Cse352
Artifficial Intelligence
Classification Learning
Short Review

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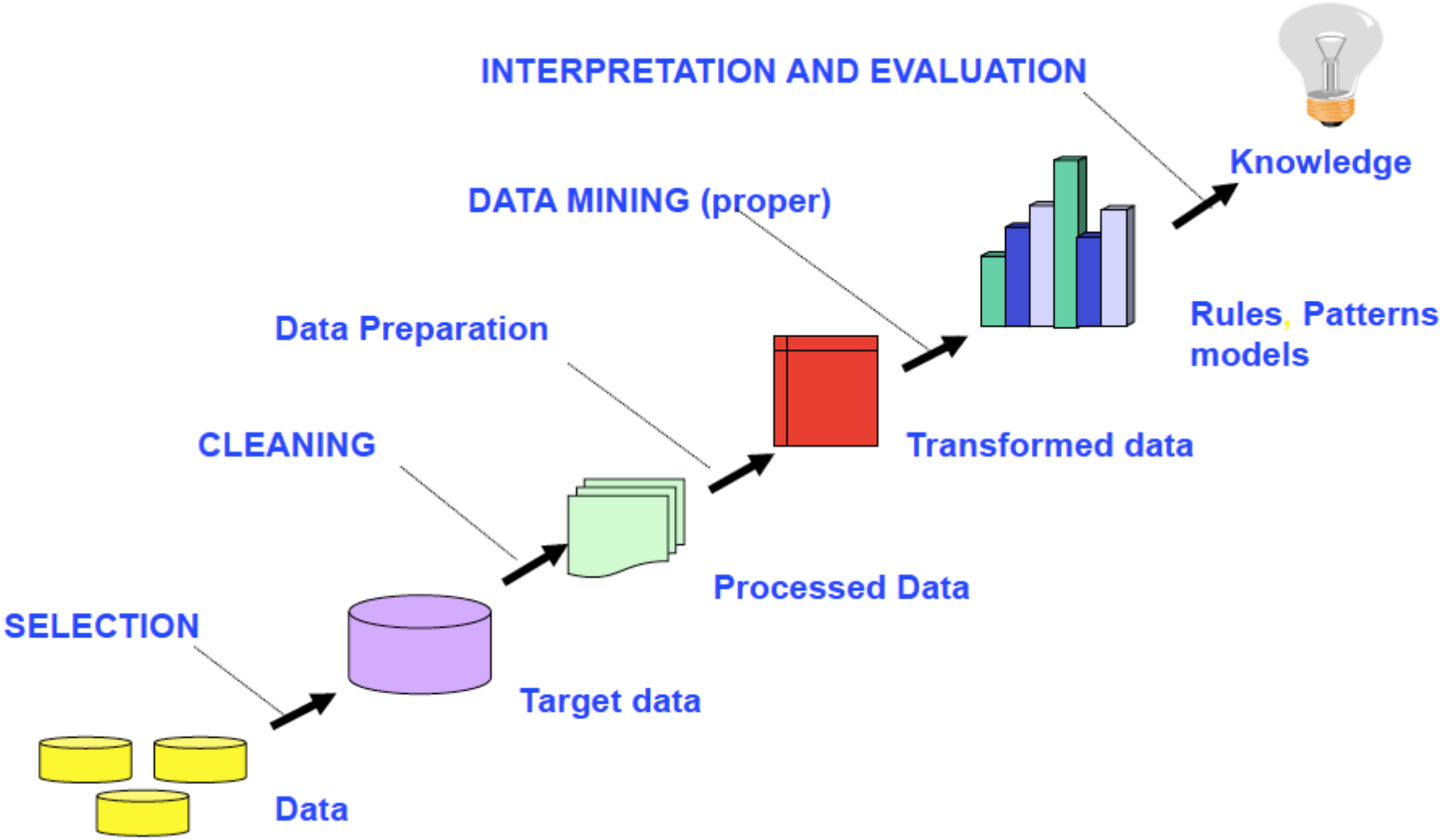
Data Mining Process



Preprocessing stage

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

- Data in the real world is dirty: incomplete, noisy and inconsistent.
- Quality decisions must be based on quality Data.

Preprocessing stage

- Data cleaning
- – Fill in missing values, smooth noisy data (binning, clustering, regression), identify or remove outliers, and resolve inconsistencies
- Data integration
- – Integration of multiple databases, data cubes, or files

Preprocessing stage

- **Data transformation**

- **Normalization** and aggregation
- **Data reduction** and attribute selection
- Obtains reduced presentation in volume but produces the same or similar analytical results (stratified sampling, PCA, cluster)

- **Data discretization**
- Part of data reduction but reduces the number of values of the attributes by dividing the range of attributes into intervals (segmentation by natural partition, hierarchy generation)
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Learning, Data Mining Proper

- DM, Learning proper is a step in the
- **DM, Learning process** in which algorithms are applied to obtain **patterns** in data.

- It can be re-iterated- and usually is

Descriptive/Non-Descriptive Models

- **Statistical** and **Descriptive**
- **Statistical models** use historical data to predict some unknown or missing numerical values
- **Descriptive models** aim to find patterns in the data that provide some information about what the data contains
- In case of Classification they often present the knowledge as a set of **rules** of the form IF.... THEN…

Classifications Models

- **Descriptive:** Decision Trees, Rough Sets, Classification by Association
- **Statistical:** Neural Networks, Bayesian Networks, Cluster, Outlier analysis, Trend and evolution analysis
- **Optimization method:** Genetic Algorithms – can be descriptive

Classification

- **Classification:**
- Finding models (rules) that describe (characterize) or/ and distinguish (discriminate) classes or concepts for future prediction
- **Classification Data Format**:
- a data table with key attribute removed.
- Special attribute, called a class attribute must be distinguished.
- The values: c1, c2, ...cn of the class atrribute C are called **class labels**
- The class label attributes are discrete valued and unordered.

Classification

- **Goal:**
- **FIND** a minimal set of **characteristic and/or discriminant rules**, or **other descriptions** of a class C, or all classes, or some classes

- We also want the found rules to involve as few attributes as it is possible

Classification

- **Stage 1:** build the basic patterns structure- **training**
- **Stage 2:** optimize parameter settings; can use (N:N) re-substitution- **parameter tuning**
- Re-substitution error rate = training data error rate
- **Stage 3:** use **test data** to compute- predictive accuracy/error rate - **testing**

Decision Tree

- DECISION TREE
- A flow-chart-like tree structure；
- Internal node denotes an attribute;
- Branch represents the values of the node attribute;
- Leaf nodes represent class labels

DT Basic Algorithm

- The **basic DT algorithm** for decision tree construction is a greedy algorithm that constructs decision trees in a top-down recursive divide-and-conquer manner

- Tree STARTS as a single node representing all training dataset (data table with records called samples)
- **IF** the samples (records in the data table) are all in the same class, **THEN** the node becomes a leaf and is labeled with that class
- The algorithm uses the same process recursively to form a **decision tree** at each partition

DT Basic Algorithm

- The recursive partitioning **STOPS** only when any one of the following conditions is TRUE
- **1.** All records (samples) for the given node belong to the same class
- **2.** There are no remaining attributes on which the samples (records in the data table) may be further partitioned – a **LEAF** is created with **majority vote** for training sample
- **3.** There is no records (samples) left – a **LEAF** is created with **majority vote** for training sample

- **Majority voting** involves converting node N into a leaf and labeling it with the most common class in **D** which is a set of training tuples and their associated class labels

Attribute Selection Measures

- **Some Heuristics:**
- Some Decision Tree Attribute Selection Measures are:
- **Information Gain, Gini Index**

- **We use them for selecting the attribute that "best" discriminates the given tuples according to class**

Neural Networks

- Neural Network is a set of connected INPUT/OUTPUT UNITS, where each connection has a WEIGHT associated with it
- Neural Network **learns** by adjusting the weights so as to be able to correctly classify the training data and hence, after testing phase, to **classify unknown data**
- Neural Network needs long time for training Determining network topology is difficult
- Choosing single learning rate impossible (train with subset)
- Neural Network has a **high tolerance** to noisy and incomplete data
- NN is generally better with larger number of hidden units

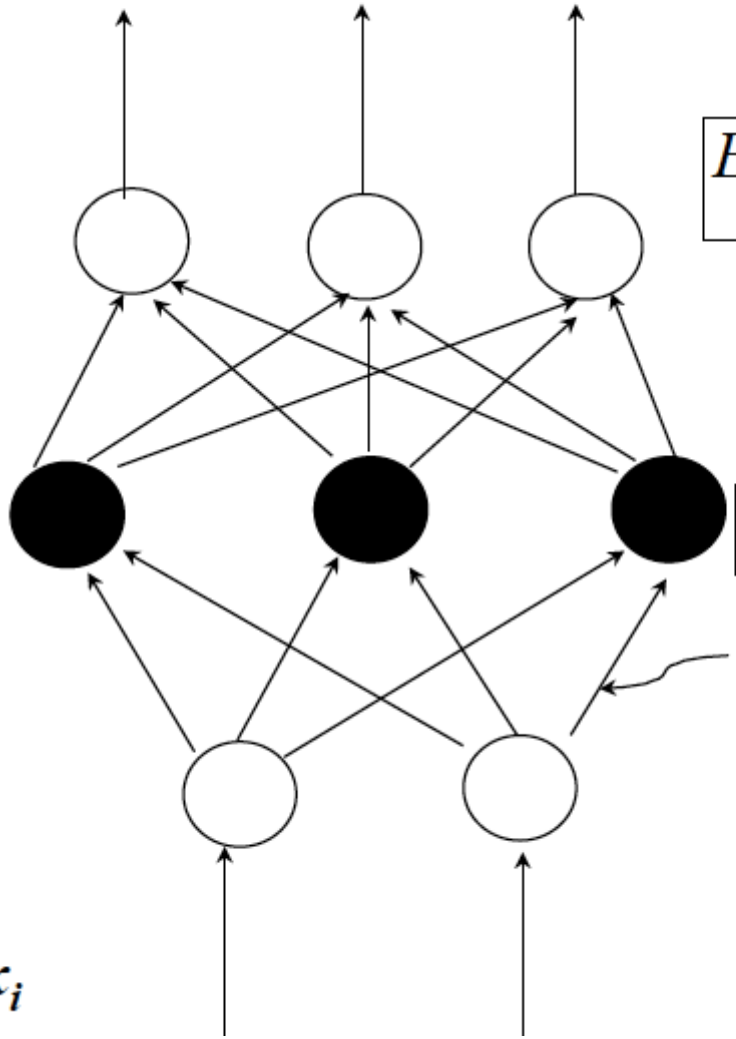
Neural Networks

- The inputs to the network correspond to the attributes and their values for each training tuple
- Inputs are fed simultaneously into the units making up the input layer
- Inputs are then weighted and fed simultaneously to a hidden layer
- The number of hidden layers is arbitrary, although often only one or two
- The weighted outputs of the last hidden layer are input to units making up the output layer, which emits the network's prediction

Neural Networks

- For each training sample, the weights are first set random then they are modified as to minimize the mean squared error between the network's classification (prediction) and actual classification
- **Backpropagation Algorithm:**
- STEP ONE: initialize the weights and biases
- STEP TWO: feed the training sample
- STEP THREE: propagate the inputs forward
- STEP FOUR: backpropagate the error
- STEP FIVE: backpropagate the weights, biases
- STEP SIX: repeat and apply Terminating Conditions

Backpropagation Formulas



$$Err_j = O_j(1-O_j)\sum_k Err_k w_{jk}$$

$$\theta_j = \theta_j + (l)Err_j$$

$$w_{ij} = w_{ij} + (l)Err_j O_i$$

$$Err_j = O_j(1-O_j)(T_j - O_j)$$

$$O_j = \frac{1}{1+e^{-I_j}}$$

$$I_j = \sum_i w_{ij} O_i + \theta_j$$

Back propagation

- **Terminating Conditions**:
- **Process Stops** when:
- All wij in the previous epoch are below some threshold
- The percentage of samples misclassified in the previous epoch is below some threshold
- a pre- specified number of epochs has expired

Building a classifier

- **Building a classifier** consists of two phases**: training** and **testing**.
- We use the training data set to **create patterns**: rules, trees, or to train a Neural or Bayesian network
- We evaluate created patterns with the use of **test data**
- We **terminate** the process of building a classifier
- if it has been **trained** and **tested** and the **predictive accuracy** is on an acceptable level.
- CLASSIFIER is a **final product** of the process.
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- PREDICTIVE ACCURACY of a classifier is a percentage of well classified data in the test data set.

Training and Testing

- The **main methods** of predictive accuracy evaluations are:
- Re-substitution (N ; N)
- Holdout (2N/3 ; N/3)
- k-fold cross-validation (N- N/k ; N/k)
- Leave-one-out (N-1 ; 1)