What MDL can bring to Pattern Mining
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Types of patterns in terms of Formal Concept Analysis

Pattern Mining. What kind of patterns we should compute?

Introduction

Background Knowledge: Assumptions on Interestingness

Idea: use measures that reflect knowledge of experts about "interestingness" of patterns

Examples of interestingness measures for concept (A,B)

(area) "Interesting patterns are those that take the biggest area in dataset"[2]

(length) "Interesting patterns are the most detailed ones that are quite frequent in dataset"

[separation] "Interesting patterns are separated from the best from the context"

combined measures, etc.

Pattern Mining. What kind of patterns we should compute?

Total number of patterns is 2^|D|

Types of patterns in terms of Formal Concept Analysis

FCA. Basic Notions

A formal context (Ganter and Wille, 1999; Wille, 1982) is a triple (G,M,I), where G is a set objects, M is a set attributes, I ⊆ G × M is a relation called incidence relation.

The derivation operator (ς) is defined for Y ⊆ G and Z ⊆ M as follows:

ς(Y, Z) = \{ g ∈ G | \forall z ∈ Z: (g, z) ∈ I \}

A (formal) concept is a pair (Y, Z), where Y ⊆ G and Z ⊆ M and Y = Z ⪯ \mathcal{Z}. Y is called the (formal) extent and Z is called the (formal) intent of the concept (Y, Z).

A concept lattice (or Galois lattice) is a partially ordered set of concepts, the order ≺ is defined as follows: (Y, Z) ≺ (C, D) if Y ⊆ C and D ⊆ Z.

A concept (C, D) is a subconcept of (C, D) if and only if C ⊆ C and D ⊆ D.

Formal concepts ordered by generality relation (A, B) ≺ (A', B'), if A ⊆ A'.

Types of patterns (defined for concept (A,B)):

Closed Itemsets (intents) B. Minimal generators are minimal subsets B ⊆ B ≺ A.

Generators are any patterns between minimal generators and closed itemsets.

Minimal Description Length (MDL) Principle. Basic Definitions

The main principle: the best set of patterns is the set that best compresses the database [Breunig et al., 2011].

Objective: L(D; CT) = |D| + |CT| (w.r.t. CT), where L(D; CT) is the length of the dataset encoded with the code table CT and |CT| is the length of the code table CT computed w.r.t. D.

Key notions:

- Encoding length: length that "compresses", i.e. the most frequently used ones have the shortest encoding length.

- Code table: a set of selected patterns with their encoding lengths.

- Disjoint covering: principle of compression by patterns.

Total length:

L(D; CT; L) = \sum_l |B_l| \cdot \log_2 |B_l| + \sum_l \log_2 \sum_l |B_l| + \log_2 |B_l|

for each level: L(D; CT; L) = \sum_l \log_2 |B_l| + \log_2 \sum_l |B_l| + \log_2 \sum_l |B_l|

MDL: is there a place for background knowledge?

Idea: MDL as an additional filtering stage in pattern selection.

MDL-optimal (blue) vs top-n (green) closed itemsets

Non-redundancy

Distance to the 1st NN

Top-n concepts have a lot of “twins”, while MDL-optimal ones are pattern distinctive (w.r.t. Euclidean distance).

Non-redundancy

Average length of the longest paths built from posets (lattices)

A long path is an indicator of redundancy, since in that case patterns characterize the same objects at different levels of abstraction. Short paths correspond to “flat” structures with more varied patterns.

Pattern mining with area len, sep and area, sep...

The rate of covered "crosses" in object-attribute relation

A subset of selected patterns can be considered as a concise representation of a dataset. Thus, it is important to know how much information is lost by compression. It can be measured by the rate of covered attributes. Values close to 1 correspond to the lossless compression.

MDL ensures better covering and allows for the biggest gain for area-based orderings.

Data coverage

The rate of covered “crosses” in object-attribute relation

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MDL ensures better covering and allows for the biggest gain for area-based orderings.

Typicality (representativeness)

It is measured by the usage of patterns, i.e. the frequency of the occurrence of patterns in the greedy covering, so the usage does not exceed the frequency.

It is not obvious which values are better. The high values of usage correspond to a subset of common patterns, while low values indicates that a subset contains less typical, but still interesting (w.r.t. interestingness measures) patterns.

The usage of MDL-optimal patterns is almost the same for different orders while the usage of top-n is dependent on ordering.

References