

Chapter 1

Clustering–Based Stability and Seasonality Analysis for Optimal Inventory Prediction

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ABSTRACT

This chapter exemplifies how clustering can be a versatile tool in real life applications. Optimal inventory prediction is one of the important issues faced by owners of retail chain stores. Researchers have made several attempts to develop a generic forecasting model for accurate inventory prediction for all products. Regression analysis, neural networks, exponential smoothing, and Autoregressive Integrated Moving Average (ARIMA) are some of the widely used time series prediction techniques in inventory management. However, such generic models have limitations. The authors propose an approach that uses time series clustering and time series prediction techniques to forecast future demand for each product in an inventory management system. A stability and seasonality analysis of the time series is proposed to identify groups of products (local groups) exhibiting similar sales patterns. The details of the experimental techniques and results for obtaining optimal inventory predictions are shared in this chapter.

1. INTRODUCTION

This chapter exemplifies how clustering can be a versatile tool in real life applications. Traditionally, clustering techniques group similar patterns, which can be used for creating profiles. We show

how clustering can be a very useful first step in prediction. Optimal inventory prediction is one of the important issues faced by owners of retail chain stores. Determination of how, when and what quantities of products are to be reordered is a key to running a profitable business. Researchers have

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made several attempts to develop a generic forecasting model for accurate inventory prediction for all products. The demand quantity of a particular item or a group of related items can be considered as a time series. Time series prediction techniques that predict future values of a time series plays a critical role in forecasting quantity demand in business operations. Regression analysis, neural networks, exponential smoothing and autoregressive integrated moving average (ARIMA) are some of the widely used time series prediction techniques in inventory management.

Many researchers focus on finding a generic forecasting solution for all the products. However, products are distinguished by their seasonal sales patterns and volatilities in sales demand. One generic solution may not always be able to predict the most accurate demand for each product. Hence, these approaches are not always successful.

Limitations of generic forecasting model are overcome by developing specialized or targeted forecasting models. A variety of prediction techniques are combined with clustering to develop inventory prediction models. Clustering facilitate to explore stability underneath temporal variations. This chapter describes stability and seasonality analysis used to develop inventory prediction model.

We also elaborate on the effectiveness of stability analysis by applying it to a larger volume of data and further analyze stability for multiple years. We demonstrate that a group of stable products obtained using stability analysis is similar for different years. We also share our observations regarding how stable products from a particular year carry forward to subsequent years. A cross tabulation is used for trend analysis that emphasizes importance of stability analysis for multiple years.

The details of the experimental techniques and results for obtaining optimal inventory predictions are shared in this chapter. We elaborate usefulness of clustering in sales forecasting of objects that show similar sales patterns.

The experimental data set is obtained from an independent small retail chain of specialty stores. Information of customers, products, and their business operations from January 2005 to December 2009 is used for experimentation. More than 600,000 sales transactions are recorded in 60 months. In total, there are 25,378 distinct customers and 15,045 different products. Table 1 shows specific characteristics of the data set.

The chapter is organized into eight sections. Section 2 presents related research work of researchers who are exploring Data Mining and related techniques to enhance inventory prediction. Section 3 discusses the limitation of Generic Forecasting Model for inventory prediction. This section demonstrates two such cases in a real world retail store, which show how generic forecasting model can fail. Section 4 introduces some statistical measures obtained by preprocessing the data before the actual process of cluster analysis. Sections 5 and 6, present detailed description of clustering based Stability and Seasonality analysis. Section 7 reveals whether stable products for a year are also present in the list of stable products for subsequent years. We put forward our conclusions regarding the process of use of clustering for optimal inventory prediction in Section 8.

2. RELATED WORKS

As discussed in introduction, several models for inventory management have been proposed by a number of researchers. Varieties of time series

Table 1. An overview of experimental data set

Attribute	2005	2006	2007	2008	2009
Number of products	5782	7567	8034	8948	9409
Number of customers	4203	6159	10501	11548	13247
Number of transactions	55774	99852	75664	131499	147995

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