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Procedia Computer Science 122 (2017) 1031–1038

Procedia Computer Science

www.elsevier.com/locate/procedia

Information Technology and Quantitative Management (ITQM 2017)

A Multi Attribute Value Theory approach to rank association rules for leveraging better business decision making

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Abstract

Market Basket Analysis or Association Rule Mining (ARM) is an approach to discover the purchase patterns of the customers by extracting and analyzing the basket of items which sell together. Businesses are also keen to discover those rules which can generate more profits. These profitable purchase patterns of customers once identified can lead to better product assortment decision making for businesses. Better Product Assortment decisions can surely be a competitive advantage for businesses in terms of customer satisfaction and profit generation. The concepts of support and confidence in the association rules help to extract the rules with frequent and reliable co-occurrences of the items in customers' purchases. The profitable rules can be assessed using the domain-related measures such as item set value and the cross-selling profit associated with the association rules. We propose a ranking mechanism to combine the different criteria of Confidence, Support, Item Set Value and Cross-Selling Profit to get an overall interestingness measure; using Multi-Attribute Value Theory (MAVT) approach; which in turn uses DIVIZ as the implementation tool. These association rules can be used as a leverage for the marketing activities like cross-selling promotions, shelf placement etc. and other crucial decisions like product assortment selection.

Peer-review under responsibility of the scientific committee of the 5th International Conference on Information Technology and Quantitative Management, ITQM 2017.

Keywords: Market Basket Analysis; Association Rules; Interestingness measure; Multi-Attribute Value Theory; Preferences; Business Decision Making

1. Introduction

"Data Mining is a step of knowledge discovery in databases consisting of applying data analysis and discovery algorithms that, under acceptable computational efficiency limitations, produce a particular enumeration of patterns over the data."[1] This paper uses concepts of Association Rule Mining (ARM) proposed by Agrawal et al [2]which is one of the main Data Mining Techniques. Association Rule Mining or Market Basket Analysis is an important Data Mining technique used to find interesting business rules or patterns hidden in the data. Market Basket Analysis uses certain set of criteria or constraints like Support and Confidence to generate rules. But rules so discovered always contain an element of suspicion that they may not be statistically valid. These rules may satisfy the criteria or constraints like support and confidence in sample data but not in the whole data distribution [3]. Thus, it becomes important to perform statistical validity for the rules before they are used for practical purposes because the very nature of Data Mining is data driven [4]. Agarwal et al. [2] introduced Association Rules also known as Market Basket Analysis which is helpful in decisions about marketing activities, e.g., promotional pricing or product placements. A rule is defined as:

- $X \rightarrow Y$ where $X,Y \subseteq I$ *and* $X \cap Y = \emptyset$; Here X and Y are known as item set
- X is called the Antecedent and Y is called the Consequent
- For instance from the table 1 given below if we have a rule {hard disk, laptop}→{mouse} then : Support =1/5=.2 and Confidence= 1/1=1

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Peer-review under responsibility of the scientific committee of the 5th International Conference on Information Technology and Quantitative Management, ITQM 2017.
10.1016/j.procs.2017.11.470

Table 1. A transaction level database

T.ID	EXTERNAL HARD DISKS	WIRELESS MOUSE	LAPTOP	WIRELESS KEYBOARD
1	1	1	0	0
2	0	0	1	0
3	0	0	0	1
4	1	1	1	0
5	0	1	0	0

Classical ARM can solve problems for Boolean attributes, since the association concerned is whether an item is present in a transaction or not, being a binary value 0 or 1. But a real world data base may contain attributes in different formats like integer, categorical (logical), real etc. Since we cannot apply classical ARM, we look for an alternate solution. We can handle such attributes by partitioning the attribute domains, and then transforming the problem into binary one. Suppose we have product catalogue data with attribute values of price and service (expected in 3 yrs.) cost associated with each laptop product as shown in figure 1:

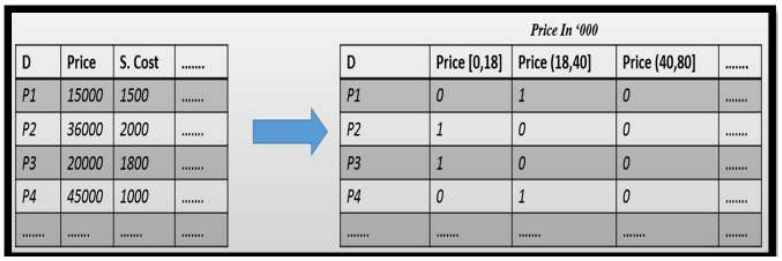

Fig. 1. Numerical attributes translated into Boolean attributes using partition

This partitioning approach induces a problem of sharp boundary which can be dealt with smoothening of boundary transitions with concepts like Fuzzy Sets etc. The Association Rules are generated based on Support and Confidence using Apriori Algorithm.

In the work presented in this paper, frequent rules are mined which are subjected to constraints or interestingness measures of confidence and support. Once the frequent and reliable rules are in place, measures like cross-selling profit and item set value are calculated for each rule which are useful in terms of business profits. These rules are ranked using a Multi-Attribute Value Theory Approach. The rules thus achieved are ready to be used in business intelligence. The rest of the paper is organized as follows. A brief literature review is presented in Section 2; and the proposed methodology is covered in Section 3. An illustrative example is presented in Section 4. Finally, the conclusions and future work is covered in Section 5.

2. Literature Review

The literature review is organized in three sections. We firstly take a brief look at the development of Association Rules. Then we discuss the past research works on the statistical validity of these rules and why research emphasizes this aspect. Finally, we discuss the research works done to find interesting rules based on criteria like support and confidence and DEA as a MCDM method in developing an aggregate score for rating the interesting rules.

2.1 Association Rule Mining

Association Rules also known as Market Basket Analysis is helpful in decisions about the marketing activities e.g., promotional pricing or product placements by identifying the hidden purchase patterns in data [2]. Association rule mining provides a flexibility to the decision makers to define the MBA model and its parameters like support and confidence in a way that suits the problem context and data [5]. It is important in terms of actual implementation of Association rules that only interesting rules should be left after final filtration; thus it is necessary to rank rules from data mining due to the number of quality rules [6] and business resource constraint [7]. A variety of domains like marketing, healthcare, logistics etc. supply their domain database to use Association Rule mining for Business Intelligence [8,9]. Support and confidence are taken as two measures to evaluate the interestingness of association rules [2,10]. Association rules are regarded as interesting if their