2012

Advanced Techniques for Efficient Modeling of Electrically Large Structures on Desktop PCs

Kolundzija, B.M., Tasic, M.S., Olcan D.I., Zoric, D.P., Stevanetic, S.M., "Advanced techniques for efficient modeling of electrically large structures on desktop PCs", Applied Computational Electromagnetics Society Journal, Special Issue on Computational Electromagnetics Workshop, CEM 11, Vol. 27, No. 2, pp. 123-131, February, 2012.

Link to Publication

Abstract: The method of moments (MoM), applied to surface integral equations (SIEs) in the frequency domain, enables very accurate analysis of composite metallic and dielectric structures. Particularly, on a desktop PC, the electrical size of solvable problems is very limited by memory and time resources. This limit can be significantly extended by using advanced techniques, which are shortly revealed. The focus of the paper is to present results that illustrate current possibilities of MoM/SIEs solution on a desktop PC: (1) monostatic RCS of a cube of side 80 wavelengths, (2) beam steering of an array of 30 by 30 microstrip patch antennas at 9.2 GHz, and (3) beam steering of 4 by 4 patch antennas at 5 GHz, placed on a 19 m long helicopter.

On Increasing Capabilities of GPU In-Core Solver Applied to Method of Moments

Zoric, D.P., Olcan, D.I., Kolundzija, B.M., "On increasing capabilities of GPU in-core solver applied to method of moments", Proc. of EuCAP 2012: 6th European Conference on Antennas and Propagation, 26-30 March 2012., Prague, Czech Republic, pp. 391-394, ISBN: 978-1-4577-0919-7, DOI: 10.1109/EuCAP.2012.6206020

Link to Publication

Abstract: We increase the computation and memory capabilities of GPU in-core solver by using block LU decomposition, RAM for storing the whole matrix and VRAM for storing currently used block(s) of data. Using up to 3 GPUs gives parallelization efficiency of up to 70%. The matrix of EM problems with 50 000 unknowns can be LU decomposed within 4 minutes on a PC with used GPUs.

Physical Optics Driven Method of Moments using Maximally Orthogonalized Basis Functions

Kolundzija, B.M., Tasic, M.S., "Physical Optics Driven Method of Moments using Maximally Orthogonalized Basis Functions", Proc. of 28th Annual Review of Progress in Applied Computational Electromagnetics (ACES 2012), Columbus, OH, USA, April 10-14, 2012, pp. 174-180.

Link to Publication

Abstract: -

Efficient Method of Moment Simulation Based on Higher Order Bases and CPU/GPU Parallelization

Kolundzija, B.M., Olcan, D.I., Zoric, D.P., "Efficient method of moment simulation based on higher order bases and CPU/GPU parallelization", Proc. of 2012 IEEE International Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting, Chicago, IL, USA, July 8-14, 2012, ISBN: 978-1-4673-0460-3, ISSN: 1522-3965. DOI: 10.1109/APS.2012.6348419

Link to Publication

Abstract: Full wave analysis of arbitrary structures in frequency domain is presented, as applied in WIPL-D Pro, software for 3D EM simulation. Currents induced over metallic structures and equivalent currents placed over material boundaries are found by solving electric field integral equation (EFIE) and PMCHW integral equations, respectively. High efficiency of the method is achieved by a) combining the Galerkin testing with higher order bases to obtain the symmetrical matrix equation of reduced size, and b) parallelization performed at CPU and/or GPU, for matrix fill and incore or out-of-core matrix solution.

GPU Accelerated EM Modelling in Frequency Domain: Comparison of Performance of Various GPU Cards

Zoric, D.P., Olcan, D.I., Kolundzija, B.M., "GPU accelerated EM modelling in frequency domain: comparison of performance of various GPU cards", ISAP 2012 - International Symposium on Antennas and Propagation, 29. October - 2. November 2012, Nagoya, Japan.

Link to Publication

Abstract: In this paper, we compared performances of different NVIDIA CUDA-enabled GPUs in accelerating MoM based software for EM modelling in frequency domain, WIPL-D. Three different GeForce GPUs were used: GTX 480, GTX 580 and GTX 680. The performance was measured on three EM problems: PEC sphere, Luneburg lens, and microstrip patch antenna array placed at the helicopter fuselage. The best performance in matrix fill was achieved on GTX 580, and the best performance in matrix inversion was achieved on GTX 680. Also, it was shown that the most critical parameter for achieving better performance is GPU memory bandwidth.

2011

Advances in PO driven MoM

Tasic, M.S., Kolundzija, B.M., "Advances in PO driven MoM", International Conference on Electromagnetics in Advanced Applications (ICEAA) 2011, Torino, Italy, September 12-16, 2011 , pp. 1124-1127, ISBN:.978-1-61284-976-8, DOI: 10.1109/ICEAA.2011.6046507

Link to Publication

Abstract: Electric size of scatterers that can be analyzed by Method of Moment (MoM) is limited by memory and time resources. This limit can be significantly extended by using physical optics (PO) driven MoM. In this paper PO driven MoM is accelerated using Graphics Processor Units (GPUs). Thus, solution of scatterers requiring 1 million unknowns is enabled in one day at PC computer. Numerical results are shown for fighter scatterer at 4 GHz and 5.5 GHz.

Accelerating WIPL-D Numerical EM Kernel by Using Graphics Processing Units

Kolundzija, B.M., Olcan, D.I., Zoric, D.P., Maric, S.M., "Accelerating WIPL-D numerical EM kernel by using graphics processing units", 10th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Services TELSIKS 2011., Nis, October, 2011, pp. 413-419, ISBN: 978-1-4577-2018-5, DOI: 10.1109/TELSKS.2011.6143233

Link to Publication

Abstract: We present acceleration for numerical solving of electromagnetic (EM) problems by using method of moments (MoM) and NVIDIA graphics processing units (GPU). Three stages of MoM are accelerated: matrix fill, solution of complex linear equations and post-processing. The results show that GPUs can be efficiently used for EM simulations.

Benchmarking GPU Accelerated WIPL-D Out-of-Core Solver

Zoric, D.P., Olcan, D.I., Kolundzija, B.M., "Benchmarking GPU Accelerated WIPL-D Out-of-Core Solver", 27th Annual Review of Progress in Applied Computational Electromagnetics (ACES), March 27-31, 2011., Williamsburg, Virginia, USA, pp. 734-739.

Link to Publication

Abstract: -

Solving Electrically Large Electrodynamic Problems Using Graphics Processing Units

Zoric, D.P., Olcan, D.I., Kolundzija, B.M., "Solving Electrically Large Electrodynamic Problems Using Graphics Processing Units", Proceedings of the 5th European Conference on Antennas and Propagation (EUCAP), April 10-15, 2011, Rome, Italy, pp. 2263-2267, ISBN: 978-1-4577-0250-1

Link to Publication

Abstract: We present results for solving electrically large electrodynamic problems using NVIDIA graphics processing units. The problems are solved using method of moments, surface integral-equation formulation, and higher-order basis functions. The large dense system of linear equations, which is filled by using method of moments, is solved with out-of-core approach accelerated with graphics processing units. Three electrically

large examples are considered: a perfect electric conducing cube scatterer with up to 33 λ side length, a horn antenna with up to 125 λ length, and Cassegrain reflector antenna with up to 280 λ reflector diameter. The presented results show that problem of up to 200 000 unknown (complex) coefficients can be solved within 24 h on one personal computer with one graphics processing unit.

Solving Electrically Large EM Problems by Using Out-Of-Core Solver Accelerated with Multiple Graphical Processing Units

Zoric, D.P., Olcan, D.I., Kolundzija, B.M., "Solving electrically large EM problems by using out-of-core solver accelerated with multiple graphical processing units", 2011 IEEE International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting (AP-S 2011), July 3-8, 2011, Spokane, Washington, USA, ISSN: 1522-3965, DOI: 10.1109/APS.2011.6165482

Link to Publication

Abstract: We present results for frequency-domain MoM simulations of electrically large structures using out-of-core solver accelerated with multiple GPUs on a single personal computer. The structures analyzed in order to demonstrate the efficiency of proposed out-of-core solver are Cassegrain reflector antenna with up to 240 λ reflector diameter and Luneburg lens, up to 16 λ diameter, excited with a half-wavelength dipole. The acceleration of out-of-core solver is up to 10 times with one GPU compared to a standard CPU, or up to 20 times when using 3 GPUs.

Full-Wave Analysis of Electrically Large Structures on Desktop PCs

Kolundzija, B.M., Tasic, M.S., Olcan, D.I., Zoric, D.P, Stevanetic, S., "Full-wave analysis of electrically large structures on desktop PCs", Computational Electromagnetics International Workshop (CEM) 2011, Izmir, Turkey, August 10-13, 2011, pp. 122-127, ISBN: 978-1-4577-1685-0, DOI: 10.1109/CEM.2011.6047344

Link to Publication

Abstract: Method of moments applied to surface integral equations combined with higher-order basis functions enables full-wave analysis in frequency domain of complex and relatively large structures. The electrical size of solvable problems can be further extended using different techniques: symmetry of the problem, "smart reduction" of expansion orders, physical optics driven method of moments, iterative methods, multilevel fast multipole algorithm, out-of-core solver, and parallelization at CPU/GPU. Results are presented for: (1) monostatic RCS of cube of side 50λ (100λ), (2) beam steering of array of 40 by 40 microstrip patch antennas at 9.2 GHz, and (3) beam steering of 4 by 4 patch antennas at 2 GHz (5 GHz), placed on a 19-m long helicopter.

Calculating Highly Oscillatory EM Transients by Using Rational-Function Interpolation and FFT

Olcan, D.I., Kolundzija, B.M., "Calculating highly oscillatory EM transients by using rational-function interpolation and FFT", Proc. of 3rd International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems, IEEE COMCAS 2011, Tel Aviv, Israel September 7-9, 2011, ISBN: 978-1-4577-1692-8, DOI: 10.1109/COMCAS.2011.6105864

Link to Publication

Abstract: We compare results for EM transients calculated using frequency domain analysis coupled with FFT with and without frequency-domain rational-function interpolation, in order to reduce the total number of frequency samples needed for accurate calculation of transients. To further reduce the total analysis time, we use zero-padding, for all frequencies where excitation spectrum is negligible. The proposed approach is applied to a problem of finding transient EM fields within metallic resonator with high Q-factor. The presented results show that time-domain response can be calculated more efficiently, with preserving the overall accuracy, if the proposed rational-function interpolation in frequency domain is used.

2010

On Calculating Transient EM Responses with WIPL D

Olcan, D.I., Kolundzija, B.M., "On Calculating Transient EM Responses with WIPL D", 26th Annual Review of Progress in Applied Computational Electromagnetics (ACES), Tampere, Finland, pp. 673-678, April 26 - April 29, 2010.

Link to Publication

Abstract: -

2008

Electromagnetic Modeling of Complex and Electrically Large Structures

Kolundzija, B.M., Sumic, D., Olcan, D., Tasic, M., "Electromagnetic modeling of complex and electrically large structures", IEEE International Conference on Microwaves, Communications, Antennas and Electronic Systems, COMCAS 2008, Digital Object Identifier: 10.1109/COMCAS.2008.4562835, 2008.

Link to Publication

Abstract: Modern design procedure of antennas, microwave components and EMC facilities usually includes full wave analysis of composite metallic and dielectric structures in frequency domain. One of the methods that can be used for such full wave analysis is method of moments (MoM) applied to surface integral equations (SIEs).

Electromagnetic Simulation of Complex and Electrically Large Structures in WIPL-D Pro

Kolundzija, B. M., Sumic, D., "Electromagnetic Simulation of Complex and Electrically Large Structures in WIPL-D Pro", IEEE Microwave Magazine, vol. 9 no. 6, str. 159-162, 2008.

Link to Publication

Abstract: This article has demonstrated the application of higher order basis functions, smart reduction of expansion orders, and multilevel fast multipole method in efficient 3-D EM simulation of complex and electrically large structures (from compact multiband antenna for wireless applications to 160 lambda long aircraft scatterer) at a desktop computer.

2007

Comparison of Parallel Solution of Electrically Large Structures on a Cluster and Multi-Core Workstation

Sumic, D.S., Kolundzija, B.M., "Comparison of Parallel Solution of Electrically Large Structures on a Cluster and Multi-core Workstation", Proc. ISAP Int. Symp., pp. 983-986, CD ROM Edition: POS1-32.pdf, Niigata, Japan, Aug. 2007.

Link to Publication

Abstract: -

Computation of Time-Domain Responses via Frequency-Domain Analysis and FFT

Olcan, D.I., Kolundzija, B.M., "Computation of Time-Domain Responses via Frequency-Domain Analysis and FFT", Proc. ISAP Int. Symp., pp. 1031-1034, CD ROM Edition: POS1-44.pdf, Niigata, Japan, Aug. 2007.

Link to Publication

Abstract: -

Efficient Solution of Electrically Large and Complex Problems Using Parallel WIPL-D 3D EM Solver

Sumic, D.S. and Kolundzija, B.M., "Efficient Solution of Electrically Large and Complex Problems Using Parallel WIPL-D 3D EM Solver", Proc. IEEE AP-S Int. Symp., pp.1277-1280, CD ROM Edition: 0321.pdf, Honolulu, Hawaii, USA, July 2007.

Link to Publication

Abstract: In this paper, we present an overview of parallelization of WIPL-D 3D EM solver and present examples of electrically large structures simulated on a small computer cluster. A helicopter up to 51 lambda

long was used as a benchmark example for illustrating parallelization efficiency. Radar cross section from the 51 lambda long helicopter is calculated in 72 minutes on a low-cost 8-node cluster.

Efficient Calculation of Time-Domain Responses of Antennas Analyzed in Frequency-Domain by WIPL-D Code

Olcan, D.I. and Kolundzija, B.M., "Efficient Calculation of Time-Domain Responses of Antennas Analyzed in Frequency-Domain by WIPL-D Code", Proc. IEEE AP-S Int. Symp., pp.1437-1440, CD ROM Edition: 0361.pdf, Honolulu, Hawaii, USA, July 2007.

Link to Publication

Abstract: The improvement of the efficiency of the time-domain analysis using frequency-domain response and the Fourier transform is achieved by adjusting the current expansion at each frequency and by interpolating the results in the frequency domain. The future work will include investigation of the minimal number of frequency samples needed for the interpolation, a non-uniform sampling in the frequency domain and the search for the optimal interpolation technique.

Time-Domain Response of 3-D Structures Calculated Using WIPL-D

Olcan, D.I., Nikolic, M.M., Kolundzija, B.M., Djordjevic, A.R., "Time-Domain Response of 3-D Structures Calculated Using WIPL-D", Proc. of IEEE/ACES Conf. on Wireless Comm. and Appl. Commput. Electromag., pp. 525-531, CD ROM Edition: Paper_06.pdf, Verona, Italy, 19-23 March 2007.

Link to Publication

Abstract: -

2006

Solution of Large Complex Problems in Computational Electromagnetics using Higher Order Basis in Mom with an Out-Of-Core Solver

Yuan M., Taylor M. C., Sarkar T. K., Kolundzija B. M., "Solution of Large Complex Problems in Computational Electromagnetics using Higher Order Basis in MOM with an Out-of-Core Solver", Proc. IEEE AP-S Int. Symp., pp. 115 – 118, (ISBN: 1-4244-123-2, CD ROM Edition: 0028.pdf), Albuquerque, USA, 9-14 July 2006.

Link to Publication

Abstract: Limitations of current numerical techniques have been outlined. The objective of this article is to point out that these statements of limitations may be applicable for the methodologies like FEM, FDTD and the hybrid MOM technique that the author has considered. Indeed, for such techniques even an analysis of a

single Vivaldi element is a formidable problem. However, if one uses a higher order basis in a surface integral equation and solves this using the conventional method of moments with the commercially available code WIPL-D then it becomes clear that even the 2times2 Vivaldi array consisting of 12 elements actually can be solved on a laptop DELL INSPIRON 5150 computer using approximately 2 GB of RAM. With other techniques, such a small computing resource may only be able to model a single element. For complex composite metallic and dielectric structures, the PMCHWT formulation using a higher order basis is an efficient way to solve challenging computational electromagnetic problems

On the Efficiency of Particle Swarm Optimizer when Applied to Antenna Optimization

Olcan D. I., Golubovic R. M., Kolundzija B. M., "On the Efficiency of Particle Swarm Optimizer when Applied to Antenna Optimization", Proc. IEEE AP-S Int. Symp., pp.3297-3300, (ISBN: 1-4244-123-2, CD ROM Edition: 0775.pdf), Albuquerque, USA, 9-14 July 2006.

Link to Publication

Abstract: This paper presents the results for three different antenna optimization problems that are found using the particle swarm optimizer (PSO). The outcomes found with PSO are compared to the outcomes found with other optimization algorithms to estimate the efficiency of PSO. The first problem is finding the optimal position of the feeding probe in a radiating rectangular waveguide. The second problem is finding the maximal forward gain of a Yagi antenna. The third problem is finding the optimal feeding of a broadside antenna array. The optimization problems have 2, 6, and 20 optimization variables respectively

2005

Efficient Analysis of Microwave Devices Based on Polygonal Modeling and WIPL-D Numerical Engine

Tasic, M.S., Kolundzija, B.M., "Efficient analysis of microwave devices based on polygonal modeling and WIPL-D numerical engine", Proc. of IEEE/ACES Conf. on Wireless Comm. and Appl. Commput. Electromag., pp. 94 – 97, Honolulu, 3-7 April 2005

Link to Publication

Abstract: Surface formulation of method of moments gives the best results in electromagnetic analysis when geometrical modeling is performed with quadrilateral patches. Quadrilateral modeling, however, can be very difficult. Many structures, e.g. different microwave devices, can be easily modeled using polygonal surfaces. This paper presents general method for conversion of polygonal model into quadrilateral model. Proposed method is illustrated on real microwave filter.

Extended Limits of WIPL-D on PCs

Sumic, D. S., Kolundzija, B. M., "Extended Limits of WIPL-D on PCs", Proc. of IEEE/ACES Conf. on Wireless Comm. and Appl. Commput. Electromag., Honolulu, 3-7 April 2005

Link to Publication

Abstract: In the process of electromagnetic modeling and simulation, one encounters various limits imposed by the hardware capabilities of modern computers. As the complexity or the electrical size of the problem grows, so does the need for faster processors and more RAM in order to make the analysis of such projects feasible. With the era of 64 bit computing at our door step, 4 GB is no longer the theoretical maximum addressable memory space on PC computers, which allows the analysis of demanding electromagnetic problems on every desktop. In this paper, several tests have been presented regarding the analysis of a cube of dimensions up to 30lambda times 30lambda times 30lambda. Significant advancements in modeling and analysis of electrically large structures in WIPL-D Pro code are the main focus. Tests include: running WIPL-D Pro code in the Windows and Linux 64-bit environments, employing 2 processors in parallel and speed comparisons between the latest and previous versions of the code

2002

Evaluation of Radar Cross-Section of Large Platforms by the Method of Moments at PC Computers

Kolundzija, B., Tasic M., Sarkar T., "Evaluation of Radar Cross-section of large platforms by the method of moments at PC computers", Proc. IEEE AP-S Int. Symp., San Antonio, TX., Vol. 2, pp. 94-97, March 2002

Link to Publication

Abstract: For electrically large platforms approximating potentials of higher order basis functions can be fully exploited. In this case accurate results can be obtained even with 15 unknowns per wavelength squared. This means that symmetrical platforms with total surface area of 3000 λ2 can be handled on personal computers. In the case of Mirage (whose length is about 12 meters) accurate results can be obtained at 2 GHz, at which its electrical length is 80 λ.

2001

Analysis of Composite Metallic and Dielectric Structures - WIPL-D Code

Kolundzija, B., Ognjanović, J., Sarkar T., "Analysis of composite metallic and dielectric structures - WIPL-D code", Proc. of 17th Applied Computational Electro-magnetics Conf., Monterey, CA, pp. 246-253, March 2001.

Link to Publication

Abstract: -

2000

WIPL-D: Electromagnetic Modeling of Composite Metallic and Dielectric Structures, Software and User-Manual

Kolundzija, B. M., Ognjanović, J. S., Sarkar T. K., "WIPL-D: Electromagnetic modeling of composite metallic and dielectric structures, software and user manual", Artech House 2000

Link to Publication

Abstract: This software seeks to make the job easier, cut design time, and reduce costs for designers developing an antenna embedded in a material body, passive microwave circuit components, or determining electromagnetic scattering from complex, lossy/dielectric structures. Now featuring a Windows-based interface, it delivers a powerful program for analysis of electromagnetic radiation and scattering from composite metallic and/or finite-sized dielectric/magnetic structures.

1996

WIPL: Program for Electromagnetic Modeling of Composite Wire and Plate Structures

Kolundzija, B. M., Ognjanović, J. S., Harrington, R. F. and Sarkar T. K., "WIPL: Program for electromagnetic modeling of composite wire and plate structures", IEEE Antennas and Propagation Magazine, Feb. 1996

Link to Publication

Abstract: WIPL is a program which allows fast and accurate analysis of antennas. The geometry of any metallic structure (even a very large structure) is defined as a combination of wires and plates. WIPL's analysis features include evaluations of the current distribution, near and far field, and impedance, admittance and s-parameters. The program uses an entire-domain Galerkin method. Efficiency of the program is based on the flexible geometrical model, and sophisticated basis functions. In this paper, the basic theory implemented in the program, and some results concerning TV UHF panel antennas and large horn antennas are given

Electromagnetic Modeling of Composite Metallic and Dielectric Structures

Kolundzija, B. M., "Electromagnetic modeling of composite metallic and dielectric structures", Proc. Trans Black Sea Region symp. on Applied Electromagnetics, Metsovo, (Greece), April 1996 (summary)

Link to Publication

Abstract: Starting from the equivalence theorem any composite metallic and dielectric structure can be analyzed by using SIE (surface integral equations). Such integral equations are usually solved by MoM (method of moments). Most of the existing MoM methods for solving SIE are developed for BORs (bodies of

revolution). There are only few such methods that can handle structures of arbitrary shape. These methods use sub-domain basis functions defined over triangles, requiring a very large number of unknowns even for the simplest problems. This paper presents a new MoM method for electromagnetic modeling of composite metallic and dielectric structures. The method uses entire-domain basis functions defined over bilinear surfaces, resulting in a remarkably small number of unknowns

1995

WIPL - Program for Analysis of Metallic Antennas and Scatterers

Kolundzija, B. M., Ognjanović, J. S., Harrington, R. F. and Sarkar T. K., "WIPL - program for analysis of metallic antennas and scatterers", Proc. 9th ICAP, Eindhoven, 1995

Link to Publication

Abstract: WIPL is an extremely powerful program that allows fast and accurate analysis of metallic antennas, scatterers and passive microwave circuits. This user friendly program enables the user to interactively define the geometry of any metallic structure (even a very large structure) as a combination of wires and plates, and then check this data by using a 3D drawing of the structure. WIPL's sophisticated analysis features include evaluations of the current distribution, radiation patterns, and admittance parameters. WIPL also provides the user with a variety of list and graphic output capabilities, including 2D and 3D graphics. Users need not know the analysis method to use the program. WIPL efficiently executes most computations in under 60 seconds, making the software ideal for CAD

WIPL - Program for Electromagnetic Modeling of Composite Wire and Plate Structures, Software and Manual

Kolundzija, B. M., Ognjanović, J. S., Harrington, R. F., and Sarkar T. K., "WIPL - program for electromagnetic modeling of composite wire and plate structures, software and user manual", Artech House 1995

Link to Publication

Abstract: WIPL is a low-cost PC commercial software for the analysis of metallic structures. It allows the user to interactively define the geometry of any metallic structure as a combination of wires and plates, and then check this by using a 3-D drawing of the structure. WIPL's sophisticated analysis features include evaluations of the current distribution, radiation patterns and admittance parameters. It analyzes log periodic antennas, wire antennas with corner reflector, antennas mounted on metallic vehicles, wave guide horn antennas (including coaxial to wavelength transition), slot antennas and field coupling through apertures in metallic enclosures. WIPL also provides the user with a variety of list and graphic output capabilities, including 2-D and 3-D graphics. User specification of a large number of unknowns is not required to run the program. WIPL executes most computations in under 60 seconds, making the software ideal for CAD. The system

requirements for WIPL are: IBM PC or compatible, 286 (386 or 486 recommended). 640 KB RAM, Microsoft Windows 3.1 or later. Graphics: Hercules, CGA, EGA (VGA recommended). DOS 3.3 or later.