Applied Soft Computing 13 (2013) 1332–1339

Contents lists available at SciVerse ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Heuristic-based neural networks for stochastic dynamic lot sizing problem

Ercan Şenyiğit[a], Muharrem Düğenci[b], Mehmet E. Aydin[c,*], Mithat Zeydan[a]

[a] Erciyes University, Dept. of Industrial Engineering, Kayseri, Turkey
[b] Karabük University, Dept. of Industrial Engineering, Karabük, Turkey
[c] University of Bedfordshire, Dept. of Computer Science and Technology, UK

ARTICLE INFO

Article history:
Received 1 January 2012
Received in revised form 21 February 2012
Accepted 27 February 2012
Available online 14 March 2012

Keywords:
Stochastic lot-sizing, Feed-forward neural networks, Bee algorithm, Genetic algorithms, Taguchi methods

ABSTRACT

Multi-period single-item lot sizing problem under stochastic environment has been tackled by few researchers and remains in need of further studies. It is mathematically intractable due to its complex structure. In this paper, an optimum lot-sizing policy based on minimum total relevant cost under price and demand uncertainties was studied by using various artificial neural networks trained with heuristic-based learning approaches; genetic algorithm (GA) and bee algorithm (BA). These combined approaches have been examined with three domain-specific costing heuristics comprising revised silver meal (RSM), revised least unit cost (RLUC), cost benefit (CB). It is concluded that the feed-forward neural network (FF-NN) model trained with BA outperforms the other models with better prediction results. In addition, RLUC is found the best operating domain-specific heuristic to calculate the total cost incurring of the lot-sizing problem. Hence, the best paired heuristics to help decision makers are suggested as RLUC and FF-NN trained with BA.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Lot-sizing problems have been studied with various respects for a long time whilst keeping the emphasis on modelling and optimisation of deterministic versions, which are known with the NP-Hard nature [1–3] and usually handled with heuristic methods in-line with Wagner–Whitin (WW) approach [4–6]. On the other hand, the real world versions of these problems are not as static and deterministic as modelled and handled in these ways, but, are rather dynamic and subject to probabilistic processes. That makes the problem type hard to model in easily solvable mathematical structures due to the complexity and uncertainty issues.

The stochastic dynamic lot-sizing (SDLS) problem can be formulated, in analytical or simulation models, either by assuming a penalty cost for each stock out and unsatisfied demand or by minimising the ordering and inventory costs subject to satisfying some customer service-level criterion. The analytical modelling approach is most frequently encountered in particular stochastic programming, where these models tackle only one type of uncertainty and assume a simple production system structure. Exact analytical solutions can only be developed, when the model is adequately simple. Further numbers of uncertain inputs/parameters escalate the complexity of the problems to an un-handlable state with analytical models. Due to the limitations given rise by stochastic/uncertain nature of controlling parameters in dynamic lot sizing problem (DLSP), heuristic approaches are preferred, rather than analytical models, in the solving larger-scale DLSP instances. Companies mostly work on a rolling horizon basis to form production plans consistent with new information on demand and prices which are usually uncertain and may only be known- sometimes partially over the forecast window. Since lot-sizing problem under uncertain demand and price conditions is so complex and mathematically intractable, generally, simulation techniques are used for obtaining good and feasible solutions. Simulation results have been accepted in finding total relevant cost as a real result. To reach the real total relevant cost, stochastic lot-sizing decision process under uncertain demand and price simultaneously using simulation was modelled by Manikas et al. [7] and Şenyiğit and Erol [8]. In this research, both price and demands are considered uncertain and assumed to be stochastic. On the other hand, among the heuristic approaches, artificial neural networks become very useful popular in modelling such ill-structured and/or highly complex problems, therefore stands promising to tackle SDLS problem. In fact, artificial neural networks with/without other metaheuristic approaches such as genetic algorithm have been interested in by recent research on solving various combinatorial optimization problems [3,5,9].

This paper reports the attempts of solving SDLS problems with using a variety of artificial neural networks (ANN) trained with metaheuristic algorithms, namely genetic algorithms and bees algorithm, using Taguchi experimental design patterns in experimentation. To the best of authors' knowledge, Taguchi design

* Corresponding author.
E-mail address: mehmet.aydin@beds.ac.uk (M.E. Aydin).

1568-4946/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.asoc.2012.02.026

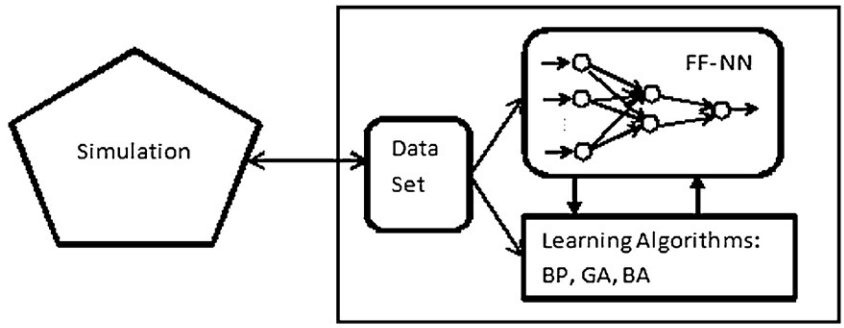

Fig. 1. The complete system architecture.

patterns have not been used to compare the performance of domain-specific heuristics. Furthermore, ANN trained with Bee algorithms have never been used in solving lot sizing problems. The data used for training and testing purposes is gathered from the simulation model of Şenyiğit and Erol [8] instead of an analytical solution. In the rest of the paper, the background of SDLS problem is introduced in the second section, while the novel approaches employed are revealed in section three and four. The experimental study is provided in section five and conclusions are indicated in section six.

2. Stochastic dynamic lot-sizing

Lot sizing studies have attracted so much interest in the literature since it is an indicative problem used to model various real world production/stock management problems. The main objective is to determine the periods of production, with minimum costs including setup and inventory costs, in which the product quantities to be produced in order to satisfy demand. Efficient lot sizing requires efficient decision making in order to minimize the overall cost since these decisions have crucial impact on production and inventory system [3,10]. Wagner–Whitin algorithm (WW) is known as the key methodology in which deterministic lot sizing problems are optimally solved [11]. However, the approach remains highly complex and very difficult to implement [12,13]. Therefore, numerous alternative methods to solve lot sizing problems have been developed besides various improvements achieved for WW [1,3,6,14]. Silver and meal (SM) and part period balancing (PPB) methods are two leading approaches among these alternative methods [15,16]. The analytical methods proposed usually consider certainty in key inputs (demand, price etc.) of the problem. However, once uncertainty is introduced into the model, it escalates to high complexity, which makes the problem hard to model in conventional ways. Then, as the probabilities play vital roles in calculations, the models turn to be stochastic. Monte-Carlo simulation implementing heuristic approaches remains the easiest way to go for robust problem solving, where simulation modelling complicates the process and leads to practical overheads [8]. In this paper, stochastic dynamic lot sizing problems with uncertain demand and price conditions have been considered; the simulation model and environment introduced by Şenyiğit and Erol [8], are used.

3. Artificial neural networks for stochastic dynamic lot-sizing

SDLS problems are mainly modelled using either analytical or heuristic methods such as artificial neural networks, which are based on and/or assisted by simulation. The main aim is to determine the best model in which optimum/near-optimum lot-sizes are identified subject to the environmental circumstances. ANN and genetic algorithms have been used in studying this sort of problems with various aims and scopes [3,17]. The durability of the ANN against noises, the fundamental characteristics of Von Neumann design reflected on the networks, and the need for sufficient, rather than detailed, knowledge about the problem are the strengths of ANNs in modelling dynamic and complicated problems such as determining the lot sizing [18]. Few studies were come acorss within the literature implementing ANN for solving lot sizing problems [9,19]. Gaafar and Choueiki [5] applied an ANN model for a single item lot sizing problem, while Megala and Jawahar [9] proposed genetic algorithm and Hopfield neural network to solve the dynamic lot sizing problem with a capacity constraint and discount price structure.

In this study, multi-layer feed-forward neural network (FF-NN) has been chosen for the purpose of modelling SDLS problems with various training strategies owing to its maturity and simplicity in modelling. The FF-NN model is supported with a set of learning algorithms for training purposes and a simulation for data cultivation. Fig. 1 depicts the system architecture in which the FF-NN models are configured, trained and tested alongside a simulation module. Since the probabilistic and variable properties of the system can easily be developed and handled using simulation, the data sets for training and testing FF-NNs are generated using simulation. The FF-NN models are configured as 3-layer feed-forward neural networks, where a learning algorithm is selected from the learning algorithms base and applied. Here, three algorithms are included in the learning algorithms base: back propagation (BP), genetic algorithm (GA) and bee algorithm (BA). BP is the classical gradient search-based learning algorithm calculates the error of the system and propagates it back to the weights of the connections of the network. On the other hand, both GA and BA are population based heuristic search algorithms used for optimisation purposes. The aim of using them in this study is to optimise the weights of the connections form the network so that the FF-NN model can predict the cost of lot-sizing system with minimum error. Once a learning algorithm is preferred, the configuration of FF-NN model is completed, then, the model is trained using the samples included in training data-set fetched from the data set unit, where the simulation results sampled in. The training phase is conducted until a certain level of learning is achieved. After that, another data-set is retrieved to test FF-NN's performance.

As declared before, the main purpose of this study is to find the optimal lot-size (amount of order) that minimizes total relevant cost under price and demand uncertainties. The cost study was carried out comparatively to identify which heuristic approach for costing would be most appropriate and relevant in performance analysis. Using simulation results, costing heuristics/techniques known as revised silver meal (RSM), revised least unit cost (RLUC), cost benefit (CB) have been chosen [8]. Then, the following four modelling approaches, called Taguchi Design of Experiment (TDOE), FF-NN model trained with BP, FF-NN model with GA and FF-NN with BA, have been implemented to solve SDLS problems.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

✓ 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