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A penalty method with trust-region mechanism for nonlinear bilevel optimization problem

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Abstract

We present a penalty method with trust-region technique for nonlinear bilevel optimization problem in this paper. This method follows Dennis, El-Alem, and Williamson active set idea and penalty method to transform the nonlinear bilevel optimization problem to unconstrained optimization problem. This method maybe simpler than similar ideas and it does not need to compute a base of the null space. A trust-region technique is used to globalize the algorithm. Global convergence theorem is presented and applications to mathematical programs with equilibrium constraints are given.

Key Words: Nonlinear bilevel optimization problem; Active-set strategy; Penalty method; Trust-region; Global convergence.

MSC 2010 : 90C30, 90B50, 65K05, 62C20.

1 Introduction

The nonlinear bilevel optimization (NBLO) problem is a nested optimization problem which has two levels in hierarchy. The NBLO problem arises when two independent decision makers, DMs, ordered within a hierarchical structure, have conflicting objectives. The DM at the lower level (follower) has to optimize his objective under the given parameters from the upper level DM (leader), who, in return, with complete information on the possible reactions of the lower, selects the parameters so as to optimize his own objective. The DM with the upper level objective $f_u(x, y)$, takes the lead, and chooses his decision vector x. The DM with lower level objective $f_l(x, y)$, reacts accordingly by choosing his decision vector y to optimize his objective, parameterized in x. Note that the upper level decision maker is limited to influencing, rather than controlling, the lower levels outcome.

In this paper, we describe and analyze a penalty method with trust-region mechanism for the following NBLO problem

$$\begin{array}{ll} \min_{x,y} & f_u(x,y) \\ s.t. & g_u(x,y) \le 0, \\ \quad \min_y & f_l(x,y), \\ \quad s.t. & g_l(x,y) \le 0, \end{array} \tag{1.1}$$

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