Introduction to Supervised and Unsuspervised Learning

Cse352 Lecture Notes

Professor Anita Wasilewska

Stony Brook University

Learning Main Objectives

- Indentification of data as a source of useful information, called also a knowledge
- Use of “learned” information (knowledge) for different applications

Data – Information - Knowledge

- **Data – as in databases**
- **Information, or knowledge is a meta information ABOUT the patterns hidden in the data**
- **The patterns must be discovered automatically**

Learning : Intuitive Definition

- **Learning** is a process that extracts previously unknown knowledge from the data

- It requires special algorithms, technologies and methods

Learning

- There are many types of learning.
- We will cover two:
- SUPERVISED LEARNING: classification
- UNSUPERVISED LERANING: clustering
- The knowledge obtained in the learning process is often presented as a set of rules of the form:

  IF.... THEN…..
- It also finds other relationships in data

Some Commercial Applications

- **Market analysis and management**
  - target marketing, customer relation management
  - **Risk analysis and management**
  - Forecasting, customer retention, improved underwriting, quality control, competitive analysis

More Applications

- Buying patterns
- Fraud detection
- Customer Campaings
- Decision support
- Medical aplications
- Marketing
- and more

Fraud Detection and Management (B1)

- **Applications**

  widely used in health care, retail, credit card services, telecommunications (phone card fraud), etc.

- **Approach**

  use historical data to build models of fraudulent behavior and use learned knowledge to help identify similar instances

Fraud Detection and Management (B2)

- Examples (historical)

  auto insurance: learn characteristics of group of people who stage accidents to collect on insurance and use them automatically to prevent fraud

  money laundering: learn characteristics of suspicious money transactions (US Treasury's Financial Crimes Enforcement Network)

  medical insurance: learn characteristics of fraudulent patients and doctors

Fraud Detection and Management (B3)

- **Detecting telephone fraud**

  Use learning methods to describe telephone call model: destination of the call, duration, time of day or week. Detects patterns that deviate from an expected norm.

  British Telecom identified discrete groups of callers with frequent intra-group calls, especially mobile phones, and broke a multimillion dollar fraud.

- **Detecting Credit Card fraud**

  Use learning methods to describe a given person (or general) credit card usage model.

  Detect patterns that deviate from an expected norm.

Market Analysis and Management

- **Customer profiling**

  We use learning algorithms (clustering or classification) to identify:

  1. what types of customers buy what products;
  2. customer preferences;
  3. the best products for different customers

Business Summary

- **Learning Process** (called also Data Mining in a case of very large data sets)
- helps to improve competitive advantage of organizations in dynamically changing environment;
- it improves clients retention and conversion
- **Different methods** are requiered for different kind of **data** and different kinds of **goals**

Scientific Applications

- Networks failure detection
- Controllers
- Geographic Information Systems
- Genome- Bioinformatics
- Intelligent robots
- Intelligent rooms
- etc… etc ….

What is NOTLearning

- Once the **patterns** are FOUND and TESTED the **learning process is finished**
- Use of the patterns **is not** Learning
- Querries to the database **are not** Learning

Evolution of Database Technology

- 1960s:

  Data collection, database creation, IMS and network DBMS

- 1970s:

  Relational data model, relational DBMS implementation

Evolution of Database Technology c.d.

- 1980s:

  RDBMS, advanced data models (extended-relational, OO, deductive, etc.) and application-oriented DBMS (spatial, scientific, engineering, etc.)

- 1990s—2000s:

  Data mining (learning is an integral part of it) and data warehousing, multimedia databases, and Web databases

  BIG DATA – new name

Learning process LP

- Learning Process is a **non trivial** process for identification of :

  Valid (tested)

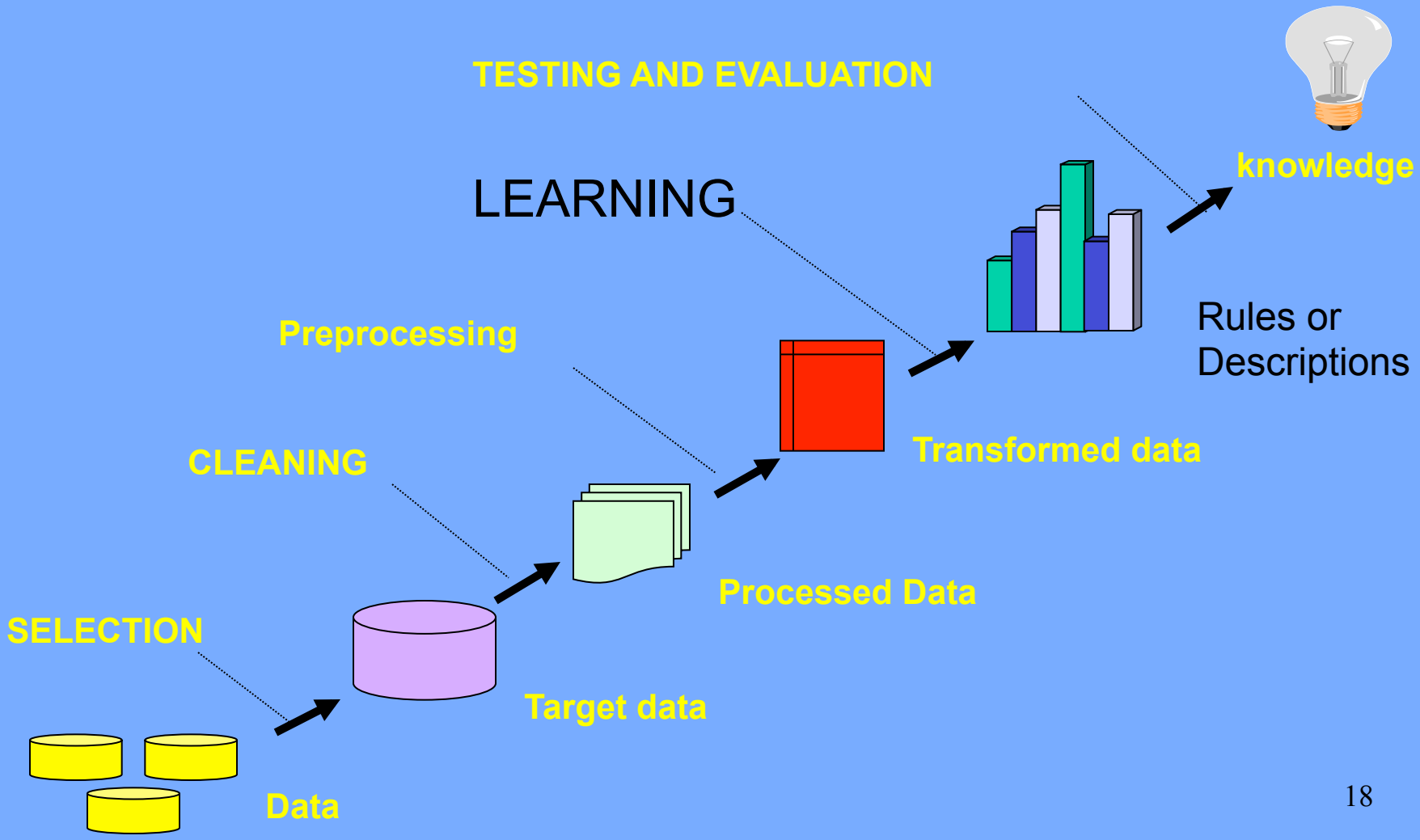
  New

  Potentially useful

  Understable (when possible)

  patterns in data

The Learning Process (LP)



LEARNING

- **Learning** is a step of the LP process in which algorithms are applied to look for **patterns in data**
- It is necessary to TEST and EVALUATE obtained **patterns**
- It is also necessary to apply first the preprocessing operation;
- to clean and preprocess the data in order to obtain **significant patterns**

Steps of the Learning Process

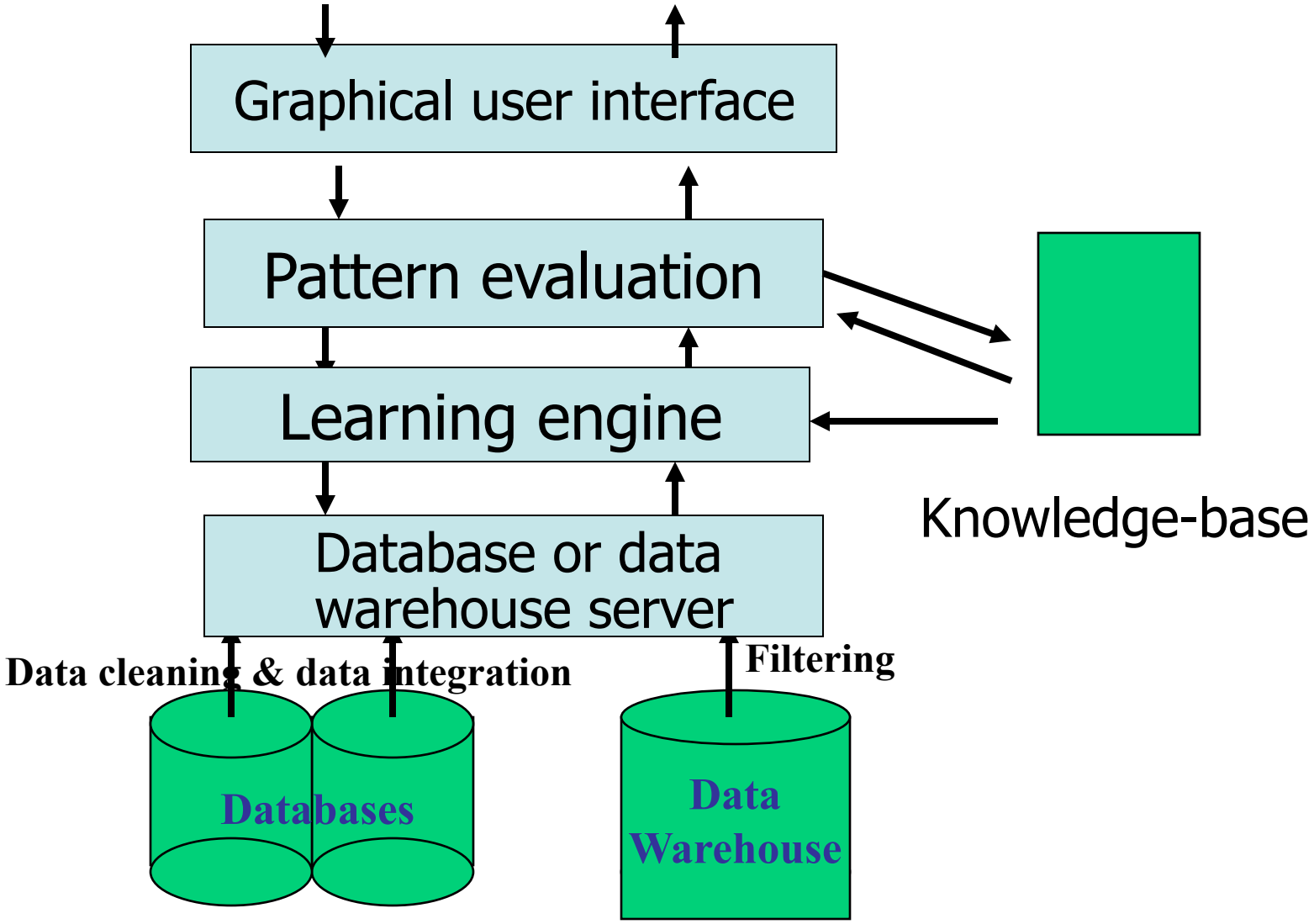
Preprocessing: includes all the operations that have to be performed **before** a learning algorithm is applied

Learning : algorithms are applied (to training data) in order to obtain the patterns

Testing: testing methods are applied **to test the learned patterns**

Interpretation: discovered patterns are presented in a proper format and the user decides if it is neccesary **to re-iterate the algorthms**

Architecture of a Typical Learning System



Learning
What Kind of Data?

- Relational Databases
- Data warehouses
- Transactional databases
- Advanced DB and information repositories
  - Object-oriented and object-relational databases
  - Spatial databases
  - Time-series data and temporal data
  - Text databases and multimedia databases
  - Heterogeneous and legacy databases
  - WWW

RELATIONAL DATA

- **We assume** for our considerations that **data used** in the learning algorithms are presented
- in a form of a **relational table** with the **key attribute removed**

Learning the **Characteristic Rules**

- ***It is a process which aim is to find rules that describe characteristic properties of a concept. They take the form***

If *concept* ***then*** *characteristics*

- C=1 → A=1 & B=3 **25%** (support: there are 25% o the records for which the rule is true)
- C=1 → A=1 & B=4 **17%**
- C=1 → A=0 & B=2 **16%**

Learing the Discriminat Rules

- ***It is a process which aim is to find rules that allow us to discriminate the objects (records) belonging to a given concept (one class) from the rest of records (classes)***

If characteristics then concept

- **A=0 & B=1 → C=1 33% 83% (support, confidence: the conditional probability of the concept given the characteristics)**
- **A=2 & B=0 → C=1 27% 80%**
- **A=1 & B=1 → C=1 12% 76%**
- Discriminant rules can be accepted even if they have a low support (and high confidence)

Learning Functionalities

- **Classification, Classification Prediction** **is also called Supervised Learning**
- **Supervised Learning**

  Finding models (rules) that describe (characterize) or/ and distinguish (discriminate) classes or concepts for future prediction

  Example: classify countries based on climate (characteristics), or classify cars based on gas mileage and use it to predict classification of a new car

  Models, algorithms, methods: decision-tree, neural network, Bayes Network, Rough Sets, genetic algorithms

  Presentation of results: characteristic and /or discriminant rules, converged neural network, or Bayes network

Clustering
(Unsupervised Learning)

- **Cluster analysis (statistical method)**

  Class label is unknown;

  algorithms group data to form new classes;

  It is also called **unsupervised learning**

  For example: cluster houses to find distribution patterns

  Clustering is based on the principle:

  maximizing the intra-class similarity and **minimizing** the interclass similarity

Clustering

- Database segmentation
- Given a set of objects (records) the algorithm obtains a division of the objects into clusters in which the distance of objects inside a claster is minimal and the distance among objects of diferent clusters is maximal
- **Unsupervised learning**

Classification (Supervised Learning)

- Given a set of objects (concept, class) described by a concept attribute or a set of attributes, a classification algorithms builds a set of discriminant and /or characterization rules (or other descriptions) in order to be able, as the next step, to classify unknown sets of objects
- This is also called a supervised learning

Classification Methods, Models, Algorithms

- DESCRIPTIVE:
  Decision Trees (ID3, C4.5)
- Rough Sets
- Genetic Algorithms
- STATISTICAL:
- Neural Networks
- Bayesian Networks

Summary

- **Learning: discovering interesting patterns from often large amounts of data**
- **A natural evolution of database technology, in great demand, with wide applications**
- **Learning process LP includes data cleaning, data integration, data selection, transformation, learning, testing, pattern evaluation, and knowledge presentation**
- **Learning can be performed in a variety of information repositories**

Preprocesing

Preprocesing

- Preprocessing is a process in which we
- select, integrate, and clean the data;
- decide which kind of patterns are needed;
- decide which algorithm is the best;
- prepare data for algorithms

Implementation Preparation (1)

- Identify the problem to be solved.
- Study it in detail
- Explore the solution space,
- Find one acceptable solution (feasible to implement)
- Specify the solution
- Prepare and preprocess the data

Preparation (2)

- Remember GIGO! (garbage in gabage out)
- Add some data, if necessary
- Structure the data in a proper form
- Be careful with incomplete and noisy data

Studying the data

- The surrounding world consists of objects (data) and the Learning Process goal is to find the **relationships among objects**
- The objects are characterized by properties (attributes, values of attributes) that have to be analized
- The results (rules, descriptions) are valid (true) under certain circumstances (data we learn from) and in certain moments (avaible data at the moment)

Types of data

- Generally we distinguish:

  Quantitative Data

  Qualitative Data

- Bivaluated: often very useful
- Null Values are not applicable
- Missing data usually not acceptable

What to take into account

- Eliminate redundant records
- Eliminate out of range values of attributes
- **Decide a generalization level**
- Decide on the accuracy level

Summary

- The preprocessing is usually required and is an essential part of the **LP process**
- If preprocessing is not performed the patterns obtained could be of no use.
- Preprocessing is a tedious task that could even take more time that the **Learning proper**