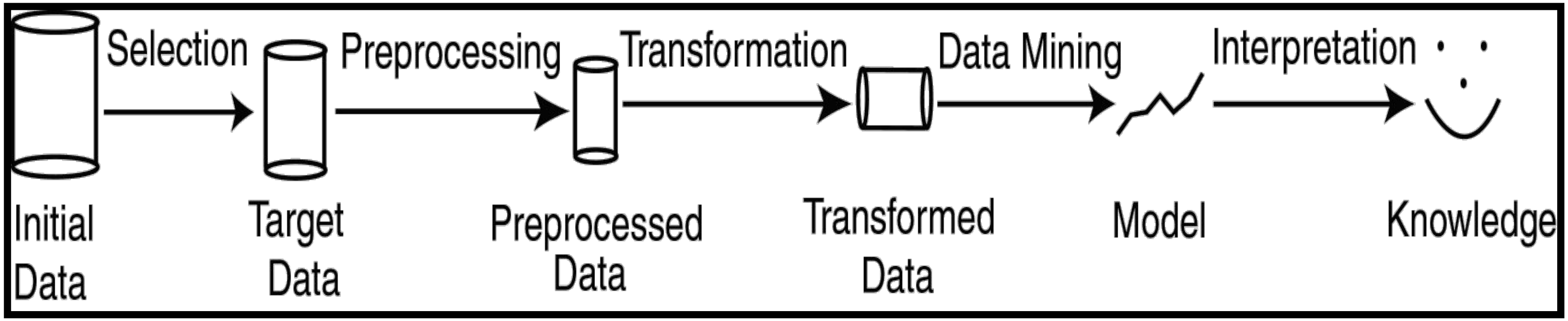
- **Database**
  - Find all credit applicants with last name of Smith.
  - Identify customers who have purchased more than $10,000 in the last month.
  - Find all customers who have purchased milk
- **Data Mining**
  - Find all credit applicants who are poor credit risks. (classification)
  - Identify customers with similar buying habits. (Clustering)
  - Find all items which are frequently purchased with milk. (association rules)

Data Mining vs. KDD

- ***Knowledge Discovery in Databases (KDD):*** **process of finding useful information and patterns in data.**
- ***Data Mining:*** **Use of algorithms to extract the information and patterns derived by the KDD process.**



KDD Process

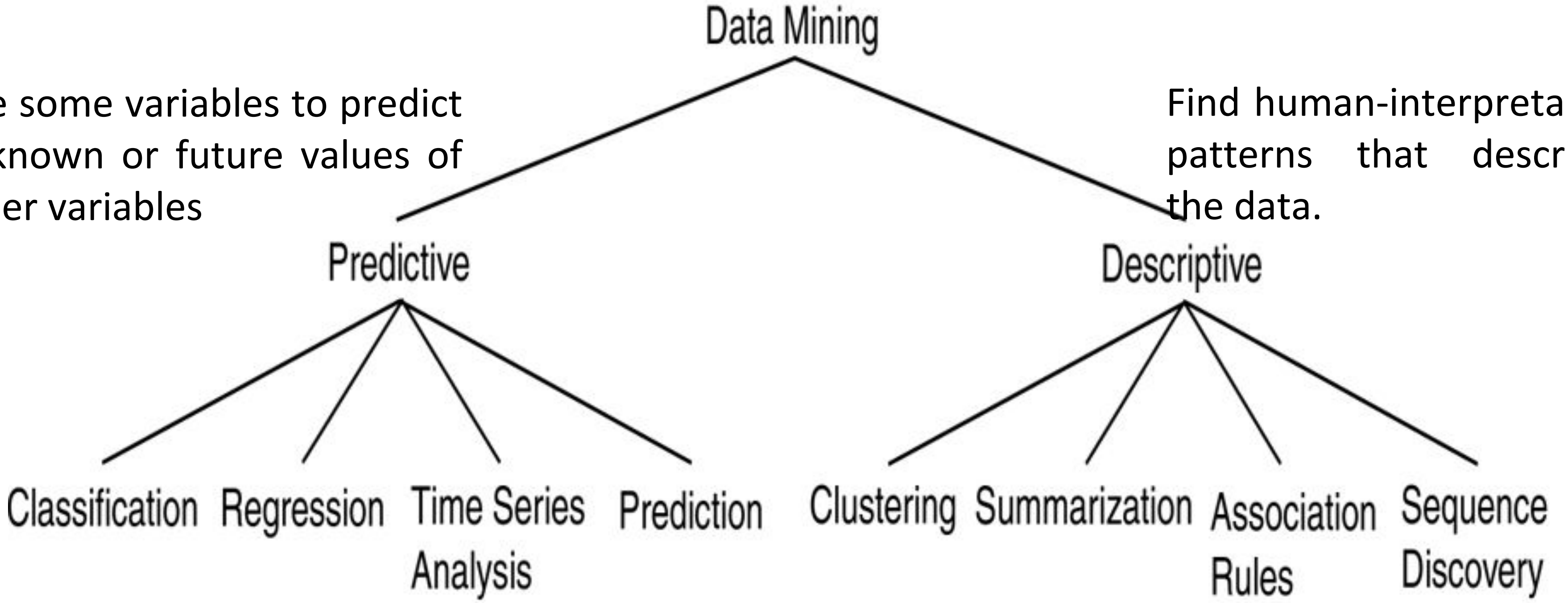


- ***Selection:*** **Obtain data from various sources.**
- ***Preprocessing:*** **Cleanse data.**
- ***Transformation:*** **Convert to common format. Transform to new format.**
- ***Data Mining:*** **Obtain desired results.**
- ***Interpretation/Evaluation:*** **Present results to user in meaningful manner.**

Data Mining Models and Tasks

Use some variables to predict unknown or future values of other variables

Find human-interpretable patterns that describe the data.



Data Mining

Predictive

Descriptive

Classification

Regression

Time Series Analysis

Prediction

Clustering

Summarization

Association Rules

Sequence Discovery

Basic Data Mining Tasks

- **Classification maps data into predefined groups or classes**
  - Supervised learning
    - The data (observations, measurements, etc.) are labeled with pre-defined classes. It is like that a “teacher” gives the classes (supervision).
    - Test data are classified into these classes too.
- **Regression is used to map a data item to a real valued prediction variable.**
  - Supervised learning
- **Clustering groups similar data together into clusters.**
  - Unsupervised learning
    - Class labels of the data are unknown
    - Given a set of data, the task is to establish the existence of classes or clusters in the data

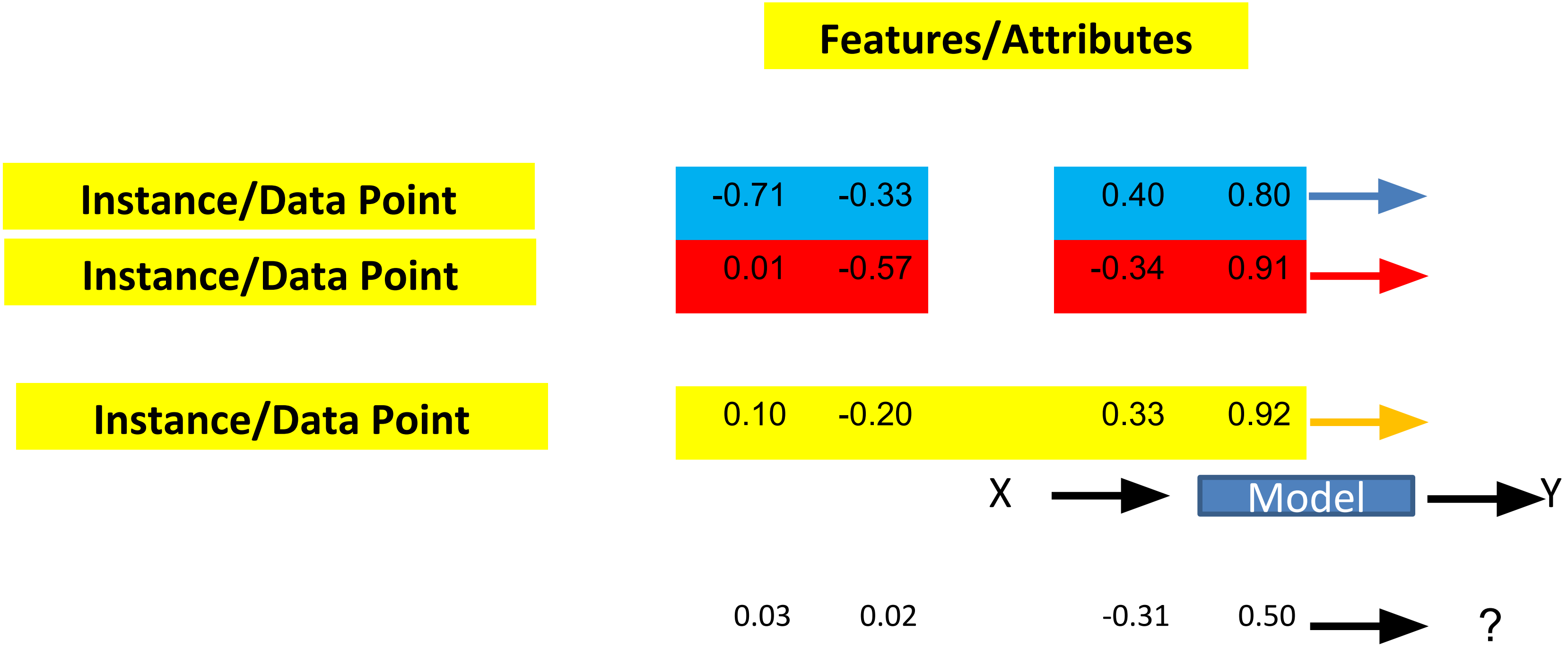
Basic Data Mining Tasks

- **Summarization maps data into subsets with associated simple descriptions.**
  - Extractive summarization
    - The main objective is to identify the significant sentences of the text and add them to the summary.
  - Abstractive summarization
    - The approach is to identify the important sections, interpret the context and reproduce in a new way
- **Link Analysis uncovers relationships among data.**
  - Affinity Analysis
  - Association Rules
  - Sequential Analysis determines sequential patterns.

Classification

- **Given a collection of records (training set)**
  - Each record contains a set of attributes and have an associated class label.
- **Find a model for class label as a function of the values of other attributes.**
- **Goal: previously unseen records should be assigned a class as accurately as possible.**
  - A test set is used to determine the accuracy of the model.
  - Usually, the given data set is divided into training and test sets, with training set used to build the model and test set used to validate it.

Classification



Features/Attributes

Instance/Data Point -0.71 -0.33 0.40 0.80

Instance/Data Point 0.01 -0.57 -0.34 0.91

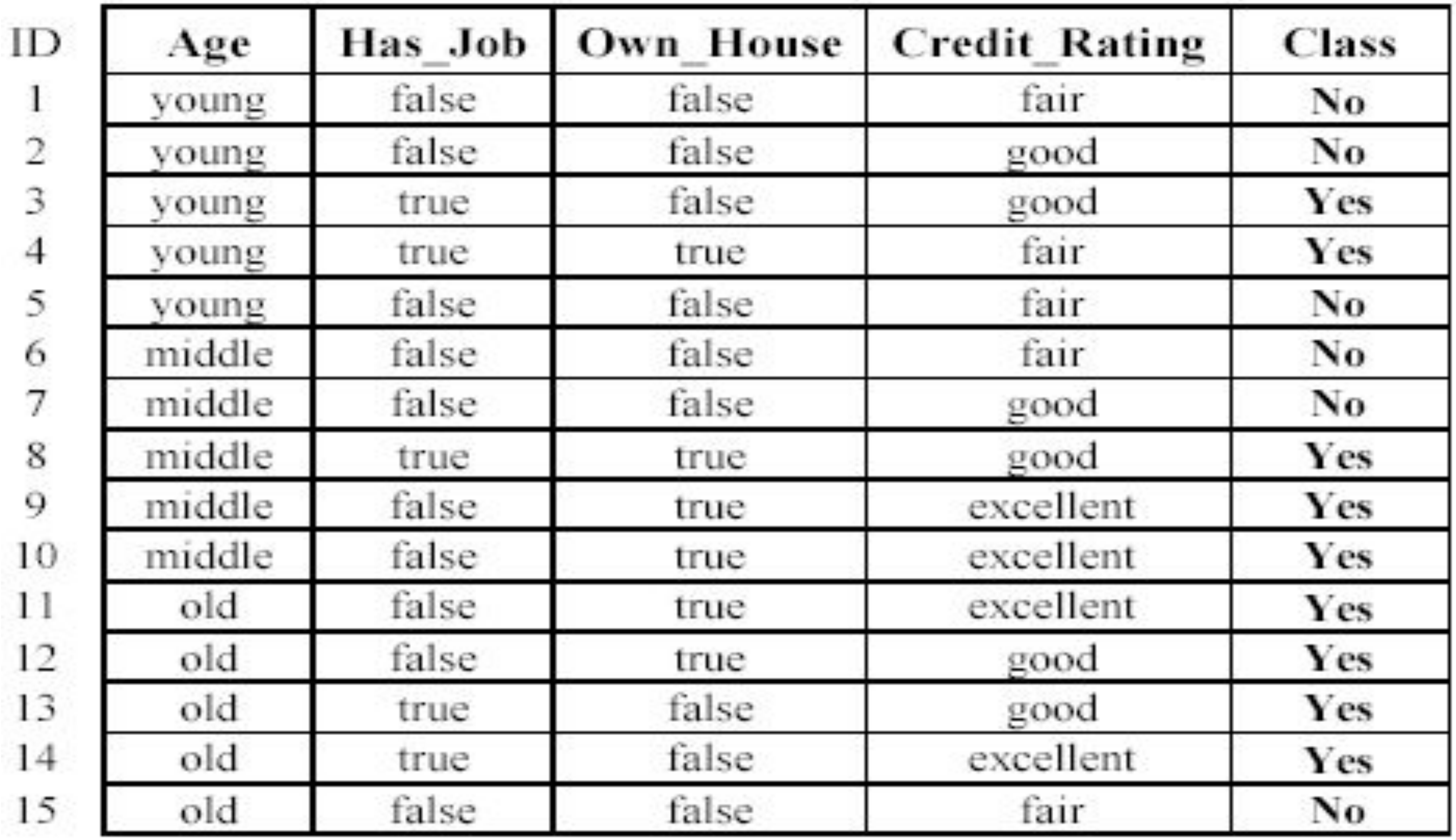
Instance/Data Point 0.10 -0.20 0.33 0.92

X → Model → Y

0.03 0.02 -0.31 0.50 → ?

An example: data (loan application)

Approved or not



ID	Age	Has_Job	Own_House	Credit_Rating	Class
1	young	false	false	fair	No
2	young	false	false	good	No
3	young	true	false	good	Yes
4	young	true	true	fair	Yes
5	young	false	false	fair	No
6	middle	false	false	fair	No
7	middle	false	false	good	No
8	middle	true	true	good	Yes
9	middle	false	true	excellent	Yes
10	middle	false	true	excellent	Yes
11	old	false	true	excellent	Yes
12	old	false	true	good	Yes
13	old	true	false	good	Yes
14	old	true	false	excellent	Yes
15	old	false	false	fair	No

Classification - Example

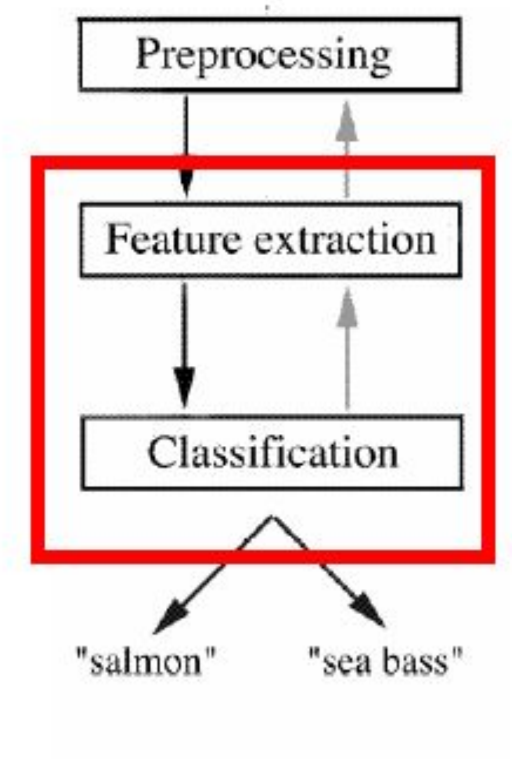
- **A fish-packing plant wants to automate the process of sorting incoming fish according to species**
- **As a pilot project, it is decided to try to separate sea bass from salmon using optical sensing**
- **Features (to distinguish):**
  - Length
  - Lightness
  - Width
  - Position of mouth

Salmon

Sea bass

Classification - Example

- **Preprocessing:**
  - Images of different fishes are isolated from one another and from background;
- **Feature extraction:**
  - The information of a single fish is then sent to a feature extractor, that measure certain "features" or "properties";
- **Classification:**
  - The values of these features are passed to a classifier that evaluates the evidence presented, and build a model to discriminate between the two species



Classification - Example

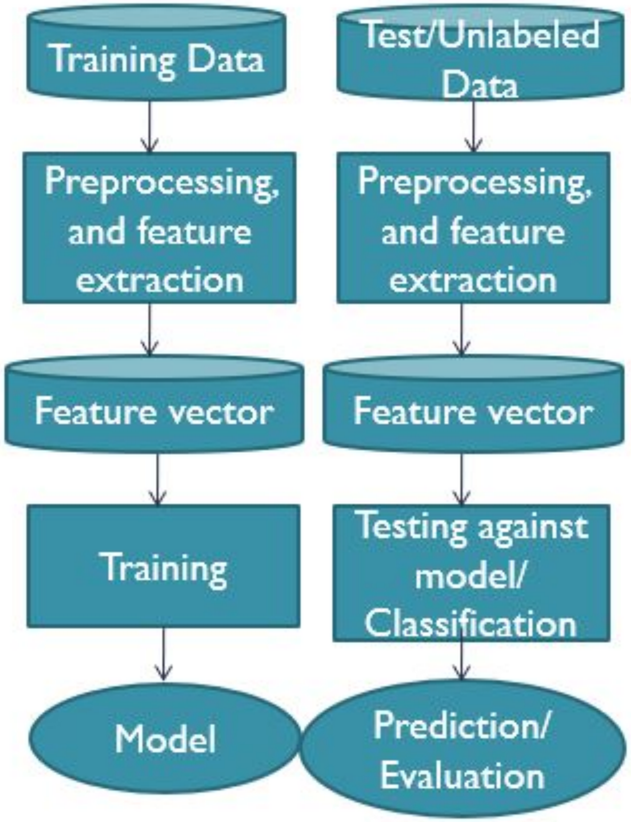
- **Domain knowledge:**
  - A sea bass is generally longer than a salmon
- **Related feature: (or attribute)**
  - Length
- **Training the classifier:**
  - Some examples are provided to the classifier in this form: <fish_length, fish_name>
  - These examples are called training examples
  - The classifier learns itself from the training examples, how to distinguish Salmon from Bass based on the fish_length

Classification - Example

- **Classification model (hypothesis):**
  - The classifier generates a model from the training data to classify future examples (test examples)
  - An example of the model is a rule like this:
  - If Length >= l* then sea bass otherwise salmon
  - Here the value of l* determined by the classifier
- **Testing the model**
  - Once we get a model out of the classifier, we may use the classifier to test future examples
  - The test data is provided in the form <fish_length>
  - The classifier outputs <fish_type> by checking fish_length against the model

Classification - Example

- **So the overall classification process goes like this **


Training Data
Test/Unlabeled Data
Preprocessing, and feature extraction
Preprocessing, and feature extraction
Feature vector
Feature vector
Training
Testing against model/ Classification
Model
Prediction/ Evaluation

Classification: Application I

- **Direct Marketing**
  - Goal: Reduce cost of mailing by targeting a set of consumers likely to buy a new cell-phone product.
  - Approach:
    - Use the data for a similar product introduced before.
    - We know which customers decided to buy and which decided otherwise. This {buy, don’t buy} decision forms the class attribute.
    - Collect various demographic, lifestyle, and company-interaction related information about all such customers.
    - Type of business, where they stay, how much they earn, etc.
    - Use this information as input attributes to learn a classifier model.

Classification: Application II

- **Fraud Detection**
  - Goal: Predict fraudulent cases in credit card transactions.
  - Approach:
    - Use credit card transactions and the information on its account-holder as attributes.
    - When does a customer buy, what does he buy, how often he pays on time, etc
    - Label past transactions as fraud or fair transactions. This forms the class attribute.
    - Learn a model for the class of the transactions.
    - Use this model to detect fraud by observing credit card transactions on an account.

Clustering

- **Given a set of data points, each having a set of attributes, and a similarity measure among them, find clusters such that**
  - Data points in one cluster are more similar to one another.
  - Data points in separate clusters are less similar to one another.
- **Similarity Measures:**
  - Euclidean Distance if attributes are continuous.
  - Other Problem-specific Measures.

Clustering: Application I

- **Market Segmentation:**
  - Goal: subdivide a market into distinct subsets of customers where any subset may conceivably be selected as a market target to be reached with a distinct marketing mix.
  - Approach:
    - Collect different attributes of customers based on their geographical and lifestyle related information.
    - Find clusters of similar customers.
    - Measure the clustering quality by observing buying patterns of customers in same cluster vs. those from different clusters.

Clustering: Application II

- **Document Clustering:**
  - Goal: To find groups of documents that are similar to each other based on the important terms appearing in them.
  - Approach: To identify frequently occurring terms in each document. Form a similarity measure based on the frequencies of different terms. Use it to cluster.
  - Gain: Information Retrieval can utilize the clusters to relate a new document or search term to clustered documents.

Association Rule Discovery: Definition

- **Given a set of records each of which contain some number of items from a given collection;**
  - Produce dependency rules which will predict occurrence of an item based on occurrences of other items.

TID	*Items*
1	Bread, Coke, Milk
2	Beer, Bread
3	Beer, Coke, Diaper, Milk
4	Beer, Bread, Diaper, Milk
5	Coke, Diaper, Milk

Rules Discovered:

{Milk} --> {Coke}

{Diaper, Milk} --> {Beer}

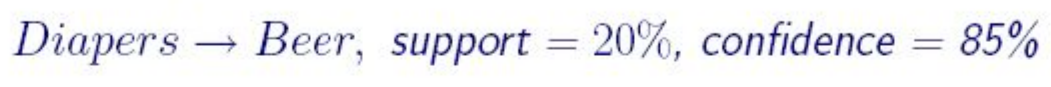
Association Rule Discovery: Application I

- **Marketing and Sales Promotion:**
  - Let the rule discovered be

    {Bagels, … } --> {Potato Chips}
  - Potato Chips as consequent => Can be used to determine what should be done to boost its sales.
  - Bagels in the antecedent => Can be used to see which products would be affected if the store discontinues selling bagels.
  - Bagels in antecedent and Potato chips in consequent => Can be used to see what products should be sold with Bagels to promote sale of Potato chips!

Association Rule Discovery: Application II

- **Supermarket shelf management.**
  - Goal: To identify items that are bought together by sufficiently many customers.
  - Approach: Process the point-of-sale data collected with barcode scanners to find dependencies among items.
  - A classic rule --
    - If a customer buys diaper and milk, then he is very likely to buy beer:



$$Diapers \rightarrow Beer, \ \textit{support} = 20\%, \ \textit{confidence} = 85\%$$

Acknowledgements

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  - An Introduction to Data Mining, Prof. S. Sudarshan