DOWNLOAD PDF COMPUTATIONAL ELECTRODYNAMICS

Chapter 1 : Allen Taflove (Author of Computational Electrodynamics)

Computational electromagnetics, computational electrodynamics or electromagnetic modeling is the process of modeling the interaction of electromagnetic fields with physical objects and the environment.

Short Bio 1st June Zongfu has a B. He has been an assistant professor since September Information and Energy Our research revolves around extracting two things from light: The approaches start from fundamental optical sciences, and leverage machine learning and nanotechnologies. The focus themes are 1 visual perception and 2 sustainability and energy. Current Research Optical Sciences Fundamental optical science and computational methods are the foundation of our research. We are particularly interested in breakthroughs that have potential for emerging applications. For example, inspired by the intriguing concept of index-near-zero materials, we enhance the optical cross section over times, which could make super-sensitive photo-sensing pixels. Another example is emerging topological photonics, which changes the laws of electromagnetic scattering that govern applications from cell phones to molecular imaging. Concepts such as nonreciprocal optics also have revolutionary potential in communication and energy conversion. We recently showed quantum-classic hybrid electrodynamics could show promising potential to overcoming the most challenging problems in this field. Multi-modal visual sensors Visual sensory functions are indispensable in autonomous systems, such as self-driving cars. Conventional visual systems are mostly based on imaging sensors consisting of arrays of light-sensitive pixels, each of which measures the intensity of the light falling on it. The issue with such pixels is that they are incapable of acquiring other important aspects of multimodal information of light, such as its incident angle, wavelength, and phase. While the intensity information is enough for conventional applications such as photography, its limitations become apparent in advanced visual tasks. For example, it is impaired by fog and rain, and can only see in straight lines not around corners. As a result, expensive optical instruments, such as the LIDAR systems used for ranging in autonomous cars, are often used to assist vision. Our goal is to identify the pathway that could overcome these fundamental issues in traditional visual hardware. Radiative cooling for clean water Darkling beetles living in the Namib desert have developed an ingenious surviving technique: We are developing passive radiative condensers that require zero energy input and generate clean water from thin air. Here we exploit the universe as a free coldness reservoir for water condensation. The beetles use this cooling source to condense water from air, but only at nighttime. Our daytime radiative condenser works even under sunlight Fig. This condenser can be used alone or together with solar stills. The goal is to realize on-demand clean water anywhere, anytime. Simulation Technology Emerging applications of artificial intelligence make physical simulation more and more important. Computer simulation can be used to generate data, which tends to be expensive to collect in experiment. It can also be used to construct the traning enviroment for robotics. Here our focus is on fidelity, throughput, scale, and the fusion of experiment and simulation data. We use GPU, neural networks, and adjoint methods Quantum-classical hybrid electrodynamics We are developing computational tools to model classical-quantum hybrid devices. It combines classical and quantum electrodynamics simulators. We use the tool to investigate quantum antennas, quantum photonic crystals, quantum metasurfaces, all made from two-level systems such as quantum dots and atoms.

Chapter 2 : Computational Electrodynamics: The Finite-Difference Time-Domain Method by Allen Taflove

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Education[edit] Taflove received B. To a large degree, all of these software constructs derive directly from FDTD techniques first reported by Prof. Taflove and his students over the past 40 years. Publications and citations[edit] In , Prof. In , he edited the research monograph, Advances in Computational Electrodynamics: Subsequently, he and Prof. Susan Hagness of the University of Wisconsin-Madison expanded and updated the book in a year second edition, and then further expanded and updated the second edition in a third edition. Ardavan Oskooi of Kyoto University and Prof. Taflove had authored or co-authored a total of 27 articles or chapters in books and magazines, refereed journal papers, and 14 U. His books, journal papers, and U. Taflove in have since become widely used, having appeared in this exact form in approximately , and , Google Scholar search results, respectively, as of Sept. Research[edit] Beginning in , Prof. Taflove has collaborated with Prof. The techniques being pursued are based upon a spectroscopic microscopy analysis of light backscattered from histologically normal tissue located away from a neoplastic lesion in what has been termed the field effect. On May 5, , a large collaboration headed by Prof. FDTD modeling has helped establish the fundamental physics foundation of Prof. The latter paper rigorously shows that spectroscopic microscopy permits determining the nature of deeply subdiffraction three-dimensional refractive-index fluctuations of a linear, label-free dielectric medium in the far zone. The resulting wide range of distance scales that can be characterized within a cell may permit correlations to be developed appropriate for field-effect detection of a wide variety of early-stage cancers with clinically useful sensitivity and specificity. Federal court case[edit] In and , Prof. Federal courts in a case initiated in July and then pursued through the appeals process by two plaintiffs who questioned the originality of some of the Taflove-Chang publications. Regarding the latter, the District Court stated: Moreover, consideration of the amount of relief obtained in the litigation also strongly favors defendants. Given that defendants received no award as a result of the litigation, they are entitled to this presumption. There is significant evidence, for example, that the suit was motivated in key part by personal animosity.

Chapter 3 : Computational electrodynamics of disordered systems - Department of Physics - NTNU

TID Computational Electrodynamics ACE3P (Advanced Computational Electromagnetics 3P) Code Suite. conformal, higher-order, C++/MPI-based parallel finite-element based electromagnetic codes.

Integral equation solvers[edit] The discrete dipole approximation[edit] The discrete dipole approximation is a flexible technique for computing scattering and absorption by targets of arbitrary geometry. The formulation is based on integral form of Maxwell equations. The DDA is an approximation of the continuum target by a finite array of polarizable points. The points acquire dipole moments in response to the local electric field. The dipoles of course interact with one another via their electric fields, so the DDA is also sometimes referred to as the coupled dipole approximation. The resulting linear system of equations is commonly solved using conjugate gradient iterations. The discretization matrix has symmetries the integral form of Maxwell equations has form of convolution enabling Fast Fourier Transform to multiply matrix times vector during conjugate gradient iterations. Method of moments element method[edit] The method of moments MoM [2] or boundary element method BEM is a numerical computational method of solving linear partial differential equations which have been formulated as integral equations i. It can be applied in many areas of engineering and science including fluid mechanics , acoustics , electromagnetics , fracture mechanics , and plasticity. MoM has become more popular since the s. Conceptually, it works by constructing a "mesh" over the modeled surface. However, for many problems, BEM are significantly computationally less efficient than volume-discretization methods finite element method , finite difference method , finite volume method. Boundary element formulations typically give rise to fully populated matrices. This means that the storage requirements and computational time will tend to grow according to the square of the problem size. By contrast, finite element matrices are typically banded elements are only locally connected and the storage requirements for the system matrices typically grow linearly with the problem size. These usually involve fields in linear homogeneous media. This places considerable restrictions on the range and generality of problems suitable for boundary elements. Nonlinearities can be included in the formulation, although they generally introduce volume integrals which require the volume to be discretized before solution, removing an oft-cited advantage of BEM. It is an accurate simulation technique and requires less memory and processor power than MoM. The FMM was first introduced by Greengard and Rokhlin [3] [4] and is based on the multipole expansion technique. The first application of the FMM in computational electromagnetics was by Engheta et al. Plane wave time-domain[edit] While the fast multipole method is useful for accelerating MoM solutions of integral equations with static or frequency-domain oscillatory kernels, the plane wave time-domain PWTD algorithm employs similar ideas to accelerate the MoM solution of time-domain integral equations involving the retarded potential. The equivalent circuit formulation allows for additional SPICE type circuit elements to be easily included. Further, the models and the analysis apply to both the time and the frequency domains. Besides providing a direct current solution, it has several other advantages over a MoM analysis for this class of problems since any type of circuit element can be included in a straightforward way with appropriate matrix stamps. The PEEC method has recently been extended to include nonorthogonal geometries. This helps in keeping the number of unknowns at a minimum and thus reduces computational time for nonorthogonal geometries. It is easy to understand. It has an exceptionally simple implementation for a full wave solver. FDTD is the only technique where one person can realistically implement oneself in a reasonable time frame, but even then, this will be for a quite specific problem. FDTD belongs in the general class of grid-based differential time-domain numerical modeling methods. The equations are solved in a cyclic manner: Since about , FDTD techniques have emerged as the primary means to model many scientific and engineering problems addressing electromagnetic wave interactions with material structures. An effective technique based on a time-domain finite-volume discretization procedure was introduced by Mohammadian et al. Approximately 30 commercial and university-developed software suites are available. Finite element method[edit] The finite element method FEM is used to find approximate solution of partial differential equations PDE and integral equations. The solution approach is based either on eliminating the time derivatives completely steady state problems , or rendering the PDE into an equivalent ordinary differential equation , which is then solved using standard techniques such as finite differences , etc. In solving partial differential equations , the primary challenge is to create an equation which approximates the equation to be studied, but which is numerically stable , meaning that errors in the input data and intermediate calculations do not accumulate and destroy the meaning of the resulting output. There are many ways of doing this, with various advantages and disadvantages. The finite element method is a good choice for solving partial differential equations over complex domains or when the desired precision varies over the entire domain. Finite integration technique[edit] The finite integration technique FIT is a spatial discretization scheme to numerically solve electromagnetic field problems in time and frequency domain. It preserves basic topological properties of the continuous equations such as conservation of charge and energy. FIT was proposed in by Thomas Weiland and has been enhanced continually over the years. This method stands out due to high flexibility in geometric modeling and boundary handling as well as incorporation of arbitrary material distributions and material properties such as anisotropy , non-linearity and dispersion. Furthermore, the use of a consistent dual orthogonal grid e. Cartesian grid in conjunction with an explicit time integration scheme e. PSTD causes negligible numerical phase velocity anisotropy errors relative to FDTD, and therefore allows problems of much greater electrical size to be modeled. The fields are therefore held as a function of time, and possibly any transverse spatial dimensions. The method is pseudo-spectral because temporal derivatives are calculated in the frequency domain with the aid of FFTs. Because the fields are held as functions of time, this enables arbitrary dispersion in the propagation medium to be rapidly and accurately modelled with minimal effort. Locally one-dimensional[edit] This is an implicit method. In this method, in two-dimensional case, Maxwell equations are computed in two steps, whereas in three-dimensional case Maxwell equations are divided into three spatial coordinate directions. It offers very strong benefits compared with the FDTD method for the modelling of optical waveguides, and it is a popular tool for the modelling of fiber optics and silicon photonics devices. Physical optics[edit] Physical optics PO is the name of a high frequency approximation short- wavelength approximation commonly used in optics, electrical engineering and applied physics. It is an intermediate method between geometric optics, which ignores wave effects, and full wave electromagnetism , which is a precise theory. The word "physical" means that it is more physical than geometrical optics and not that it is an exact physical theory. The approximation consists of using ray optics to estimate the field on a surface and then integrating that field over the surface to calculate the transmitted or scattered field. This resembles the Born approximation , in that the details of the problem are treated as a perturbation. Uniform theory of diffraction[edit] The uniform theory of diffraction UTD is a high frequency method for solving electromagnetic scattering problems from electrically small discontinuities or discontinuities in more than one dimension at the same point. The uniform theory of diffraction approximates near field electromagnetic fields as quasi optical and uses ray diffraction to determine diffraction coefficients for each diffracting object-source combination. These coefficients are then used to calculate the field strength and phase for each direction away from the diffracting point. These fields are then added to the incident fields and reflected fields to obtain a total solution. Validation[edit] Validation is one of the key issues facing electromagnetic simulation users. The user must understand and master the validity domain of its simulation. The measure is, "how far from the reality are the results? Comparison between simulation results and analytical formulation[edit] For example, assessing the value of the radar cross section of a plate with the analytical formula:

Chapter 4 : Computational electromagnetics - Wikipedia

Computational Electrodynamics has 7 ratings and 2 reviews. This extensively revised and expanded third edition of the Artech House bestseller, Computatio.

Chapter 5 : ARTECH HOUSE USA : Computational Electrodynamics, Third Edition

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Chapter 6 : Computational electrodynamics methods â€” Northwestern Scholars

Taflove, A & Hagness, SC , Computational Electrodynamics: The Finite-Difference Time-Domain Method. 2nd edn, Artech House, Norwood, MA. Computational Electrodynamics: The Finite-Difference Time-Domain Method.

Chapter 7 : Allen Taflove - Wikipedia

Allen Taflove is a full professor in the Department of Electrical Engineering and Computer Science of Northwestern's McCormick School of Engineering, since Since , he has pioneered basic theoretical approaches, numerical algorithms, and applications of finite-difference time-domain computational solutions of Maxwell's equations.

Chapter 8 : Allen Taflove and Finite-Difference Time-Domain (FDTD) Methods in Computational Electrodyn

This extensively revised and expanded third edition of the Artech House bestseller, Computational Electrodynamics: The Finite-Difference Time-Domain Method, offers engineers the most up-to-date and definitive resource on this critical method for solving Maxwell's equations.

Chapter 9 : Computational Electromagnetics and Electrodynamics|NVIDIA

While classic finite-difference time-domain (FDTD) solutions of Maxwell's equations have served the computational electrodynamics (CED) community very well, formulations based on Godunov methodology have begun to show advantages.