Chapter 33
Frequent Itemset Mining and Association Rules

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Category: Technologies for Knowledge Management

INTRODUCTION

With the advent of mass storage devices, databases have become larger and larger. Point of sale data, patient medical data, scientific data, and credit card transactions are just a few sources of the ever-increasing amounts of data. These large datasets provide a rich source of useful information. Knowledge Discovery in Databases (KDD) is a paradigm for the analysis of these large datasets. KDD uses various methods from such diverse fields as machine learning, artificial intelligence, pattern recognition, database management and design, statistics, expert systems, and data visualization.

KDD has been defined as "the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data." (Fayyad, Piaetsky-Shapiro, Smyth, 1996). The KDD process is diagramed in Figure 1.

First, organizational data is collated into a database. This is sometimes kept in a data warehouse, which acts as a centralized source of data. Data is then selected from the data warehouse to form the target data. Selection is dependent on the domain, the end-user's needs, and the data mining task at hand. The preprocessing step cleans the data. This involves removing noise, handling missing data items, and taking care of outliers. Reduction coding takes the data and makes it

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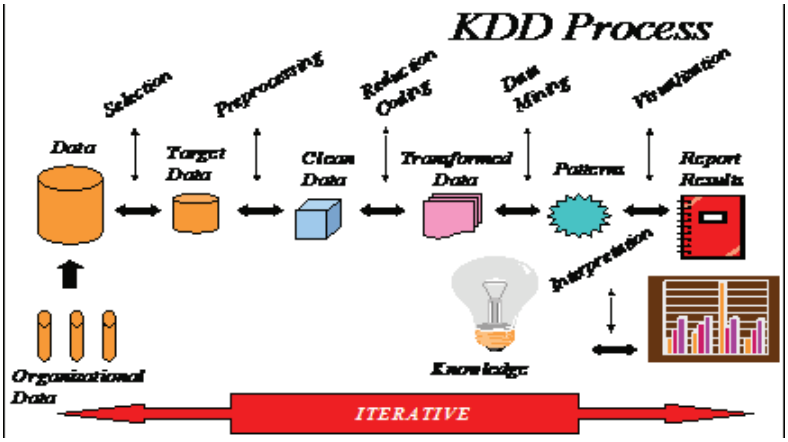
Figure 1. The KDD Process



usable for data analysis, either by reducing the number of records in the dataset, or the number of variables. The transformed data is fed into the data mining step for analysis to discover knowledge in the form of interesting and unexpected patterns that are presented to the user via some method of visualization. One must not assume that this is a linear process. It is highly iterative with feedback from each step into previous steps. Many different analytical methods are used in the data mining step. These include decision trees, clustering, statistical tests, neural networks, nearest neighbor algorithms, and association rules. Association rules indicate the co-occurrence of items in market basket data or in other domains. It is the only technique that is endemic to the field of data mining.

Organizations, large or small need intelligence to survive in the competitive market place. Association rule discovery along with other data mining techniques are tools for obtaining this business intelligence. Therefore, association rule discovery techniques are available in tool kits that are components of knowledge management systems. Since knowledge management is a continuous process, we expect that knowledge management techniques will, alternately, be integrated into the KDD process. The focus for the rest of this article will be on the methods used in the discovery of association rules.

BACKGROUND

Association rule algorithms were developed to analyze market basket data. A single market basket contains store items that a customer purchases at a particular time. Hence, most of the terminology associated with association rules stems from this domain. The act of purchasing items in a particular market basket is called a transaction. Market basket data is visualized as boolean, with the value 1 indicating the presence of a particular item in the market basket, notwithstanding the number of instances of an item, and a value of 0 indicating its absence. A set of items is said to satisfy a transaction, if each item's value is equal to 1. Itemsets refer to groupings of these items based on their occurrence in the dataset. More formally, given a set $I = \{ i_1, i_2, i_3, \ldots i_n \}$ of items, any subset of I is called an itemset. A *k-itemset* contains k items. Let X and Y be subsets of I such that $X \cap Y = \varphi$. An association rule is a probabilistic implication $X \Rightarrow Y$. This means if X occurs, Y also occurs. For example, suppose a store sells, among other items, shampoo (1), body lotion (2), hair spray (3), and beer (4), where the numbers are item numbers.