Principles of Knowledge Discovery in Data

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Chapter 4: Data Mining Operations

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Source:
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Summary of Last Chapter

- What is the motivation behind data preprocessing?
- What is data cleaning and what is it for?
- What is data integration and what is it for?
- What is data transformation and what is it for?
- What is data reduction and what is it for?
- What is data discretization?
- How do we generate concept hierarchies?

Course Content

- Introduction to Data Mining
- Data warehousing and OLAP
- Data cleaning
- **Data mining operations**
- Data summarization
- Association analysis
- Classification and prediction
- Clustering
- Web Mining
- Spatial and Multimedia Data Mining
- *Other topics if time permits*

Chapter 4 Objectives

Realize the difference between data mining operations and become aware of the process of specifying data mining tasks.

Get an brief introduction to a query language for data mining: DMQL.

Data Mining Operations Outline

- What is the motivation for ad-hoc mining process?
- What defines a data mining task?
- Can we define an ad-hoc mining language?

Motivation for ad-hoc Mining

- Data mining: an interactive process
  - user directs the mining to be performed
- Users must be provided with a set of **primitives** to be used to communicate with the data mining system.
- By incorporating these primitives in a **data mining query language**
  - User's interaction with the system becomes more flexible
  - A foundation for the design of graphical user interface
  - Standardization of data mining industry and practice

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Data Mining Operations Outline

- What is the motivation for ad-hoc mining process?
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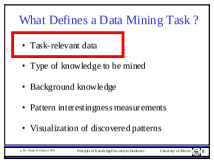
What Defines a Data Mining Task ?

- Task-relevant data
- Type of knowledge to be mined
- Background knowledge
- Pattern interestingness measurements
- Visualization of discovered patterns

Task-Relevant Data



- Database or data warehouse name
- Database tables or data warehouse cubes
- Condition for data selection
- Relevant attributes or dimensions
- Data grouping criteria

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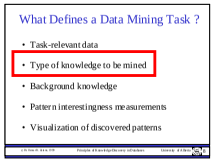
Types of Knowledge to Be Mined



- Characterization
- Discrimination
- Association
- Classification/prediction
- Clustering
- Outlier analysis
- and so on …

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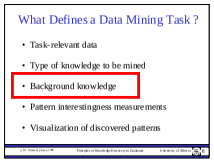
Background Knowledge



- Concept hierarchies
  - schema hierarchy
    - *Ex.* street < city < province_or_state < country
  - set-grouping hierarchy
    - *Ex.* {20-39} = young, {40-59} = middle_aged
  - operation-derived hierarchy
    - e-mail address, login-name < department < university < country
  - rule-based hierarchy
    - low_profit (X) <= price(X, P1) and cost (X, P2) and (P1 - P2) < $50

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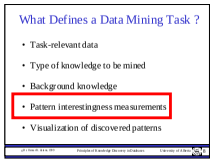
Pattern Interestingness Measurements



- Simplicity

  Ex. rule length
- Certainty

  Ex. confidence, P(A\B) = Card(A ∩ B)/ Card (B)
- Utility

  potential usefulness

  Ex. Support, P(A∪B) = Card(A ∩ B) / # tuples
- Novelty

  not previously known, surprising

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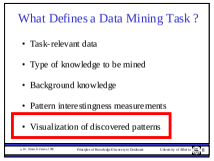
Visualization of Discovered Patterns

- Different background/purpose may require different form of representation
  - *Ex.*, rules, tables, crosstabs, pie/bar chart, etc.
- Concept hierarchies is also important
  - discovered knowledge might be more understandable when represented at high concept level.
  - Interactive drill up/down, pivoting, slicing and dicing provide different perspective to data.
- Different knowledge requires different representation.



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A Data Mining Query Language (DMQL)

- Motivation
  - A DMQL can provide the ability to support ad-hoc and interactive data mining.
  - By providing a standardized language like SQL, we hope to achieve the same effect that SQL have on relational database.
- Design
  - DMQL is designed with the primitives described earlier.

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Syntax for DMQL

- Syntax for specification of
  - task-relevant data
  - the kind of knowledge to be mined
  - concept hierarchy specification
  - interestingness measure
  - pattern presentation and visualization
- Putting it all together — a DMQL query

Source:JH

Syntax for Task-relevant Data Specification

- ***use database*** database_name,

  or *use data warehouse* data_warehouse_name
- ***from relation***(s)/cube(s) [*where* condition]
- ***in relevance*** *to* att_or_dim_list
- ***order by*** order_list
- ***group by*** grouping_list
- ***having*** condition

Source:JH

Syntax for Specifying the Kind of Knowledge to be Mined

➢ Characterization

mine characteristics **[*as* pattern_name]**
analyze **measure(s)**

➢ Discrimination

mine comparison **[*as* pattern_name]**
for **target_class** ***where*** **target_condition**
{*versus* contrast_class_*i* *where*
contrast_condition_*i*}
analyze **measure(s)**

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Syntax for Specifying the Kind of Knowledge to be Mined

➢ Association

mine associations **[*as* pattern_name]**

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Syntax for Specifying the Kind of Knowledge to be Mined (Cont.)

➢ Classification

mine classification **[*as* pattern_name]**
analyze **classifying_attribute_or_dimension**

➢ Prediction

mine prediction **[*as* pattern_name]**
analyze **prediction_attribute_or_dimension**
{*set* {attribute_or_dimension_*i*= value_*i*}}

Source:JH

Syntax for Concept Hierarchy Specification

- To specify what concept hierarchies to use

  use hierarchy <**hierarchy**> **for** <**attribute_or_dimension**>

- We use different syntax to define different type of hierarchies
  - schema hierarchies

    define hierarchy time_hierarchy on date as [date,month quarter,year]
  - set-grouping hierarchies

    define hierarchy age_hierarchy for age on customer as

    level1: {*young, middle_aged, senior*} < level0: all

    level2: {20, ..., 39} < level1: *young*

    level2: {40, ..., 59} < level1: *middle_aged*

    level2: {60, ..., 89} < level1: *senior*

Source:JH

Syntax for Concept Hierarchy Specification (Cont.)

- operation-derived hierarchies

  define hierarchy age_hierarchy for age on customer as

  {age_category(1), ..., age_category(5)} := cluster(default, age, 5) < all**(age)**
- rule-based hierarchies

  define hierarchy profit_margin_hierarchy on item as

  level_1: low_profit_margin < level_0: all

  if (price - cost) ≤ $50

  level_1: medium-profit_margin < level_0: all

  if ((price - cost) > $50) and ((price - cost) ≤ $250))

  level_1: high_profit_margin < level_0: all

  if (price - cost) > $250

Source:JH

Syntax for Interestingness Measure Specification

- Interestingness measures and thresholds can be specified by the user with the statement:

  with <**interest_measure_name**> threshold = **threshold_value**
- **Example:**

  with support threshold **= 0.05**

  with confidence threshold **= 0.7**

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Syntax for Pattern Presentation and Visualization Specification

- We have syntax which allows users to specify the display of discovered patterns in one or more forms.

  display as <**result_form**>
- To facilitate interactive viewing at different concept levels, the following syntax is defined:

Multilevel_Manipulation ::= *roll up on* attribute_or_dimension
| *drill down on* attribute_or_dimension
| *add* attribute_or_dimension
| *drop* attribute_or_dimension

Source:JH

Putting It All Together: the Full Specification of a DMQL Query

use database **OurVideoStore_db**

use hierarchy **location_hierarchy for B.address**

mine characteristics as **customerRenting**

analyze **count%**

in relevance to **C.age, I.type, I.place_made**

from **customer C, item I, rentals R, items_rent S, works_at W, branch**

where **I.item_ID = S.item_ID and S.trans_ID = R.trans_ID**

and R.cust_ID = C.cust_ID and R.method_paid = ``Visa''

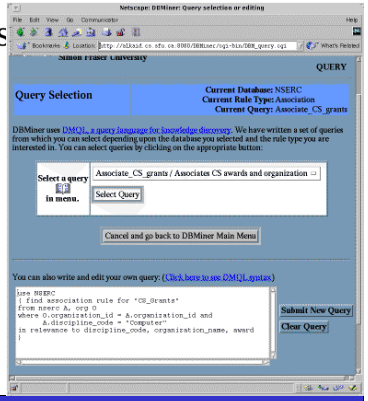
and R.empl_ID = W.empl_ID and W.branch_ID = B.branch_ID and B.address = ``Alberta'' and I.price >= 100

with **noise** threshold = **0.05**

display as **table**

Designing Graphical User Interfaces Based on a Data Mining Query Language

- Data collection and data mining query composition
- Presentation of discovered patterns
- Hierarchy specification and manipulation
- Manipulation of data mining primitives
- Interactive multi-level mining
- Other miscellaneous information



Summary: Five Primitives for Specifying a Data Mining Task

- task-relevant data
  - database/date warehouse, relation/cube, selection criteria, relevant dimension, data grouping
- kind of knowledge to be mined
  - characterization, discrimination, association...
- background knowledge
  - concept hierarchies,..
- interestingness measures
  - simplicity, certainty, utility, novelty
- knowledge presentation and visualization techniques to be used for displaying the discovered patterns
  - rules, table, reports, chart, graph, decision trees, cubes ...
  - drill-down, roll-up,....

Source:JH