Decision trees for supervised multi-criteria inventory classification

Francesco Lolli\textsuperscript{a*}, Alessio Ishizaka\textsuperscript{b}, Rita Gamberini\textsuperscript{a}, Elia Balugani\textsuperscript{a}, Bianca Rimini\textsuperscript{a}

\textsuperscript{a}Department of Sciences and Methods for Engineering, University of Modena and Reggio Emilia, Via Amendola 2 – Padiglione Morselli, 42100 Reggio Emilia, Italy
\textsuperscript{b}Centre of Operations Research and Logistics, Portsmouth Business School, University of Portsmouth, Richmond Building, Portland Street, Portsmouth PO1 3DE, United Kingdom

Abstract

A multi-criteria inventory classification (MCIC) approach based on supervised classifiers (i.e. decision trees and random forests) is proposed, whose training is performed on a sample of items that has been previously classified by exhaustively simulating a predefined inventory control system. The goal is to classify automatically the whole set of items, in line with the fourth industrial revolution challenges of increased integration of ICT into production management. A case study referring to intermittent demand patterns has been used for validating our proposal, and a comparison with a recent unsupervised MCIC approach has shown promising results.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing.

Keywords: multi-criteria inventory classification; decision trees; machine learning; inventory control; intermittent demand

1. Introduction and research background

Forecasting, inventory control and MCIC represent strictly interrelated fields of research. When dealing with a huge amount of items, firms are often interested in grouping them with the aim of simplifying their management. Each class is thus managed by means either of the same inventory control system or the same forecasting technique. With regards to classification approaches oriented to the inventory control, inventory managers often associate the

* Corresponding author. Tel.: +39 0522522635
E-mail address: francesco.lolli@unimore.it
same target cycle service level (i.e. the probability of not incurring in a stock-out during a replenishment cycle) to
the items belonging to the same cluster for the safety stock calculation or the same target fill rate (the percentage of
demand not satisfied) or the same type of re-order policy (e.g. continuous or periodic review systems). However,
current methodologies produce classification models based on criteria and threshold values that may not be adequate
for the predefined set of re-order policies or cycle service levels associated with the obtained classes. This limitation
has been recently underlined by [1]. In general, three ABC classes of ordered importance are defined and then
inventory control policies are attached to them. These policies are negotiated with (or imposed by) the suppliers (e.g.
deliveries can be done only on Fridays) and are often fixed before the classification of the items. Actually, the best
service-cost assignment of items to one of the classes can be obtained by means of an exhaustive simulation search
of the best policy at single item level. However, an exhaustive search is highly onerous, especially when the number
of items is high. Therefore, companies prefer to use predefined criteria for the classification without running an
exhaustive classification search. Historically, items are classified into three classes, ABC, according to a single
criterion, which is often the usage value. The assignment is typically based on an arbitrary percentage, for example
class A receives 20% of the items with the highest usage value, class B receives the next 30% and class C the
remaining 50%. [2] recognised that multiple-criteria would give more precision in the definition of classes by
augmenting the item characterisation. Therefore, several multi-criteria methods have been proposed for enriching
the inventory classification: AHP and its extensions [3, 4, 5, 6, 7, 8]; TOPSIS [9]; the weighted linear optimisation
[10, 11, 12, 13, 14, 15, 16, 17]; fuzzy logic [18]; and case-based reasoning [19, 20]. Artificial intelligence-based
methods are applied as well to learn and replicate classical ABC classifications [21] or actual decision of inventory
managers [22]. These last methods assume that a classification has already been produced in some way and
considered correct. Once the classes have been established, a unique inventory control method (e.g. type of policy,
cycle service level, fill rate and etc) is selected for all items of the same class [23]. However, there is no certitude
that the criteria used for the classification are appropriate to guarantee the best performance of the inventory method.
Indeed, it has been empirically shown that MCIC methods based on the annual dollar usage and the unit cost criteria
have a low cost-service performance [1]. Moreover, it may be argued that different MCIC methods reach different
classifications [24] when applied to the same dataset, and this trivially proves that these methods are not robust. [24]
introduced new procedures for reaching the consensus among different MCIC approaches, but the relationship of the
criteria with the inventory system is not even explored, and the class cardinalities are again pre-defined. [25]
provided the first contribution devoted to constructing a criterion aimed to minimise the inventory cost. The
calculation of this criterion is based on the probability that there is no stock out during the lead time. [26] derived
another criterion which incorporates the cost of stock out. In both cases, the items are ranked and the classification is
done arbitrarily with the first 20% assigned to group A, 30% to group B and 50% to group C.

As already underlined, selecting the optimal item classification and the best policy for each class can be done by
an exhaustive search, but it is highly time-consuming for thousands of items. Meta-heuristics [27, 28, 29] or exact
methods [30] have been proposed to solve this combinatorial problem through simplified assumptions without
recurring to the exhaustive solution, but the classification still remains opaque.

In this paper, the classification rules will be generated through supervised classifiers well-established into
machine learning field by starting from the exhaustive solution on a subset of items, on which the classifiers are
trained. This approach bridges the gap between the theories of MCIC and inventory control when the exhaustive
classification is impractical on the whole set of items, and a set of re-order policies is already defined and
unchangeable. In particular, decision trees and random forests are compared as effective tools for overcoming the
main concerns of MCIC, which are: i) the need for a set of predefined criteria that are not robustly linked with the
inventory control system; ii) the predefined cardinalities of the generated classes defined a priori without any
justification.

Among the machine learning techniques available for classification purposes, decision trees and random forests
have been selected for theoretical simplicity and readability of the results. The connection between input features
and obtained results in other methods, such as neural networks and non-linear SVM, is harder to analyse. Examining
a decision tree it is possible to rank the splits and obtain a visual representation of what features are the most
impacting in the classification process. Said features can be monitored by the management with the controlling
unwanted shifts towards categories more expensive to manage. For the intermittent spare parts related to new
دریافت فوری
متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات