Forecasting Demand in Supply Chain Using Machine Learning Algorithms

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ABSTRACT

Managing inventory in a multi-level supply chain structure is a difficult task for big retail stores as it is particularly complex to predict demand for the majority of the items. This paper aims to highlight the potential of machine learning approaches as effective forecasting methods for predicting customer demand at the first level of organization of a supply chain where products are presented and sold to customers. For this purpose, we utilize Artificial Neural Networks (ANNs) trained with an effective second order algorithm, and Support Vector Machines (SVMs) for regression. We evaluated the effectiveness of the proposed approach using public data from the Netflix movie rental online DVD store in order to predict the demand for movie rentals during an especially critical for sales season, which is the Christmas holiday season. In our analysis we also integrated data from two other sources of information, namely an aggregator for movie reviews (Rotten Tomatoes), and a movie oriented social network (Flixster). Consequently, the approach presented in this paper combines the integration of data from various sources of information and the power of advanced machine learning algorithms for lowering the uncertainty barrier in forecasting supply chain demand.

Keywords: Supply Chain Demand Forecasting, Machine Learning, Artificial Neural Networks, Support Vector Machines

INTRODUCTION

The Supply Chain (SC) of both manufacturing and commercial enterprises comprises a highly distributed environment, in which complex processes evolve within a network of interacting companies. A typical SC includes different levels as shown in the diagram of Figure 1. As shown in this figure, and reading the diagram from right to left (“Customer Information Flow”), the first level of organization is “Sales” where products are sold to customers; the second level of organization is “Distribution” where products are delivered from in-house or 3PL (3rd Party Logistics) warehouses to retailers; the third organization level is “Storage” where products are stored in warehouses for future distribution; the fourth level of organization is “Production” where products are produced within plants according to determined production and inventory schedules; finally, the fifth organization level is “Supply” which comprises of the suppliers that provide raw materials transported to production plants.

The optimization of SC operational procedures is crucial for businesses since these operations directly affect customer service, inventory and distribution costs, and responsiveness to the ever changing markets. To this end, decision making in supply chain systems should consider intrinsic uncertainties, while coordinating the interests and goals of the multitude of processes involved. Since supply can rarely meet demand at any given period, the demand information is distorted as it is transmitted up the chain and this can misguide upstream members in their inventory and production decisions (“bullwhip” effect) (Lee, Padmanabhan, & Whang, 1997a), (Lee, Padmanabhan, & Whang, 1997b).

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Machine learning approaches can offer effective tools for both modeling and managing operations in the uncertain environment of the supply chain, especially since the associated data techniques are capable of handling complex interdependencies. As a result, these data techniques may form the basis for the development of optimization methods and systems that optimize effectively the various objectives of the supply chain (Minis & Ampazis, 2006). This paper presents the application of machine learning methods in supply chain demand forecasting. More specifically, we focus on the first level of SC which is directly related to customer side demand forecasting in an uncertain environment. Forecasting the expected demand for a certain period of time for one or more products is one of the most important targets in an enterprise since it directly affects revenue as well as customer satisfaction. To this end, we utilize Artificial Neural Networks (ANNs) and Support Vector Machines (SVMs) as an approach for forecasting demand in order to create a supply chain framework with dynamic characteristics.

The remainder of this paper is structured as follows: In the next section we present a review of previous studies on demand forecasting in SC using traditional and machine learning techniques. After that we analytically describe the techniques used in the present work, that is, the theoretical principles behind ANNs, the OLMAM training algorithm, and SVMs. A real-world case study utilizing data for the Netflix online DVD rental store is presented in Section “Information Sources”. The section immediately after that presents the results of the machine learning techniques. Finally in the last section we discuss the conclusions drawn from this study.

RELATED WORK

Machine learning methods have already been used in a variety of SC optimization tasks. Especially ANNs, as a new methodology, have been used used for optimization of transportation management, resources allocation and scheduling, for modeling and simulation, and decision support (Minis & Ampazis, 2006). For the task of forecasting SC demand, a variety of machine learning methods have been used as statistical forecasting models for smoothing and classifying noisy data to match the relationships between complicated SC operations. However SC data usually exhibit trends and seasonal patterns that should be taken into account in order to produce high quality forecasts (Granger, 1996). In an early study it was demonstrated that retailers with significant market share were more likely to use statistical models for more accurately forecasting seasonal sales than smaller retailers, who relied
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