46th Annual Iranian Mathematics Conference
25-28 August 2015
Yazd University

Solving bi-level integer programming problems with multiple linear objectives at lower level by using particle swarm optimization

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Abstract

Bilevel programming problems are hierarchical optimization problems that consist of the objective of the leader at its first level and that of the follower at the second level. In this paper, we propose a method for solving bi-level integer programming problems with multiple linear objectives at lower level. We begin by finding the convex hull of its original set of constraints using the cutting-plane algorithm. Then, we apply particle swarm optimization (PSO) algorithm to solve this problem. A numerical example illustrates the proposed method.

Keywords: Bi-level optimization, Multiobjective optimization, Particle swarm optimization.
Mathematics Subject Classification [2010]: 90c08,90c10

1 Introduction

Bilevel programming involves two optimization problems where the constraint region of the first level problem is implicitly determined by another optimization problem. Gavete and Gale [1] consider the bilevel problems for which the lower level problem is a linear multiobjective program and constraints at both levels define polyhedra, they proved that the feasible region consists of faces of the polyhedron defined by the constraints. Particle swarm optimization (PSO) is an optimization algorithm proposed by Kennedy and Eberhart in 1995 [2]. The bi-level integer programming with multiple linear objective functions at lower level problem (BIPMLO) can be formulated as:

$$\begin{aligned} \min_{x_1} \quad & f(x_1, x_2) \\ \text{s.t} \quad & A_1^1 x_1 + A_2^1 x_2 \leq b^1 \\ & x_1 \geq 0, \text{ integer} \end{aligned} \tag{1}$$

where x_2 solves

$$\begin{aligned} \min_{x_2} \quad & (d_1 x_2, \ldots, d_k x_2) \\ \text{s.t} \quad & A_1^2 x_1 + A_2^2 x_2 \leq b^2 \\ & x_2 \geq 0, \text{ integer} \end{aligned} \tag{2}$$

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