Expert Systems With Applications 93 (2018) 39–49

Contents lists available at ScienceDirect

Expert Systems With Applications

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

Solving the interval linear programming problem: A new algorithm for a general case

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ARTICLE INFO

Article history:
Received 19 June 2017
Revised 7 October 2017
Accepted 8 October 2017
Available online 9 October 2017

Keywords:
Optimal solution set
Interval linear programming
Interval linear equations system
Monte Carlo simulation

ABSTRACT

Based on the binding constraint indices of the optimal solution to the linear programming (LP) model, a feasible system of linear equations can be formed. Because an interval linear programming (ILP) model is the union of numerous LP models, an interval linear equations system (ILES) can be formed, which is the union of these conventional systems. Hence, a new algorithm is introduced in which an arbitrary characteristic model of the ILP model is chosen and solved. The set of indices of its binding constraints is then obtained. This set is used to form and solve an ILES using the enclosure method. If all the components of the interval solutions to this system are strictly non-negative, the optimal solution set (OSS) of the ILP model is determined as the subscription of the zone created by reversing the signs of the binding constraints of the worst model and the binding constraints of the best model. The solutions to several problems obtained by the new algorithm and a Monte Carlo simulation are compared. The proposed algorithm is applicable to large-scale problems. To this end, an ILP model with 270 constraints and 270 variables is solved.

1. Introduction

Many real world system parameters are inexact and are determined as interval numbers. Therefore, interval linear programming (ILP) is an efficient method to characterize inexact parameters in decision-making problems. Recently, obtaining the optimal solution set (OSS) and the optimal range of the objective values of the ILP problem has become important to researchers. Allahdadi and Mishmast Nehi (2013) determined the OSS of the ILP model from the worst and best model constraints when all of the components of the optimal solutions to the ILP model are strictly non-negative. In fact, by assuming the positivity of all of the components of the feasible point of the best model, if the number of constraints and variables are equal, the exact OSS of the ILP model is parallel to the region that is the subscription of the feasible zone of the best model and the feasible zone created by reversing the inequality signs of the worst model constraints. Several methods have been proposed to solve the ILP model. Some of the methods transform the ILP model into two sub-models (Allahdadi, Mishmast Nehi, Ashayerinasab, & Javanmard, 2016; Fan & Huang, 2012; Huang, Baetz, & Patry, 1995; Huang & Moore, 1993; Lu, Cao, Wang, Fan, & He, 2014; Tong, 1994; Wang & Huang, 2014; Zhou,Huang, Chen, & Guo, 2009). The solution area of these methods is formed by solving these sub-models and obtaining their optimal solutions. One solution, the BWC method (Tong, 1994), obtains the largest interval of the objective function values. In addition, some of these methods, such as a novel ILP (Huang & Moore, 1993), a two-step method (TSM) (Huang et al., 1995), and another solution (SOM-2) (Lu et al., 2014) have been proposed. However, part of the solution area of these methods may be infeasible. Several techniques have been developed to remove the infeasible part of the solution area of these methods, such as the modified ILP (MILP) (Zhou et al., 2009), improved TSM (ITSM) (Wang & Huang, 2014), and robust TSM (RTSM) (Fan & Huang, 2012). Allahdadi et al. (2016), introduced two improvement methods, namely, IMILP and IILP, to delete the non-optimal solutions to the solution areas of the MILP and ILP methods, respectively.

An arbitrary point is a feasible solution to the ILP model if it belongs to the feasible zone of the best model, and it is optimal if it is an optimal solution to an arbitrary characteristic problem of the ILP model. If the optimal solution to a linear programming (LP) model exists, then it lies in the extreme point set or bounds of the feasible region of the LP model. In fact, the optimal solution to the LP problem is the solution to a linear equations system (LES), whose equations are the binding constraints of the LP model. By considering the variables (such as dual variables) corresponding to the binding constraints of the LP model and by multiplying them in the columns of the technological matrix, an LES can be formed

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https://doi.org/10.1016/j.eswa.2017.10.020
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