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Advanced Materials Science Research

Preconditioning boundary integral equations in electromagnetic scattering and thermonuclear energy research

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Biography

Bruno Carpentieri obtained a Laurea degree in Applied Mathematics in 1997 from Bari University. He furthered his Ph.D studies in Computer Science in Toulouse, France. After some professional experiences as a postdoctoral researcher at University of Graz, as an Assistant Professor at University of Groningen and as a Reader at Nottingham Trent University, since May 2017 he is holding an Associate Professor appointment in Applied Mathematics at the Faculty of Computer Science, University of Bozen-Bolzano where he is currently coordinating the activities of the Center for Information and Database Systems Engineering. The specialty of his research is numerical linear algebra with applications and high-performance computing.

Abstarct

Surface and volume integral equations are widespread modelling tools for many computational science and engineering applications, e.g., in computational electromagnetics and acoustic simulations, multi-component fl uid fl ows, multiphase problems in materials science, energy research, elasticity and other fi elds. The numerical discretization of integral equations typically leads to high dimensional dense linear systems whose solution is very demanding of fast algorithms with reduced complexity and of large computational resources. For example, scattering of a plane wave by a perfectly conducting spherical object with a diameter of 1800 wavelengths modelled by surface integral equations gives rise to a fully populated matrix with more than three billion unknowns. Nearly all truly dense large linear systems arising from scientifi c applications come from the solutions of integral equations and in emerging fi elds of statistical learning and machine/deep learning. Standard direct solution methods are not affordable to solve problems of this size even on modern parallel computers due to their large memory requirements. Iterative Krylov methods can mitigate the memory limitations of direct methods, but they need fast matrix-vector products and robust preconditioners to achieve linear or almost linear complexity. In this talk, we discuss trends and problems in the design of preconditioned Krylov subspace methods for solving largescale integral equations problems where dense and large matrices arise. We cover various numerical linear algebra aspects, such as the choice of the iterative method, characteristics and performances of fast matrix-vector products, and the design of algebraic preconditioners based on multilevel incomplete LU factorization, sparse approximate inverses, inner-outer methods, and other approaches combined with fast solvers. As shown by examples, the developed numerical tools can enable effi cient solutions of boundary integral formulation of electromagnetics scattering problems in radar-cross-section applications in industry on a moderate number of cores and processors. Some of these techniques have been tested in a recently developed fast fusion research simulation software with the unprecedented capability of simultaneously considering three-dimensional effects of conductors surrounding the plasma and the inherent non-linearity of the plasma behaviour itself. The code is currently used worldwide to analyse fusion devices currently in use, in the construction phase and under design. Both real world case studies are discussed.

Publications

1. Off-diagonal low-rank preconditioner for difficult PageRank problems - ZL Shen, TZ Huang, B Carpentieri, C Wen, XM Gu, XY Tan - Journal of Computational and Applied Mathematics 346, 456-470 - 2019
2. Multilevel inverse-based factorization preconditioner for solving sparse linear systems in electromagnetics - Y Bu, B Carpentieri, Z Shen, T Huang - Computational Electromagnetics International Workshop (CEM), 2015, 1-3 - 2015
3. A cost-effective smoothed multigrid with modified neighborhood-based aggregation for Markov chains - ZL Shen, TZ Huang, B Carpentieri, C Wen - Mathematical Problems in Engineering - Vol. 2015, Article ID 816935, 15 pages - 2015
4. Preconditioning for Large-Scale Boundary Integral Equations in Electromagnetics [Open Problems in CEM] - B Carpentieri - IEEE Antennas and Propagation Magazine 56 (6), 338-345 - 2014
5. Effects of asymmetric vertical disruptions on ITER components - R Albanese, B Carpentieri, M Cavinato, S Minucci, R Palmaccio, et al - Fusion Engineering and Design 94, 7-21 - 2015

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