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Book of Abstracts

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Sumário

Plenary Conferences

Continuation in Optimization: From interior point methods for large-scale optimization to Big Data optimization

Gondzio, Jacek

In this talk we will discuss similarities between two homotopy-based approaches: - (inexact) primal-dual interior point method for LP/QP, and - preconditioned Newton conjugate gradient method for big data optimization. Both approaches rely on clever exploitation of the curvature of optimized functions and deliver efficient techniques for solving optimization problems of unprecedented sizes. We will address both theoretical and practical aspects of these methods.

References:

1 J. Gondzio, Interior point methods 25 years later, EJOR 218 (2012) pp. 587–601. DOI: 10.1016/j.ejor.2011.09.017
2 K. Fountoulakis and J. Gondzio, A second-order method for strongly convex L1-regularization problems, Mathematical Programming 156 (2016), pp. 189–219. DOI: 10.1007/s10107-015-0875-4
3 K. Fountoulakis and J. Gondzio, Performance of first- and second-order methods for big data optimization, interior point method for convex quadratic programming, Technical Report ERGO-15-005, School of Mathematics http://www.maths.ed.ac.uk/ gondzio/reports/trillion.html

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Interior point methods and DC power systems - How to squeeze a matrix

Oliveira, Aurelio Ribeiro Leite

Interior point methods have been successfully applied for solving optimal power system problems very early since their appearance. In particular, they achieve even better performance for the so called DC formulation since often such formulation leads to quadratic problems with separable variables. In this talk, some formulations are discussed and interior point methods designed to solve such specific problems are developed. The resulting linear system matrix pattern is exploited and due to the power system structure and physics laws, the obtained matrix operations can be, in a large amount, reduced. That matrix studies are presented, starting from a simple formulation, and are generalized to more complete formulations up to a full model proposed for the Brazilian network transmission power system.

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Metaheuristic approaches to continuous global optimization

Resende, Mauricio

Metaheuristics were introduced in the 1980s as effective algorithms to solve hard combinatorial optimization problems. More recently their application has been extended to continuous global optimization. In this talk we review two such metaheuristics: Continuous GRASP (CGRASP) and Biased Random-Key Genetic Algorithms (BRKGA). We apply them to the problem of minimizing a function of continuous variables subject to box constraints. Several applications are described.

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Contributed Abstracts

Interior-Point Methods experiences in Brazilian Power System

Azevedo, Anibal Tavares and Oliveira, Aurelio Ribeiro Leite and Soares, Secundino and Rider, Marcos and Castro, Carlos

In this article three application of interior-point methods in Brazilian power system will be described and analyzed: - Long-term generation scheduling of large-scale hydrothermal systems; - Security constrained optimal active power flow via network model; - How to efficiently incorporate facts devices in optimal active power flow model. The Brazilian power system is an interesting example of application of interior-point methods since resulting mathematical models are large-scale ones.

Keywords:
Interior-point method, long-term hydro-thermal scheduling, DC optimal power flow

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A heuristic to switch the preconditioned iterative linear system solver in interior point using Ritz values

Bartmeyer, Petra Maria and Bocanegra, Silvana and Oliveira, Aurelio Ribeiro Leite

When dealing with large-scale linear programming problems Interior Point Methods (IPM) have great importance. The Mehrotra predictor-corrector version is an IPM that requires the solution of two linear systems at each iteration to compute the Newton direction. The efficiency of such method depends upon the linear system solver. Iterative solvers are interesting because they need less memory and preserve sparsity. However, the condition number of the matrix system influences the method convergence. Therefore, the linear systems must be preconditioned. An efficient hybrid approach has been used to solve these systems by applying the conjugate gradient method with two preconditioners: the Controlled Cholesky factorization (CCF) and the Splitting Preconditioner (SP). The CCF achieves good results for the first iterations and the splitting is better on the final iterations. The performance of the hybrid approach will improve if the optimal time of changing preconditioners could be identified. An important factor in this analysis is the condition number, which can be computed using eigenvalues. In order to avoid the expensive process for computing eigenvalues we use Ritz values. The Ritz values are approximations for eigenvalues, which are obtained using the matrix projection in a Krylov subspace of smaller dimension. We are developing a heuristic to identify when to switch between the CCF and the SP. The Ritz values are used to approximate some parameters of the preconditioned matrix such as: the condition number, the spectrum and the existence of clusters. Such parameters and the number of preconditioned conjugated gradient iterations will be used to measure the efficiency of the hybrid approach.

Keywords:
Ritz value, hybrid preconditioner, predictor-corrector

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Interior point method with the continued iteration

Berti, Lilian Ferreira and Oliveira, Aurelio Ribeiro Leite and Ghidini, Carla Taviane Lucke da Silva

In this work, the continued iteration is presented and incorporated into the predictor corrector interior point method with multiple centrality corrections in order to reduce the number of iterations and consequently the computational time necessary to solve large-scale linear programming problems. In the continued iteration a new direction is computed and combined with the predictor corrector one. Computational results show the improvement achieved by the proposed approach.

Keywords:
linear programming, interior point methods, continued iteration

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Mean-variance model for portfolio selection with returns based on GARCH and Random Walk

Bocanegra, Silvana and Régis, Filippo César Guedes and Fernandes, Leonardo Henrique Silva

Optimization models have been widely used in financial decisions problems. The well-known Markowitz'mean-variance optimization model consists of finding assets in the stock market that produce a minimum variance portfolio (risk minimum) with a target value of expected return. This problem can be formulated in a convex quadratic programming form and solved by interior point methods. The main weakness of the Markowitz model is the computation of the expected return parameter, which has been done by the arithmetic mean of the historical returns. We are proposing the use of Random Walk and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) instead of the arithmetic mean to calculate the expected returns. We provided numerical experiments with a convex optimization software package called CVXOPT for evaluate the impact of these modifications on the Markowitz model. This package makes possible to develop efficient solvers that exploit various types of problem structure. Its standard solver for quadratic programming is a primal-dual path-following method based on the Nesterov-Todd scaling. We are using time series with historical values assets selected per economic segment, which constitute the indexes of the following stock markets: Nasdaq, Dow Jones and *BM&amp*; FBOVESPA. The numerical experiments were performed upon different levels of return and risk, and the related data allowed us to find the efficient frontier. With this information, we found investment opportunities for different investor profiles: aggressive, conservative and moderate. For markets with a developed economy, that present low volatility, the best results were obtained using the GARCH model. While in the developing economies with high volatility, the original model with arithmetic mean presents better results.

Keywords:
Financial problems, Mean-Variance optimization model, GARCH, RandomWalk

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Interior Point Methods for Power Flow Optimization with Security Constraints

Casacio, Luciana and Oliveira, Aurelio Ribeiro Leite and Lyra Filho, Christiano

This work deals with power flow optimization with security constraints, focusing on the problem of short term hydroelectric scheduling, called pre-dispatch. Since the energy demand varies throughout the day, the generation must satisfy daily targets, established by long-term scheduling models. This study considers that the hydroelectric plants and the transmission systems must provide an optimal flow of energy under security constraints, which allow meeting energy demands for normal operating conditions and when disturbances happen. Algebraic techniques are used to exploit the sparse structure of the problem, aiming the design of an interior point algorithm, efficient in terms of robustness and computational time. Case studies compare the proposed approach with a general purpose optimization solver for quadratic problems and with an algorithm for the pre-dispatch problem that does not consider security constraints. The results show the bene fits of using the proposed method, obtaining optimal power flow that are suitable to consider contingencies, with numerical stability and appropriate computational time.

Keywords:
Optimal power flows, Security constraints, Pre-dispatch problem

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Spectral analysis of the Splitting preconditioner with sparse base

Castro, Cecilia Orellana and Oliveira, Aurelio Ribeiro Leite

A new ordering of constraint matrixâs columns of a linear programming problem is proposed in order to improve the performance of Splitting preconditioner applied to the Normal Equations system in the Interior Point method. This proposal emphasizes the computing of a sparse base for the Splitting preconditioner. Further, we prove that the new ordering limits uniformly the condition number of the preconditioned matrix by an amount which depends only of the problem data. A similar result was obtained for the alternative system of the Splitting preconditioner with size (n-m). On the other hand, since the most expensive computational effort is to find the set of independent columns to form the base, we are studying how to take advantage of computed columns from one iteration to the next in which a new baseâs computation is required.

Keywords:
Splitting preconditioner, condition number, sparse base

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Strategies to compute the splitting preconditioner to solve the linear systems from interior point methods

Ghidini, Carla Taviane Lucke da Silva and Oliveira, Aurelio Ribeiro Leite

In this work, the predictor-corrector interior point method is considered, which is one of the most important variants of interior point methods due to its efficiency and fast convergence. In the predictor-corrector method, two linear systems at each iteration must be solved to determine the predictor-corrector direction. The solution of such systems is the step that requires more processing time and should therefore be performed efficiently. To solve both systems the conjugate gradient method is used. Since such systems are very ill-conditioned near an optimal solution, the design of specially tailored preconditioners is an important implementation issue. On the other hand, although the early linear systems do not present the same features, it is advisable to adopt hybrid preconditioners. Initially, the controlled Cholesky factorization is adopted. Its major advantage is the control parameter that allows the preconditioner to vary all way from a diagonal preconditioner to the full Cholesky factorization if desired. After some iterations, the splitting preconditioner is then used. This preconditioner has a very good behavior near a solution of the linear program. However, this good feature has a price, the splitting preconditioner can be very expensive to compute. In this way a careful implementation should be performed in order to achieve competitive results regarding both: speed and robustness. Several strategies to implement the splitting preconditioner are presented. Some are well known, already applied in other contexts, while some were developed specifically for the splitting preconditioner. Numerical experiments with large-scale linear programming problems are performed in order to illustrate the performance of the given strategies.

Keywords:
Preconditioner, linear system, predictor-corrector method

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The multi-objective dispatch problem by hyperbolic smoothing, progressive bounded constraint strategy, and nonlinear rescaling method

Gonçalves, Elis and Balbo, Antonio Roberto and Silva, Diego Nunes and Nepomuceno, Leonardo and Soler, Edilaine Martins

The economic and environmental dispatch problem with valve-point loading effects (EEDP-VP) is formulated as a multi-objective, nonlinear, non-convex, non-differentiable problem and it aims to minimization of two conflicting goals: the cost of power thermoelectric generation and the amount of pollutant emissions, while accounting for operational constraints of the system. Due to the difficulties imposed by the non-differentiabillity and non-convexities, the great majority of solution techniques for solving the highlighted problem generally involve heuristic or meta-heuristic methods. In this study, a deterministic approach is proposed for solution to problem, involving the following strategies: smoothing technique is used to handle non-differentiability, in this case, the smoothing hyperbolic, while the inertia correction strategy generates descent directions only; the multi-objective nature of the problem is handled by the progressive bounded constraint method; an interior-exterior point method is used to solve the subproblems resulting from the the progressive bounded constraint strategy. The method is applied to the generation systems and the results show that the Pareto-curve is obtained efficiently. The proposed approach, resulting from the integration of all such methods and techniques, assures the calculation of the optimal Pareto-set for the EEDP-VP problem, in contrast to the approximated Pareto-set calculated by heuristic approaches.

Keywords:
Economic and environmental dispatch problem, Interior-exterior point methods

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First Efficient Iterations in the Primal-Dual Interior-Point Method

Heredia, Manolo Rodriguez and Oliveira, Aurelio Ribeiro Leite

A Hybrid Approach (HA) is used to compute the search direction in the Primal-Dual Interior-Points Method by Preconditioned Conjugate Gradient Method in two phases. In the first iterations is used the Controlled Cholesky Factorization preconditioner (CCF) and after a phase change criterion the Splitting Preconditioner (PS) is used. In order to improve the efficiency and robustness of the AH by the reduction the number of restarts during the construction of the preconditioner CCF, we propose a modification in the parameters that control the filling and correction of failure that occur in the diagonal. The computation of new parameters is done by considering the relationship between the components of CCF obtained before and after the diagonally failure. Numerical experiments in large-scale linear programming problems corroborated that this approach is competitive. We obtain these results because we use geometric tools to obtain the parameter that control the correction of diagonally failure.

Keywords:
Controlled Cholesky Fatorization

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Irradiational cut from knapsack problem

Lozada, Eleazar Gerardo Madriz

In this work, we present a method to approximate the optimal solution of the knapsack problem. From an interior point of the viable problem, we consider a subspace in order that the only point with integer coordinates is the viable given point. The problem is divided into two sub-problems, in a way that for each sub-problem we want to find the closest viable points of that subspace. Then, a cut is added to the problem and we have a new set of solutions. As the initial set of solutions is a finite set, we apply our method sequentially and we obtain an approximation of the optimal solution of the Knapsack problem.

Keywords:
CUT, KNAPSACK

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Interior point methods and column generation for convex optimization problems

Munari, Pedro and González-Brevis, Pablo; Gondzio, Jacek

Interior point methods (IPMs) have become a crucial tool in optimization. Their application goes beyond linear programming as they are nowadays used to solve large-scale problems that support the decision making process in situations involving network modeling, vehicle routing, financial optimization and many others. To achieve such a variety of applications, IPMs have to be combined with other solution methods, such as column generation and cutting plane methods, and even with tree search methods based on branch-and-bound. In this talk, we present the results of combining the primal-dual interior point method with the column generation technique, to solve difficult convex optimization problems. In particular, we focus on the results of the multiple kernel learning problem, a key application in machine learning for data analysis. As the results indicate, IPMs play an important role in this context, as they make it possible to solve problems quickly and provide solutions that are more accurate in practice.

Keywords:
Primal-dual, Column generation, Convex optimization, Machine Learning

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A robust and efficient proposal for solving the linear system arising in interior-point methods for linear programming

Oliveira, Danilo Elias and González-Lima, María D. and Oliveira, Aurelio Ribeiro Leite

The main computational effort of primal-dual interior point methods for linear programming relies on the computation of the search direction by solving one or more linear systems per iteration. Nowadays, most of the methods used to find the search direction do not obtain very accurate solutions, that is because the systems produced by them tend to be ill-conditioned for points close to the solution set, even for non-degenerate problems. Thus, finding the search direction in an efficient way is a key step to obtain very accurate solutions for linear programming problems. We present in this work an efficient proposal to find the search direction by combining the stable system, presented by GonzÃ¡lez-Lima, Wei and Wolkowicz (2009), and the hybrid iterative method presented by Bocanegra, Campos and Oliveira (2007). For the first outer iterations, we use the hybrid method, where a conjugate gradient method is preconditioned by an incomplete Cholesky decomposition. Then, near to the solution set, we use the Gauss-Seidel method to solve the stable system, where the Jacobian is non singular and not necessarily ill-conditioned. By this way, we are able to obtain very accurate solutions for the linear problem. By using a similar idea than the one used by Oliveira and Sorensen (2005) to obtain the splitting preconditioner, we are able to write the Jacobian of the stable system in a block format, where the blocks in the main diagonal are diagonal matrices and the off-diagonal blocks are close to the null matrices, near the solution set. For degenerate problems a perturbation to the main diagonal is added. Our experiments have shown that the use of our proposal leads to very accurate solutions of the linear programming problem with a small extra computational cost.

Keywords:
linear programming, primal-dual interior point methods, linear system

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Review of interior point methods for semidefinite programming

Paredes, Miguel

This talk seeks to introduce the concepts of semidefinite programming and explains some interior point methods, those methods are normally applied for linear programming and can also be applied for semidefinite programming with some considerations for work in a semidefinite algebra. Additionally, an example of relaxation with semidifinite programming for binary quadratic problems.

A predictor-corrector nonlinear rescaling approach for solving nonsmooth economic dispatch problems

Silva, Diogo Nunes and Balbo, Antonio Roberto and Nepomuceno, Leonardo and Baptista, Edméa Cássia

The main goal of this work is to present a predictor-corrector nonlinear rescaling method, to solve nonsmooth economic dispatch problems. In the nonlinear rescaling method, a transformation is applied on the inequality constraints, leading to an equivalent optimization problem. In this work, we apply the modified logarithmic barrier function transformation. In constrast to the classical logarithmic barrier function, the transformations employed by the nonlinear rescaling method are well defined on a relaxation of the feasible set, which includes its boundary. Thus, the iterates produced by the method can be exterior points. Considering the non-convex nature of the nonsmooth economic dispatch problem, we also present an inertia correction strategy, whose purpose is to ensure that the method produces descent directions and to avoid convergence to stationary points which are not local minima. We present a hyperbolic smoothing technique to handle the non-differentiability of the objective function. In order to evaluate the robustness and efficiency of our approach, we present the results for some instances of the nonsmooth economic dispatch problem.

Keywords:
Nonlinear rescaling, hyperbolic smoothing, nonsmooth economic dispatch

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Numerical experiments with alternative linear systems for the splitting preconditioner applied to interior point methods

Silva, Fábio Rodrigues and Oliveira, Aurelio Ribeiro Leite and Fontova, Marta Ines Velazco

In this work, we carried out numerical experiments with alternative linear systems for the splitting preconditioner applied to preconditioned Conjugate Gradient iterative method, in the context of iterative solution of linear programming problems by interior point methods. We consider the Mehrotra's predictor-corrector method, that search the solution of the linear programming problem by applying Newton's method in the perturbed Karunsh-Kuhn-Tucker's optimality conditions. The preconditioned Conjugate Gradients method is used for the solution of the linear systems. In previous works, a hybrid preconditioning strategy was proposed and computational experiments show its superior performance against direct methods in solving linear systems for some linear programming problems classes. Such approach takes place in two phases: phase 1 uses a kind of incomplete Cholesky preconditioner with an adaptive fill-in as a function of the available memory in the computer; phase 2 uses a preconditioner based on LU factorization, specialized for the latest iterations of interior point methods. In phase 2, the preconditioned matrix is indefinite and can be reduced to a positive definite linear system of one of the sizes of Schur complement. We perform computational experiments with a square matrix of size equals to the difference between the number of columns and rows of constraints matrix, aiming to benchmark the versions developed for this purpose. It was proposed four strategies for the preconditioned augmented system recovery solution. We show the results in terms of four performance metrics and compare the proposed versions with the hybrid version presented in previous works, solving a set of 35 selected test problems from different mathematical programming problems libraries. The results show that, in general, the developed versions present better computational performance over the hybrid version.

Keywords:
Linear Programming, Preconditioning, Linear Systems, Conjugate Gradient Methods

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New heuristics for a family of simple algorithms

Silva, Jair and Oliveira, Aurelio Ribeiro Leite and Ghidini, Carla T. L. S.

In this work, we present new heuristics for the parameter p of a family of simple algorithms. This family of algorithms is used to accelerate the convergence of a version of PCx code which is an implementation of interior point methods by adding a hybrid iterative approach with two preconditioners for solving linear systems of the interior point method. As the choice of the parameter p determines the performance of this family, an appropriate choice of the parameter p is essential for the success of this approach. A family of algorithms is applied at the transition of the preconditioners in order to improve both the speed and robustness of the PCx code. Preliminary numerical experiments with this approach are presented.

Keywords:
Heuristic, Preconditioning, Interior Point Methods

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A comparison of the logarithmic barrier and modified logarithmic barrier functions in a primal-dual interior and exterior point method, with strategies for determining new search directions applied to the Reactive Optimal Power Flow.

Souza, Rafael Ramos and Balbo Antonio Roberto and Nepomuceno, Leonardo and Pinheiro, Ricardo Bento Nogueira

In this work we present a primal-dual interior and exterior point method, which explores and compares the logarithmic barrier function and modified logarithmic barrier function. It is proposed a strategy for simplifying the Cholesky procedure called quadratic test, to verify the positivity of the Hessian matrix of the problem. Through combinations of the predictor and corrector directions, strategies are proposed for determining new search directions, considering complementary conditions of the problem variables. The method with the strategies proposed was implemented in Matlab and solves the problem of Reactive Optimal Power Flow, in order to minimize losses of active power in transmission, the tests were carried out using the 39 bus system and IEEE 57 and 118 bus systems.

Keywords:
Reactive optimal power flow, primal-dual interior and exterior points methods

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A New Approach for Finding a Basis for the Splitting Preconditioner for Linear Systems from Interior Point Methods

Suñagua, Porfirio and Oliveira, Aurelio Ribeiro Leite

The class of splitting preconditioners for the iterative solution of linear systems arising from Mehrotra's predictor-corrector method for large scale linear programming problems needs to find a basis through a sophisticated process based on the application of a rectangular LU factorization. This class of splitting preconditioners works better near a solution of the linear programming problem when the matrices are highly ill-conditioned. In this study, we develop and implement a new approach to find a basis for the splitting preconditioner, based on standard rectangular LU factorization with partial permutation of the scaled transpose linear programming constraint matrix. In most cases, this basis is better conditioned than the existing one. In addition, we include a penalty parameter in Mehrotra's predictor-corrector method in order to reduce ill-conditioning of the normal equations matrix. Computational experiments show a reduction in the average number of iterations of the preconditioned conjugate gradient method. Also, the increased efficiency and robustness of the new approach become evident by the performance profile. To show that this approach is competitive with direct methods, we compare the processing times with one of the efficient method like PARDISO.

Keywords:
Linear Programming, Splitting Preconditioner, Rectangular, LU factorization

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Approximated Normal Equations Systems in interior points methods

Tsuchiya, Luciana Yoshie and Oliveira, Aurelio Ribeiro Leite

One of the most commonly used approaches to solve the normal equations arising in primal-dual interior-point methods is the direct solution by using the Cholesky factorization on the matrix system. The major disadvantage of this approach is the number of generated fill-in, which implies in a great computational cost (memory and time) to solve the linear system. When the Cholesky factorization is very expensive, iterative methods, as the preconditioned conjugate gradient method, become more appropriate to solve the normal equations system. A preconditioner which could be used is the controlled Cholesky factorization, which is a kind of incomplete Cholesky factorization. The consequence of solving the normal equations with an iterative method is the arising of a residual error on the right hand side of the equation. However, if this error satisfy certain conditions in each iteration, it is possible to compute a good direction in the sense that convergence is reached. In order, to deal with the fill-in problem in the Cholesky factorization and motivated by the fact that an approximate direction with good properties can be computed in the interior point methods, we propose a method that directly solves an approximated system of normal equations keeping the fill-in under control. Our proposal is to replace the Cholesky factorization of the normal equations matrix by its controlled Cholesky factorization. Thus, in early iterations we compute an approximate direction from the original one, obtaining a less dense matrix as possible, making the solution of the system faster. In later iterations we may need to compute factorizations closer to the full Cholesky factorization, in such a way that the convergence method is not affected.

Keywords:
Normal Equation, Cholesky Factorization, Controlled Cholesky Factorization

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Influence of matrix reordering on the performance of the iterative methods for solving linear systems arising from interior point methods.

Velazco, Marta and Silva, Daniele and Oliveira, Aurelio Ribeiro Leite

This study analyzes the influence of sparse matrix reordering with regards to the solution of linear systems originating from interior point methods. In particular, the latter are solved by the conjugate gradient method preconditioned by a two phase hybrid preconditioner that uses the controlled Cholesky factorization during the initial iterations and in the remaining ones adopts the splitting preconditioner. This approach presents satisfactory computational results in the solution of linear systems with symmetric positive-definite matrices. The reordering of reverse Cuthill- McKee heuristics, the Sloan algorithm and minimum degree are all analyzed in this study. Through numerical experiments, we observe that these heuristics can bring benefits with regards to accelerating the rate of convergence of the conjugate gradient method, and with regards to reducing processing time and solving problems not solved by other approaches.

Keywords:
Preconditioner, Reordering Heuristics

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Computing the splitting preconditioner for interior point method using an incomplete factorization approach

Velazco, Marta and Oliveira, Aurelio Ribeiro Leite

Splitting preconditioner is very effective in the last iterations of interior point methods for linear programming problems. However, the preconditioner may be expensive to compute since it needs to find a set of linearly independent columns from the constraint matrix in order to build a non singular matrix. In this work, a new version of the splitting preconditioner is computed waiving the need to obtain a non-singular matrix since the controlled Cholesky factorization will be used to compute the preconditioner from the normal equations of a subset of matrix A columns. Such an approach is practicable since the controlled Cholesky factorization can compute a factorization of a non singular matrix by adding a suitable diagonal perturbation. Numerical experiments show that the new approach improves previous performance results for both robustness and time on some large-scale linear programming problems.

Keywords:
Splitting preconditioner, controlled Cholesky factorization

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Contributed Posters

Genetic Algorithms Application in Reordering Sparse Matrices

Cavalheiro, E. M. B and Silva, D. C. and Almeida, S. M.

This work consists in the analysis of the performance of genetic algorithms and heuristics based on graph theory as options for reordering of matrices in the context of resolution of linear systems. More specifically, in the resolution of systems arising from interior point methods using the conjugate gradient method precondicioned by controlled Cholesky factorization. For this purpose, variations of genetic algorithms and also the heuristics LexBFS, neighborhood, count of columns, and minimum degree without clicks were implemented, based on the reverse Cuthill-McKee (RCM) and minimum degree heuristics. The ease of implementation and rapid results achievement were priorized. These heuristics were integrated into an implementation of the predictor-corrector method in MATLAB. Thus numerical experiments using NETLIB library problems were performed. It was observed that the heuristics presented similar results for small instances, being the genetic algorithm better in some cases. The column count and minimum degree without clicks heuristics showed better results for larger instances. Also these heuristics were compared with the RCM and minimum degree heuristics, using MATLAB routines. RCM and minimum degree showed better results when compared with genetic algorithms and heuristics based on graph theory, except for the problems SCTAP2, SCTAP3 , TRUSS and WOODW, for which the genetic algorithm showed better performance than the RCM heuristics, reducing the processing time of the conjugate gradient method. The LexBFS and neighborhood heuristics showed the worst performance. However, in most cases the structure of the matrices after the LexBFS reordering are similar to the matrices obtained by the RCM reordering, but in a mirrored form. The same applies to the neighborhood and minimum degree heuristics. Perhaps the use of the reverse ordering of these heuristics can generate good results.

Keywords:
Genetic Algorithms, Reordering for Matrices, Linear Systems

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Interior Point Method Applied to the Pre-dispatch Hydroelectric System with security constraints and maneuvers

Cogubum, Maria Cristina Tiemi Hamada and Oliveira, Aurelio Ribeiro Leite and Carvalho, Silvia Maria Simões

The interior point methods are developed for minimizing the pre-dispatch generation and transmission loss of a hydroelectric DC power system where programmed maneuvers and security constraints occur. The resulting matrix structure is exploited aiming an efficient implementation. Considering that the energy demand varies along the day, the power generation should follow the (electric charge) variation. With the change in demand, it is necessary to perform some programmed maneuvers to efficiently adapt the transmission network to this load enabling it to keep the system stable. Security constraints, in turn, seek to prevent the most important contingencies related to line transmission loss, generators shut down, and violation of bounds on previously known bottlenecks. According to the National Operating System the consideration of such maneuvers and additional constraints approaches this model to the problem of the Brazilian pre-dispatch system. The developed implementation is compared with an existing one that does not consider neither additional topology change or security constraints in matters regarding computational efficiency and solution quality.

Keywords:
Power Systems, Interior Point Methods, Predispatch Problem, Linear Programming

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A New Primal-Dual Method for Compressed Sensing Problems

Kikuchi, Paula Aparecida and Oliveira, Aurelio Ribeiro Leite and Cantane, Daniela Renata

An efficient technical to acquire and reconstruct signals is called Compressive Sensing (CS), it is applied in the areas of photography, magnetic resonance, tomography, and many others. The Compressive Sensing theory asserts that we can recover certain signs and images through few samples. This is possible because the signal of interest is sparse, and the system matrix satisfies the Restricted Isometry Property (RIP). The solution of the overdetermined system Ax=b, where A is a Real matrix mxn, x is a Real vector nx1, b is a Real vector mx1, is our objective. It is shown that in certain situations, the exact recovery of the solution x can be found by the Basis Pursuit problem. Assume that x° is the solution of interest, and it has a sparse image through a redundant and coherent dictionary W, where W is a Real or Complex matrix E nxl, and n is less or equal l. Therefore W*x° is sparse, where * denotes the conjugate transpose operator. If W*x° is sparse, under certain conditions on matrices A and W, we can rewrite the Basis Pursuit problem. Some formulations of this problem are proposed, where the non-differentiability on the norm l1 is handled, and the problem is rewritten by a Pseudo-Huber function. Our goal is to apply the interior point method on the optimality conditions of the obtained problem, where changes in the optimality conditions are perfomed in order to obtain more efficient results known in the literature.

Keywords:
interior point methods, signal processing

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Interior Point Methods applied in Hydraulic Network Optimal Operation

Lima, Aline Maria and Oliveira, Aurelio Ribeiro Leite

In this work, the primal-dual interior point method is developed to minimize cost problem of pumping and losses on water distribution. The matrix structure is exploited objectifying an efficient implementation. In the distribution problem, the nets are complex and the diameters are small, making that the losses have great importance, becoming the distribution problem more difficult.

Keywords:
Water distribution network, Interior Point Methods, Network flow models

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Interior-Point Primal-Dual method as an alternative for estimating of parameters for stochastic context-free grammar

Lopez, Esther Sofia Mamian and Oliveira, Aurelio Ribeiro Leite

Statistical Natural Language Processing (NLP) comprises all quantitative approaches to automated language processing, including probabilistic modeling, information theory, and linear algebra. In probabilistic modeling, an important line of research is text parsing. There are many different approaches for parsing work, whose goal consists in perform a formal analysis of a string of symbols, either in natural language or in computer languages, conforming to the rules of a formal grammar, resulting in a parser tree which describe their syntactic structure. The stochastic context free grammar (SCFG) is a statistical model for syntactic analysis, where for each grammar's production has been assigned one probability. The process for estimate the probability values is called learning grammar which is an automatic process. Usually, the Inside-Outside algorithm is employed to perform such estimations. However, the automatic estimation of SCFG using the Inside-Outside algorithm is limited in practice by its O(n3) complexity. We propose to use an approach based in interior point methods as an alternative for estimating the probabilities rules.

Keywords:
Interior-Point Primal-Dual method,

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A new approach for changing phases in a hybrid preconditioner for interior point methods

Madrid, Kelly Cadena and Ghidini, Carla Taviane lucke da Silva and Oliveira, Aurelio Ribeiro Leite

The most important step to solve linear programming problems using the predictor corrector interior point method is to solve two distinct linear systems at each iteration with the same coefficient matrix to determine both predictor and corrector directions. Notice that this is the most computationally expensive step. The Preconditioned Gradient Conjugated iterative method can be used to solve these systems. Since they are very ill conditioned close to a solution, a way to get around this is to work with a hybrid preconditioning approach , which uses the Controlled Cholesky Factorization preconditioner in the first iterations, and after a certain number of iterations, when the matrix becomes even more ill-conditioned, it switch to the Splitting preconditioner, which works very well for this type of matrices. To change the preconditioner at the right time is critical for a better performance. Currently, the heuristics used for it is quite simple and based on the number of conjugate gradient iterations. In this paper, we present a new heuristic based on an estimative of the condition number of the system matrix in order to obtain a more efficient and robust interior point method.

Keywords:
Interior point methods, Preconditioners, Iterative methods

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A new modified version of the Controlled Cholesky Factorization for hybrid preconditioning of linear system arising in IPM

Prado, Leonardo Cavalcante and Silva, Lino Marcos

Preconditioners from Incomplete Cholesky Factorization like Controlled Cholesky Factorization are very important in IPM because they play a fundamental role on hybrid approaches of preconditioning with the splitting preconditioner. However, the building of this new preconditioner can be affected by breakdowns during the process of factorization. It occurs when small or negative pivots are found. In general, when this occurs, the diagonal of the matrix is increased by a positive number and the incomplete factorization is restarted. This technique works well for many linear programming problems but the CPU time for solving them can be increased by this approach. On the other side, we can build efficient and low cost preconditioners for shifted linear systems by incomplete Cholesky factorization updates. In this work we are proposing to apply a new updating in the controlled Cholesky factorization and to use it in the earlier IPM iterations in the hybrid precondition approach. The numerical experiments, shows some interesting results.

Keywords:
IPM, preconditioner, controlled Cholesky factorization

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The Simplex Method and application in radiotherapy.

Salvador, Thais Reigadas and Carvalho, Silvia Maria Simões

Radiothepary treatment success depends on good planning. For an optimal planning, mathematical techniques are being used in order to maximize radiation at tumor and minimize radiation in the surrounding regions, thus linear programming models has been great tools to assist the construction of treatment plans for radiation therapy. Thus, this work aims: studying the key concepts involved in planning the treatment of cancer by radiotherapy; study the models the linear program- ming (PL) applied to optimal planning; make a broad study on the technique of Simplex Method for PL and compare the results obtained by the simplex method to interior points method.

Keywords:
Simplex Method, Radiotherapy, Interior Point Method

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Iterative methods to solve the linear systems from interior point methods.

Silva, Igor Moreira and Guidini, Carla Taviane Lucke Silva and Silva, Marilene

In this work, two non-stationary iterative methods are considered: Gradient Conjugated (GC) and MINRES. Both methods can be used to solve linear systems from the interior point methods. To accelerate the convergence of these iterative methods the preconditioning strategy is necessary. A hybrid approach to solve the linear systems, that involves the use of both methods GC and MINRES it has been proposed in the literature. However, determining the best moment to change the iterative methods is not simple. In this way, some criteria to change the method in the hybrid approach are proposed, with the intention of obtaining improvements in terms of efficiency and robustness.

Keywords:
iterative methods, linear systems, interior point method.

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A Python/C library for box-constrained global optimization with continuous GRASP

Silva, Ricardo Martins de Abreu and Resende, Mauricio G. C. and Parpalos, Panos

This paper describes libcgrpp, a GNU-style dynamic shared Python/C library of the continuous greedy randomized adaptive search procedure (C-GRASP) for bound constrained global optimization. C-GRASP is an extension of the GRASP metaheuristic (Feo and Resende, 1989) and has been used to solve unstable and nondifferentiable problems, as well as hard global optimization problems, such as chemical equilibrium systems and robot kinematics applications.

Keywords:
global optimization, continuos grasp

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Program

2nd Brazilian Workshop on Interior Point Methods

17-18 May, 2016 - Campinas, Brazil

PROGRAM

Tuesday - 17/05	
8:30	**Registration Opens**
8:45	**Opening**
9:00	**Plenary Conference (Chair: Luciana Casacio)** *Continuation in optimization: from interior point methods for large-scale optimization to Big Data optimization* Jacek Gondzio
10:00	**Cofee-break**
Contributed Session I (Chair: Aurelio Ribeiro Leite Oliveira)	
10:30	*A predictor-corrector nonlinear rescaling approach for solving nonsmooth economic dispatch problems* Diego Nunes da Silva
10:50	*Interior point methods experiences in brazilian power system* Anibal Tavares de Azevedo
11:10	*The multi-objective dispatch problem by hyperbolic smoothing, progressive bounded constraint strategy, and nonlinear rescaling method* Elis Gonçalves
11:30	*A comparison of the logarithmic barrier and modified logarithmic barrier functions in a primal-dual interior and exterior point method, with strategies for determining new search directions applied to the Reactive Optimal Power Flow.* Rafael Ramos de Souza
11:50	*Interior point methods for power flow optimization with security sonstraints* Luciana Casacio
12:10	**Lunch**
Contributed Session II (Chair: Pedro Munari)	
14:00	*Strategies to compute the splitting preconditioner to solve the linear systems from interior point methods* Carla Taviane Lucke da Silva Ghidini
14:20	*Computing the splitting preconditioner for interior point method using an incomplete factorization approach* Marta Velazco

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14:40	*A new approach for finding a basis for the splitting preconditioner for linear systems from interior point methods* Porfirio Suñagua
15:00	*Spectral analysis of the splitting preconditioner with sparse base* Cecilia Orellana Castro
15:20	*A robust and efficient proposal for solving the linear system arising in interior-point methods for linear programming* Danilo Elias de Oliveira
15:40	*Numerical experiments with alternative linear systems for the splitting preconditioner applied to interior point methods* Fabio Rodrigues Silva
16:00	**Cofee-break**
16:30	**Poster Session (Chair: Daniela Cantane)**
	Interior point methods applied in hydraulic network optimal operation Aline Maria de Lima
	Interior point primal-dual method as an alternative for estimating of parameters for stochastic context-free grammar Esther Sofia Mamian Lopez
	Iterative methods to solve the linear systems from interior point methods Igor Moreira da Silva
	A new approach for changing phases in a hybrid preconditioner for interior point methods Kelly Cadena Madrid
	A new modified version of the Controlled Cholesky Factorization for hybrid preconditioning of linear system arising in IPM Leonardo Cavalcante do Prado
	Interior point method applied to the pre-dispatch hydroelectric system with security constraints and maneuvers Maria Cristina Tiemi Hamada Cogubum
	A new primal-dual method for compressed sensing problems Paula Aparecida Kikuchi
	The simplex method and application in radiotherapy Thais Reigadas Salvador
	A Python/C library for box-constrained global optimization with continuous GRASP Ricardo Martins de Abreu Silva

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Wednesday - 18/05	
9:00	**Plenary Conference II (Chair: Anibal Azevedo)** *Interior point methods and DC power systems - How to squeeze a matrix* Aurelio Ribeiro Leite de Oliveira
10:00	**Cofee-break**
Contributed Session III (Chair: Christiano Lyra)	
10:30	*Interior point methods and column generation for convex optimization problems* Pedro Munari
10:50	*Review of interior point methods for semidefinite programming* Miguel Paredes
11:10	*Irrational cut from knapsack problem* Eleazar Gerardo Madriz Lozada
11:30	*Mean-variance model for portfolio selection with returns based on GARCH and Random Walk* Silvana Bocanegra
11:50	*Genetic algorithms application in reordering sparse matrices* Ellen Marianne Bernal Cavalheiro
12:10	**Lunch**
Contributed Session IV (Chair: Frederico Campos)	
14:00	*Influence of matrix reordering on the performance of the iterative methods for solving linear systems arising from interior point methods.* Marta Velazco
14:20	*A heuristic to switch the preconditioned iterative linear system solver in interior point using Ritz values* Petra Maria Bartmeyer
14:40	*First efficient iterations in the primal-dual interior point method* Manolo Rodriguez Heredia
15:00	*Approximate normal equations systems in interior point methods* Luciana Yoshie Tsuchiya
15:20	*New heuristics for a family of simple algorithms* Jair da Silva
15:40	*Interior point method with the continued iteration* Lilian Ferreira Berti
16:00	**Cofee-break**
16:30	**Plenary Conference III (Chair: Kelly Poldi)** *Metaheuristic approaches to continuous global optimization* Mauricio Resende
17:30	**FAPESP**