# Introduction to Supervised and UnsuspervisedLearning

**Cse352 Lecture Notes**

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# 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

  **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
- The 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

# Learning process LP

- LP is a non trivial process for identification of :

  Valid (tested)

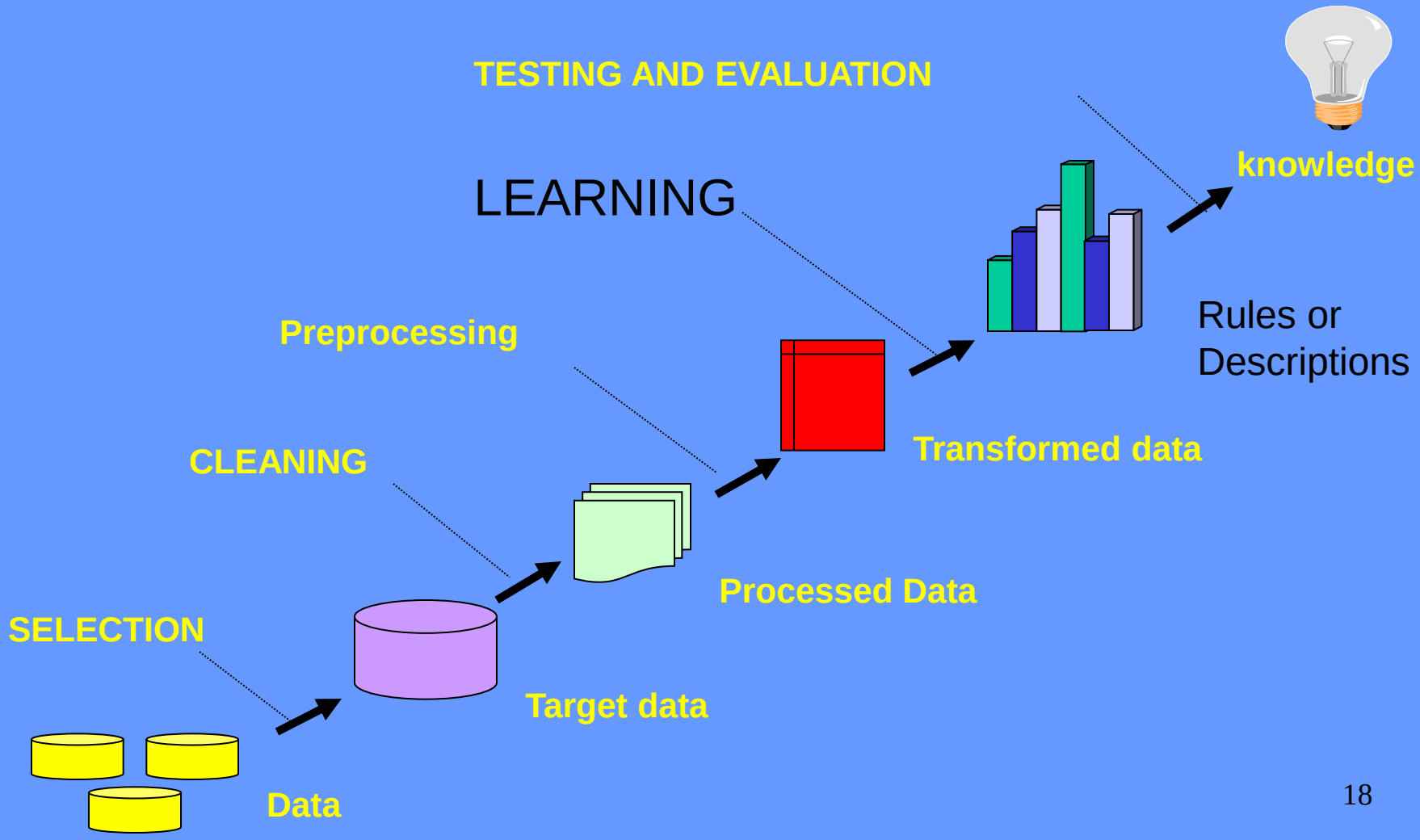
  New

  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 LP process

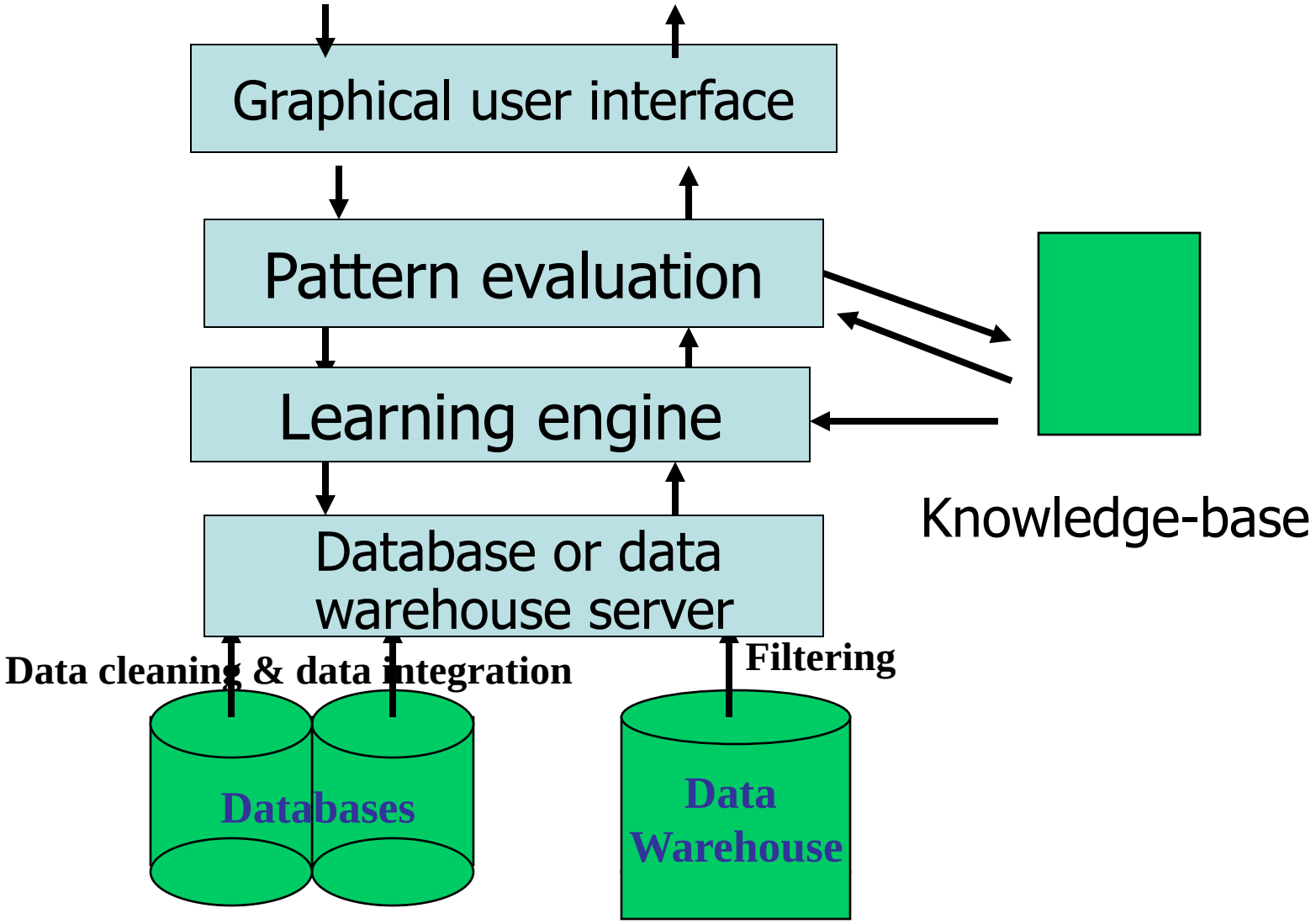
**Preprocessing:** includes all the operations that have to be performed before a learning algorithm is applied

**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

- ***Describes the 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 the 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