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DST-NRF CENTRE OF EXCELLENCE IN MATHEMATICAL & STATISTICAL SCIENCES

CoE-MaSS weekly seminar series

THE DST-NRF CENTRE OF EXCELLENCE IN MATHEMATICAL AND STATISTICAL SCIENCES (CoE-MaSS) WOULD LIKE TO PRESENT A SEMINAR BY

Prof Tapio Westerlund

(Faculty of Science and Engineering, Abo Akademi University, Turku, Finland)

"Aspects on Solving Convex and Non-Convex MINLP Problems"

Friday, 28 October 2016

10h30-11h30

Broadcast live from:
Videoconferencing Facility, 1st Floor
Mathematical Sciences Building, Wits West Campus

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Title:
Aspects on Solving Convex and Non-Convex MINLP Problems

Presenter:
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Abstract:
This presentation will focus on certain aspects in solving convex and non-convex MINLP problems. Initially a brief introduction to the development of MINLP algorithms, from LP and MILP to convex and non-convex MINLP algorithms, is given. Thereafter, the presentation will continue with a discussion on some basic issues connected to convex and non-convex MINLP methods.

Convex MINLP solvers are today almost considered as standard tools in Mathematical Programming. The computational efficiency of different solvers has been evaluated in many papers, but there are, though, essential differences in the classes of convex problems for which the "convex MINLP algorithms" have proven convergence properties. A main question to be answered could be: Does a certain "convex MINLP solver", with proven convergence properties for a sub-class of convex MINLP problems, also handle more general classes of convex problems rigorously? A sub-class of convex MINLP problems could be problems including only smooth convex functions. Does the solver still maintain its proven convergence properties if non-smooth convex functions in addition to smooth ones are included to the problem? In addition; are the convergence properties still maintained if some non-convex functions are included, but the problem is, by definition, still to be solved over a convex integer-relaxed domain?

When solving a non-convex problem, the feasible domain is often divided into sub-domains, these domains then convexified, relaxed and thereafter solved using some convex sub-solver. This is usually done by replacing the non-convex constraints with convex under-estimators. The convergence properties of the parent solver are, then, in addition to the relaxation technique, highly dependent of the sub-solver.

Focusing briefly on the relaxation technique, it will give rise to some challenging questions to be answered as well. Are convex envelopes of non-convex constraint functions generally the tightest convex under-estimators to be used when convexifying and relaxing non-convex inequality constraints? Since not, could the convex envelopes of the non-convex constraint functions be replace by some other convex functions giving tighter or even an exact border of the convex hull of the original domain? Such and related questions will shortly be discussed in this presentation.

In connection to the discussion about convex MINLP algorithms a new supporting hyperplane method for solving convex MINLP problems is presented as well, and additionally, a technique to reformulate MINLP problems, including twice-differentiable non-convex constraints, to convex ones, will be discussed.

References

[1] Eronen V.-P., Mäkelä M.M. and Westerlund T. (2014). On the Generalization of ECP and OA Methods to Non-Smooth Convex MINLP Problems. *Optimization*, **63**, 1057-1073, Taylor and Francis.

[2] Eronen V.-P., Mäkelä M.M. and Westerlund T. (2015). Extended Cutting Plane Method for a Class of Non-Smooth Non-Convex MINLP Problems. *Optimization*, **64**, 641-661, Taylor and Francis.

[3] Kronqvist J., Lundell A. and Westerlund T. (2016). The Extended Supporting Hyperplane Algorithm for Convex Mixed-Integer Nonlinear Programming Problems. *Journal of Global Optimization*, **64**, 249-272, Springer.

[4] Lundell A., Skjäl A. and Westerlund T. (2013). A Reformulation Framework for Global Optimization. *Journal of Global Optimization*, **57**, 115-141, Springer.

[5] Skjäl A., Westerlund T., Misener R. and Floudas C. A. (2012). A Generalization of the Classical αBB Convex Underestimation via Diagonal and Non-Diagonal Quadratic Terms. *Journal of Optimization Theory and Applications*, **154**, 462-490, Springer.

[6] Skjäl A. and Westerlund T. (2014). New Methods for Calculating αBB-type Underestimators. *Journal of Global Optimization*, **58**, 411-427, Springer.