INTERIOR POINT METHODS FOR MATHEMATICAL PROGRAMMING : A BIBLIOGRAPHY

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Abstract

Nothing is older than a yesterday's newspaper! In this sense, this bibliography is incomplete, of course, because of the enormous interest and ongoing research in interior–point methods for mathematical programming. These activities were initiated by Karmarkar's polynomial–time linear programming algorithm in 1984, resulting in a flood of research papers, articles, talks, developments of commercial software and so on. This working paper should be regarded as a first trial to obtain a survey over the research reports, journal articles, etc., published so far, resp. known to the author.

Acknowledgements :

Key Words : Karmarkar's algorithm, interior–point methods, projective scaling algorithm, affine scaling algorithm, path–following methods, logarithmic barrier function algorithm, potential reduction algorithm, trajectory–following method, polynomial–time algorithm, method of centers, gravitational method, box method, mathematical programming.

Remark : The reader is kindly requested to send those references to the authors which are not listed or incorrectly cited in this bibliography (if possible, a copy of the corresponding report or the article's citation with the (complete!) name of the journal, with a short abstract, cross–references and keywords), or to send a copy of his own reference list (can be handwritten!) in order to complete the current bibliography[2]. The actual list will be published elsewhere from time to time, possibly by e–mail.

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Introduction

Interior–point methods for mathematical programming are known for a long time. With respect to solving nonlinear programming problems they have turned out to be a reliable tool, see e.g. Fiacco and McCormick[196], Frisch[227, 228],Huard[358], and Lootsma[480]. But in view of solving linear programming problems they could not compete with G. B. Dantzig's simplex method. They were only regarded as theoretical alternative solution methods to, never as practical substitutes for the simplex method, see e.g. Brown and Koopmans[109], Caroll[111], Dikin[160, 161], Frisch[230], and Parisot[654]. That these methods have failed in linear programming practice at that time can be justified by the lack of modern numerical linear algebra[3] and sparse matrix technologies[4], see e. g. Marsten et al.[511].

A new polynomial–time linear programming interior point–method was presented by N. K. Karmarkar in 1984, which was claimed to be up to 100 times faster than the simplex method, in practice and for any instance. Karmarkar's announcement stirred the interest not only of the popular press, see e.g. Angier[21], Emmett[182], Fricker[226], Garfunkel et al.[234], Gleick[259], Kolata[448], Philpott[656], and Stipp[774], but also of the operations research community, see e.g. the surveys of Bazaraa et al.[80], pp. 416–418, Freund[220], Gill et al.[251], Goldfarb and Todd[281], Megiddo[524, 525], Monma[590], Todd[808, 812], Zimmermann[990], and, in some sense, den Hertog[333].

Since Karmarkar's publications[403, 404], a great amount of contributions has been made towards the theoretical analysis and practical implementations of interior–point methods, see e.g. Anstreicher[30], Bayer and Lagarias[77, 78], Lagarias[466], and Monma[591], and the investigations are still going on, see the David II–Report[154], and Resende and Wright[692]. The importance of interior–points methods is reflected by numerous talks, workshops and minisymposia held at various operations research or optimization meet-

[3] A. George and J. W. H. Liu, *Computer Solutions of Large Sparse Positive Definite Systems*, Prentice Hall, 1981.

[4] S. Pissanetzky, *Sparse Matrix Technology*, Academic Press, 1984.

ings, see e.g. the programs of the annual meetings of ORSA/TIMS or SIAM, Dolecki[170], Freund[220], Megiddo[526, 529], and Tovey[848, 849].

In order to get an overview, interior–point methods can be broadly classified into the following categories, see e.g. den Hertog[333], whereby the selected citations are thought as examples :

1. Projective scaling methods, introduced by Karmarkar[403, 404] and further investigated and extended e.g. by Akguel[17], Anstreicher[24, 25, 32, 35, 40], Asic et al.[53], Bazaraa et al.[80], Blair[93], Dennis et al.[155], Dodani and Babu[169], Ferris and Philpott[192], Franklin[206], Gay[237], de Ghellinck and Vial[244], Goldfarb and Mehrotra[278, 279], Gonzaga[292, 306], Hettich and Margraff[345], Hooker[350], Kojima[430], Kojima and Tone[447], McDiarmid[517], Mitchell[563], Mitchell and Todd[570, 571], Paris[653], Powell[677], Roos[697], Shanno[737], Shanno and Marsten[746], Shub[755], Steger[773], Todd[810], Todd and Burell[821], Tomlin[835], Vial[895], Ye[951, 956], Ye and Kojima[965], Zimmermann[992].

2. 'Pure' affine scaling methods, originally proposed by Dikin[160, 161, 162] about twenty years ago, independently rediscovered by e.g. Barnes[63], Cavalier and Soyster[116], Monma and Morton[592], Vanderbei et al.[888], and further investigated by e.g. Adler et al.[9], Barnes et al.[72] (belongs in principle to the class of path–following methods), Cavalier and Schall[115], Christiansen and Kortanek[138, 139], Hettich and Ries[346], Kortanek and Shi[457], Marsten et al.[507], Mehrotra[540], Monteiro et al.[601] (the polynomiality is derived from the polynomial result of path–following methods !), Ponnambalam and Vanelli[671], Resende and Veiga[690], Sherali[751] (in principle a path–following method), Strang[781, 782, 783], Todd[819], Wei[900, 901].
Megiddo and Shub[532] have shown that algorithms belonging to this class can be supposed to be non–polynomial.

3. Path– or trajectory–following methods, initiated by Gill et al.[253], showing a certain equivalence to Karmarkar's algorithm, and further investigated by e.g. Anstreicher et al.[43], Ben–Daya and Shetty[83, 82], Goldfarb and Liu[275], Gonzaga[291, 302], Gonzaga and Todd[308], den Hertog et al.[335], Kojima et al.[443], Lustig[484], Lustig et al.[494, 492], Marsten et al.[511], Marxen[513], McShane et al.[520], Megiddo[528], Mehrotra[542], Mehrotra and Sun[549], Monteiro and Adler[598, 599], Osborne[636, 637], Renegar[682], Roos[704, 705],Todd[817], Todd and Vial[824], Tseng[853], Vaidya[869], Zhu and Kortanek[986].

4. Affine scaling methods applied to a potential function, described in Anstreicher and Bosch[41], Freund[221], Gonzaga[295, 299, 303], Ye[959].

5. Method of centers, described e.g. in Boggs et al.[100, 102], Jarre[375, 378, 381], Jarre et al.[383], Mehrotra and Sun[552], Sonnevend[763, 765, 766], Witzgall et al.[908].

6. Gravitational method, developed in Murty[612, 613] and implemented by Chang and Murty[121].

7. Box method, as described in Zikan and Cottle[987, 988, 989].

Algorithms belonging to the class 4 are the most promising, because they do not loose their theoretical complexity in practice. Unfortunately, no computational experiences are published, at least as yet.

During the last few years practical implementations of linear programming interior–point methods were developed, which are superior to the simplex method, not necessarily for each special problem, but at least for a set of problems, such as Gay's *netlib* problem collection, see e.g. Lustig[486], Marsten et al.[507, 511], McShane et al.[520]. For solving everyday linear programming problems there exists a rule of thumb : If the problem size is small, i.e. the number of variables is lower than 500, the simplex method is superior in most cases and consequently 'still alive', otherwise solve the problem via an interior–point method.
Nowadays, there exist at least two commercial implementations. The first one is OB1, developed by Shanno and Marsten[747], see also e.g. Lustig et al.[497], and the second is the AT & T KORBX Linear Programming System[55, 126], a software/hardware combination.

A concluding remark : Talks, workshops and minisymposia are handled as technical reports, because I am rather sure that to each talk there exists an underlying report.

Title word cross-reference

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