Cse352
Artifficial Intelligence
Short Review for Midterm

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Midterm

- Midterm INCLUDES
- CLASSIFICATION
- CLASSIFOCATION by Decision TREES
- and
- PRODUCTION SYSTEMS
- PROPOSITIONAL RESOLUTION
- material you needed to review for Q1

Learning Process

- Questions:
- Describe and discuss all stages of the Data Mining-Learning Process
- Describe the role of Preprocessing stage and its main methods
- Discuss the Data Mining –Learnong Proper stage
- Describe what is Descriptive/ non Descriptive Learning Which Models you would use for the Descriptive Learning and which for the non DescriptiveLearning
- How and what decides which type of Learning is the best to use (implement)
- Give examples of types of applications and the best Models (algorithms) for them

Classification

- Describe what is CLASSIFICATION; type of data, goals and applications
- Describe all stages of the classification process
- Describe and discuss basic classification Models and their differences
- Discuss the Decision Tree Induction and its strengths and weaknesses
- Define a CLASSIFIER
- Describe a process of building a CLASSIFIER

Classification Data and Rules

Given a classification dataset **DB** with a set

A = {*a1, a2,…, an*} of **attributes** and a **class** attribute **C** with values

{c1, c2,…, ck} - **k classes**

Definition 1

Any expression ***a1 = v1 & … & ak = vk*** where ***ai*** ∈ **A** and ***vi*** are corresponding values of attributes from **A**

is called a **DESCRIPTION**

Any expression **C = *ci*** is for ***ci*** ∈ ***{c1, c2,…, ck}***

Is called a **CLASS DESCRIPTION**

Classification Data and Rules

Definition 2

A **CHARACTERISTIC FORMULA** is any expression

$$C = ck \Rightarrow a1 = v1 \ \& \ldots \& \ ak = vk$$

We write is as

CLASS ⇒ DESCRIPTION

Definition 3

A **DETERMINANT FORMULA** is any expression

$$a1 = v1 \ \Lambda \ldots \Lambda \ ak = vk \Rightarrow C = ck$$

We write it as

DESCIPTION ⇒ CLASS

Classification Data and Rules

Definition 4

A characteristic formula

CLASS ⇒ DESCRIPTION

is called a **CHARACTERISITIC RULE** of the classification dataset **DB**

iff

it is **TRUE** in **DB**, i.e. when the following holds

{o: DESCRIPTION} ∩ **{o: CLASS} not=** ∅

Where

{o: DESCRIPTION}

is the set of all records of DB corresponding to the **DESCRIPTION**

{o: CLASS} is the set of all records of DB corresponding to the **CLASS**

Classification Data and Rules

Definition 5

A discriminant formula

DESCRIPTION $\Rightarrow$ CLASS

is called a **DISCRIMINANT RULE** of **DB**

iff

it is **TRUE in DB,** i.e. the following conditions hold

1. **{o: DESCRIPTION} not= $\emptyset$**

2. **{o: DESCRIPTION} $\subseteq$ {o: CLASS}**

PROBLEM 1

Prove

that for any **classification** data base **DB**

and any of its **DISCRIMINANT RULES** of the form

DESCRIPTION ⇒ CLASS

the formula $\subseteq$

CLASS ⇒ DESCRIPTION

is a **CHARACTERISTIC RULE** of the **DB**

PROBLEM 1 Solution

By **definition 5**, for any database DB :

DESCRIPTION ⇒ CLASS

is a **DISCRIMINANT RULE** **iff**

1. {o: DESCRIPTION} not= ∅

2. {o: DESCRIPTION} ⊆ {o: CLASS}

Therefore,

{o: DESCRIPTION} ∩ {o: CLASS} not= ∅

and by **Definition 4**

CLASS ⇒ DESCRIPTION

Is the **CHARACTERISITIC RULE**

PROBLEM 2

Given a dataset:

Record	A1	A2	A3	A4	C
O1	1	1	1	0	1
O2	2	1	2	0	2
O3	0	0	0	0	0
O4	0	0	2	1	0
O5	2	1	1	0	1

Find the set **{o :DESCRIPTION}**
for the following descriptions

1) a1 = 2 & a2 = 1
2) a3 = 1 & a4 = 0
3) a2 = 0 & a3 = 2
4) c=1
5) c=0

PROBLEM 2 SOLUTION

Find the set **{o :DESCRIPTION}**
for the following descriptions

1) a1 = 2 & a2 = 1 Answer : {o1 }

2) a3 = 1 & a4 = 0 Answer : {o1 , o5}

3) a2 = 0 & a3 = 2 Answer : {o4}

4) c=1 Answer : {o1,o5}

5) c=0 Answer : {o3 ,o5}

PROBLEM 3

For the following formulae use proper definitions to determine (**it means prove**) whether **they are / are not DISCRIMINANT / CHARACTERISTIC RULES** of our dataset.

6) a1 = 1 & a2 = 1 ⇒ C = 1

7) C =1 ⇒ a1 = 0 & a2 = 1 & a3 = 1

8) C = 2 ⇒ a1 = 1

9) C = 0 ⇒ a1 = 1 & a4 = 0

10) a1 = 2 & a2 = 1 & a3 = 1 ⇒ C = 0

11) a1 = 0 & a3 = 2 ⇒ C = 1

PROBLEM 3 SOLUTION

For the following formulae use proper definitions to determine (**it means prove**) whether **they are / are not DISCRIMINANT / CHARACTERISTIC RULES** of our dataset.

6) a1 = 1 & a2 = 1 ⇒ C = 1
{o1} is a subset of {o1 , o5} so **this is a DISCRIMINANT** rule

7) C =1 ⇒ a1 = 0 & a2 = 1 & a3 = 1
{o: a1 = 0 & a2 = 1 & a3 = 1 } is an empty set so this is **not** a CHARACTERISTIC rule

8) C = 2 ⇒ a1 = 1
As the intersection is empty so this is **not** a **CHARACTERISTIC** rule

9) C = 0 ⇒ a1 = 1 & a4 = 0 ----- {o3 , o4} /\ {o5} is empty set so this is
not a CHARACTERISTIC rule

10) a1 = 2 & a2 = 1 & a3 = 1 ⇒ C = 0 ----- {o5} is not a subset of {o3 , o4} , so this is
not a DISCRIMINANT rule

11) a1 = 0 & a3 = 2 ⇒ C = 1 ----- {o4} is not a subset of {o1 , o5} , so this is
not a DISCRIMINANT rule

Classification

- Describe what is Classification; which is the goal, what data one needs etc….
- Describe all stages of the Classification Process
- Describe basic methods of training and testing
- Describe the process of building a CLASSIFIER
- What is a CLASSIFIER?

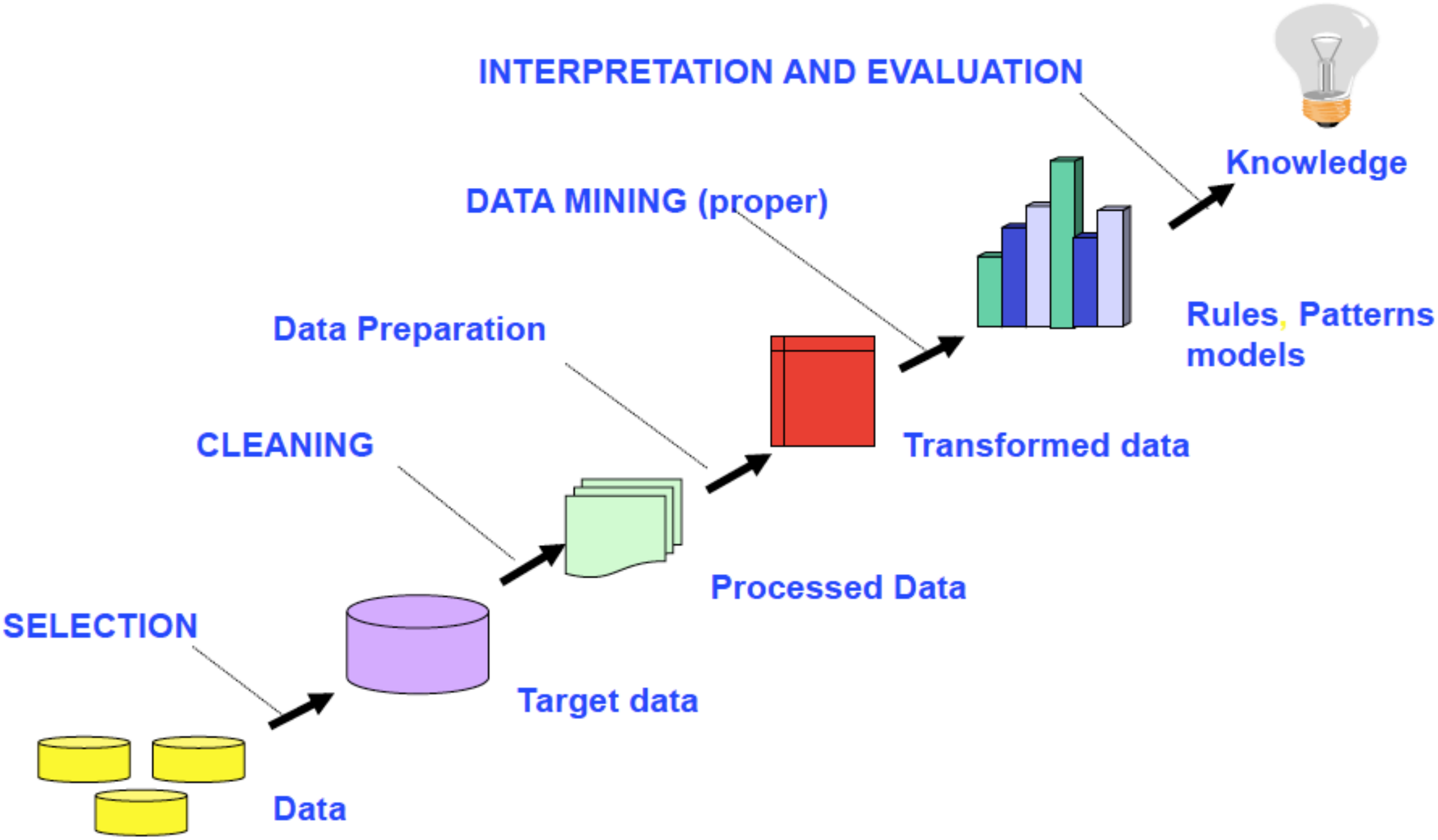
Problem: Classification by DTREE

1. Use the data below build a CLAFSSIFIER by basic DTREE algorithm
2. Use 2 different testing Method of your choice and compare the results

CLASSIFICATION DATA

Record	A1	A2	C
1	1	1	1
2	0	0	0
3	0	1	0
4	0	0	0
5	1	1	1
6	1	1	0
7	0	0	0
8	1	0	1

Data Mining Process



Preprocessing stage

- **Preprocessing:**
- includes all the operations that have to be performed before a data mining 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)
-

Learning Proper

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

- It can be re-iterated- and usually is

Descriptive / non descriptive models

- Statistical - descriptive
- Statistical data mining uses historical data to predict some unknown or missing numerical values
- Descriptive data mining aims to find patterns in the data that provide some information about what the data contains
- often presents the knowledge as a set of rules of the form IF.... THEN...

Models

- **Discriptive:** 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 the class C, or all, or some other 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:**
- Dtree: some Attribute Selection Measures
- **Information Gain, Gini Index**

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

Rule Based Systems REVIEW Exercise

- Exercise 1
- Here are three simple **expert rules**
- **R1:** If your savings are small, then don’t invest in stocks
- **R2:** If you have no children and large income, then invest in stocks
- **R3:** If you have children and small income, then invest in savings

Exercise 1

- **Conceptualize** rules **R1, R2, R3**

in **Predicate Form** using predicates

attribute(x, value of attribute)

attribute(object, value of attribute)

WRITE a format of a database TABLE needed for your conceptualization

REMARK: In order to express the rules **Predicate Form** , we must first define appropriate ATTRIBUTES and their values

Exercise 1

- **We have the following ATTRIBUTES:**

- **Savings**

  Values: **small, large**
- **Income**

  Values: **small, large**

- **InvestStocks**

  Values: **yes, no**

- **InvestSavings**
- Values: **yes, no**

- **Children**

  Values: **yes, no**

Exercise 2

- Exercise 2
- **The initial database has the following FACTS**
- F1: Savings(John, small)
- F2: Children(John, no)
- F3: Income(John, large)
- Are these FACTS true in Exercise 1 Data Table for some record o =John?
- Design a Data Table 2 in which the above **FACTS** are true
- Can you deduce InvestStocks(John, yes) on the base of the Data Table 2

Exercise 1: Predicate Form Conceptualization Data Table Example

Records	Savings	Income	InvesrStocks	InvestSavings	Children
O_1	small	small	yes	yes	yes
O_2	large	small	no	no	no
O_3	small	large	yes	yes	no

Rules in Predicate Form

- **RULES:**
- **R1:** Savings(x,small) → InvestStock (x, no)
- **R2:** Children(x, no) /\ Income(x,large)→ InvestStocks(x, yes)
- **R3:** Children(x, yes)) /\ Income(x, small)→ InvestSavings(x,yes)
-

Rules in Predicate Form

- **RULES:**
- **R1:** Savings(x,small) → InvestStock (x, no)
- **R2:** Children(x, no) /\ Income(x,large)→ InvestStocks(x, yes)
- **R3:** Children(x, yes)) /\ Income(x, small)→ InvestSavings(x,yes)

Exercise 1: Rules in Predicate Form

- **RULES:**

- **R1:** Savings(x, small) → InvestStock (x, no)

- **R2:** Children(x, no) /\ Income(x, large)→ InvestStocks(x, yes)

- **R3:** Children(x, yes)) /\ Income(x, small)→ InvestSavings(x, yes)

PART3: Exercise 2

- Exercise 2
- **The initial database has the following FACTS**
- F1: Savings(John, small)
- F2: Children(John, no)
- F3: Income(John, large)
- **1.** Are these FACTS true in Exercise 1 Data Table for a record o = John?
- **2.** Design a Data Table 2 in which the above **FACTS** are true
- **3.** Can you deduce InvestStocks(John, yes) on the base of the Data Table 2

Part 3: Exercise 3

- Given rules from Exercise 1:
- **R1:** If your savings are small, then don't invest in stocks
- **R2:** If you have no children and large income, then invest in stocks
- **R3:** If you have children and small income, then invest in savings

Exercise 3

- **Conceptualize** rules **R1, R2, R3**

In **Propositional Logic** in two ways:

1. Rules admit **only** atomic formulas; i.e. rules are built from propositional variables only – call the set of rules **PR1**
2. Rules admit atomic formulas and negation of atomic formulas – call obtained set of rules **PR2**

Part 3: Exercise 3

- Write initial databases B1 and B2

  of facts corresponding to the facts F1, F2, F3 from Exercise 2 for

- (1) propositional conceptualization 1.
- (2) propositional conceptualization 2.
- (3) use corresponding rules from sets

  PR1, PR2 to deduce all facts from

  B1 and B2, respectively

  Use **Conflict Resolution** from Busse Handout