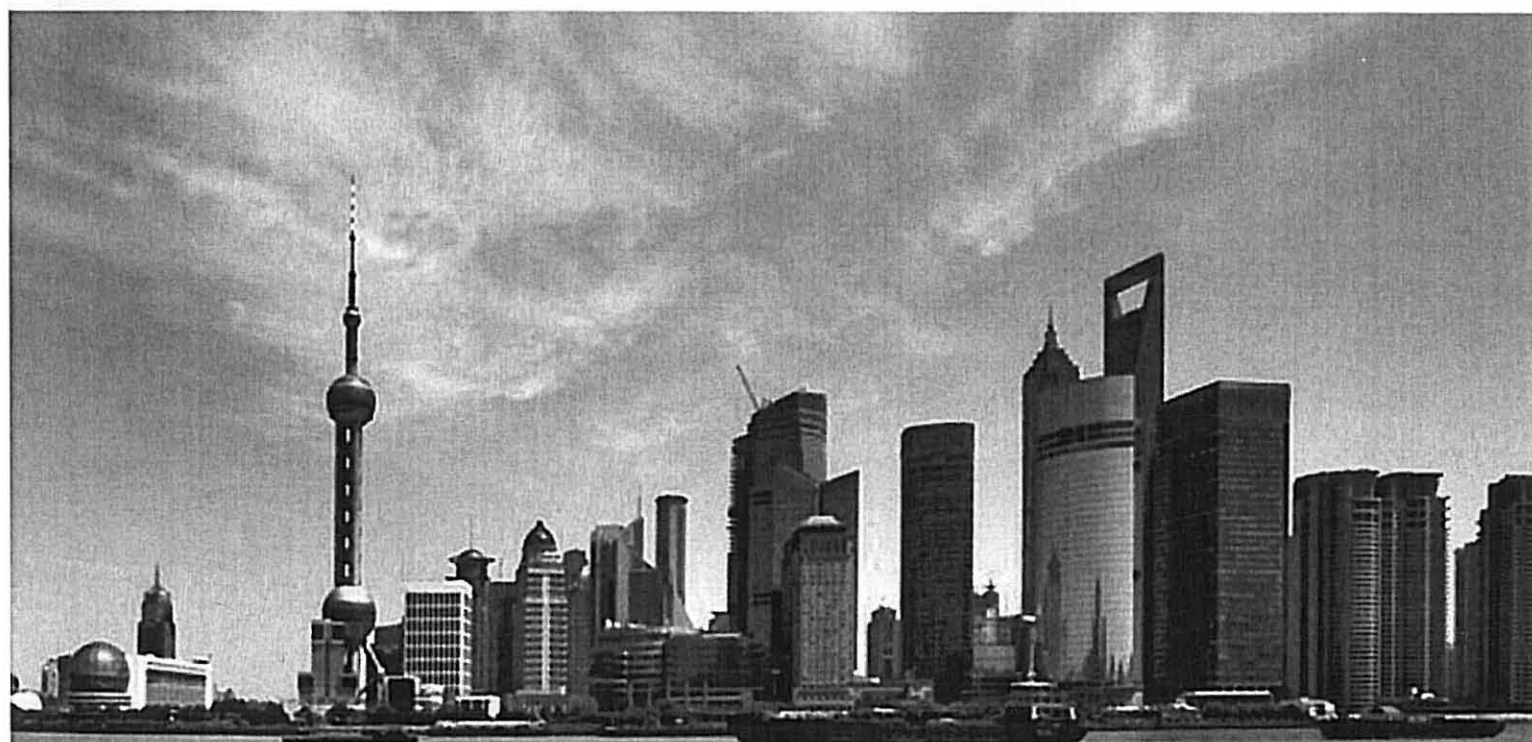


ICOTA8 第8届国际最优化方法及应用大会

The 8th International Conference on Optimization:  
**T** Techniques and Application **S**

December 10–13, 2010  
Shanghai  
Fudan University

**Book of Abstracts**



Editors: Xiaoling Sun, Xiaodi Bai  
© Fudan University. All rights reserved.

<b>Convergence Analysis of an Explicit Exchange Method for Convex Semi-infinite Programming Problems with Second-order Cone Constraints</b>	
Shunsuke Hayashi*, Soon-Yi Wu, Liping Zhang .....	88
<b>A New Exchange Method for Convex Semi-infinite Programming</b>	
Liping Zhang*, Soon-Yi Wu, Marco A. López .....	90
<b>On Saddle Points in Nonconvex Semi-infinite Programming</b>	
Jan-J. Rückmann*, Francisco Guerra-Vázquez, Ralf Werner .....	91
<b>A Regularized Explicit Exchange Method for Semi-infinite Programs with an Infinite Number of Second-order Cone Constraints</b>	
Takayuki Okuno*, Shunsuke Hayashi, Masao Fukushima .....	92
<b>An Algorithm for Semi-infinite Transportation Problems</b>	
Soon-Yi Wu*, Shen-Yu Chen .....	94
<b>Relaxed Cutting Plane Method with Convexification to Solve Nonlinear Semi-infinite Programming Problems</b>	
Ting-Jang Shiu*, Soon-Yi Wu .....	95
<b>Experiences with Reduction Method to Solve Semi-infinite Programming Problems</b>	
Ana I. Pereira*, Edite M.G.P. Fernandes .....	96
<b>Capacity-achieving Probability Measure in Communication Channels</b>	
Satoshi Ito*, Shiro Ikeda .....	98
<b>A Smoothing Penalized Sample Average Approximation Method for Stochastic Programs with Second Order Stochastic Dominance Constraints</b>	
Hailin Sun*, Huifu Xu, Yong Wang .....	99
<b>Inertial Relaxed CQ Algorithm for Solving Split Feasibility Problem</b>	
Yazheng Dang*, Yan Gao, Jin Dong .....	101
<b>Nonlinear Extension of Multi-objective Multiclass Support Vector Machine Maximizing Margins Based on One-against-all Method</b>	
K. Tatsumi*, M. Tai, T. Tanino .....	103
<b>Global Quadratic and Polynomial Optimization (SS01)</b>	
<b>Quadratic Optimization under Uncertainty with Applications</b>	
V. Jeyakumar .....	105
<b>Semi-algebraic Geometry and Global Optimization Problems with Polynomial Constraints</b>	
Guoyin Li .....	106
<b>On Stability Results for Quadratic Optimization Problems</b>	
Gue Myung Lee*, Nguyen Nang Tam, Nguyen Dong Yen .....	107
<b>Solving Large-sized Sensor Network Localization Problems using Sparsity and Continuation</b>	
Sunyoung Kim*, Masakazu Kojima .....	108
<b>Combinatorial Optimization-Theory and Applications (SSM04-A ~ SSM04-B)</b>	
<b>The Backup 2-Median Problem on Block Graphs</b>	
Yukun Cheng*, Liying Kang, Yan Hong .....	110
<b>A Lower Bound of Some Classical Ramsey Numbers <math>R(3, t)</math></b>	
Decha Samana*, Vites Longani .....	112
<b>The Hamiltonian Cycle Problem and Some Challenging Non-Convex Programs</b>	
Jerzy A. Filar .....	113



## Experiences with reduction method to solve semi-infinite programming problems

**Ana I. Pereira**

*Department of Mathematics - ESTiG, Polytechnic Institute of Braganca,  
Campus de Sta Apolónia, 5301-854 Braganca, Portugal  
apereira@ipb.pt*

**Edite M.G.P. Fernandes**

*Department of Production and Systems, University of Minho,  
Campus de Gualtar, 4710-057 Braga, Portugal  
emgpf@dps.uminho.pt*

### Abstract

In this talk, some variants of reduction-type method combined with a line search filter method to solve nonlinear semi-infinite programming problems are presented. We use the stretched simulated annealing method and the branch and bound technique to compute the maximizers of the constraint. The filter method is used as an alternative to merit functions to promote convergence from poor starting points.

**Keywords:** Semi-infinite programming. Reduction method, Line search filter method.

## 1 Introduction

The semi-infinite programming (SIP) problem is considered to be of the form

$$\min f(x) \text{ subject to } g(x, t) \leq 0, \text{ for every } t \in T \quad (1)$$

where  $T \subseteq \mathbb{R}^m$  is a nonempty set defined by  $T = \{t \in \mathbb{R}^m : a \leq t \leq b\}$ . Here, we assume that the set  $T$  does not depend on  $x$ . The nonlinear functions  $f : \mathbb{R}^n \rightarrow \mathbb{R}$  and  $g : \mathbb{R}^n \times T \rightarrow \mathbb{R}$  are twice continuously differentiable with respect to  $x$  and  $g$  is continuously differentiable functions with respect to  $t$ .

There are many problems in the engineering area that can be formulated as SIP problems. For a review of some applications, the reader is referred to [9, 5, 10].

The numerical methods that are mostly used to solve SIP problems generate a sequence of finite problems. Some examples can be found in [9, 2, 3, 4, 8, 10].

This work aims to describe a reduction method for SIP. Conceptually, the method is based on the local reduction theory. The focus of our proposal is to compare the performance of some methods in global programming theory: the simulated annealing method and the branch and bound method. This work comes in the sequence of a previous reduction-type method presented in [6].

## 2 Reduction method

A reduction approach, based on the local reduction theory, describes the feasible set of the SIP locally by finitely many inequality constraints. Thus, the SIP problem can be locally reduced to a finite one (at least conceptually, see [4]). Given a feasible point  $x_k \in \mathbb{R}^n$ , consider the so-called lower level problem  $O(x_k)$ :

$$\max_{t \in T} g(x_k, t), \quad (2)$$

where  $T_k = \{t_1, \dots, t_{L_k}\}$  is the set of its local solutions satisfying the following condition

$$|g(\bar{x}, t_l) - g^*| \leq \delta^{ML}, \quad l = 1, \dots, L_k, \quad (3)$$

where  $L_k$  represents the cardinality of  $T_k$ ,  $\delta^{ML}$  is a positive constant and  $g^*$  is the global solution value of (2).

Under some conditions, it is possible to replace the infinite set of constraints by a finite set that is locally sufficient to define the feasible region. Thus the problem (1) is locally equivalent to the so-called reduced optimization problem

$$\min_{x \in U_k} f(x) \text{ subject to } g_l(x) \equiv g(x, t_l(x)) \leq 0, l = 1, \dots, L_k. \quad (4)$$

where  $U_k$  is a open neighborhood of  $x_k$ .

A reduction method then emerges when any method for finite programming is applied to solve the locally reduced problem (4). Thus, at each iteration  $k$ , the main procedures of the algorithm are:

1. based on an approximation to the SIP problem,  $x_k$ , compute the set  $T_k$ , solving problem (2), with condition (3);
2. based on the set  $T_k$ , implement at most  $i^{\max}$  iterations to get an approximation  $x_{k,i}$ , by solving the reduced problem (4);
3. use a globalization technique to compute a new approximation  $x_{k+1}$  that improves significantly over  $x_k$ ;
4. use termination criteria to decide if the iterative process should terminate.

The remaining part of this work presents our proposals for the four steps of a global reduction method for SIP. An algorithm to compute the set  $T_k$  is known in the literature as a multi-local procedure. Our proposals are the stretched simulated annealing method and branch and bound method. To solve the reduced problem (4) an interior point method is proposed. Finally, convergence of the overall reduction method to a SIP solution is encouraged by implementing a filter line search technique.

## References

- [1] R. Hettich and K.O. Kortanek, *Semi-infinite programming: Theory, methods and applications*, SIAM Review, 35, (1993), pp. 380–429.
- [2] D-H. Li, L. Qi, J. Tam, and S-Y. Wu, *A smoothing Newton method for semi-infinite programming*, Journal of Global Optimization, 30 (2004), pp. 169–194.
- [3] C. Ling, Q. Ni, L. Qi, and S-Y. Wu, *A new smoothing Newton-type algorithm for semi-infinite programming*, Journal of Global Optimization, 47 (2010), pp. 133–159.
- [4] G-x. Liu, *A homotopy interior point method for semi-infinite programming problems*, Journal of Global Optimization, 37 (2007), pp. 631–646.
- [5] M. López, G. Still, *Semi-infinite programming*, European Journal of Operations Research, 180, (2007), pp. 491–518.
- [6] A.I.P.N. Pereira and E.M.G.P. Fernandes, *A reduction method for semi-infinite programming by means of a global stochastic approach*, Optimization, 58, (2009), pp. 713–726.
- [8] L. Qi, C. Ling, X. Tong, and G. Zhou, *A smoothing projected Newton-type algorithm for semi-infinite programming*, Computational Optimization and Applications, 42 (2009), 1–30.
- [9] R. Reemtsen and J.-J. Rückmann, *Semi-infinite programming*, Nonconvex Optimization and Its Applications, Vol 25, 1998, Kluwer Academic Publishers.
- [10] O. Yi-gui, *A filter trust region method for solving semi-infinite programming problems*, Journal of Applied Mathematics and Computing, 29 (2009), pp. 311–324.