Section 3   Electromagnetics

Chapter 1 Electromagnetic Wave Theory and Applications

Chapter 1. Electromagnetic Wave Theory and Applications

Academic and Research Staff

Professor Jin Au Kong, Dr. Kung Hau Ding, Dr. Robert T. Shin, Dr. Y. Eric Yang

Visiting Scientists and Research Affiliates

Dr. Yasunori Kanamaru,[1] Dr. Francesca Scire-Scappuzzo,[2] Dr. Leung Tsang,[3] Dr. Lars H. Bomholt,[4] Dr. Arthur K. Jordan,[5] Dr. Kevin O'Neill,[6] Dr. Jean-Claude Souyris,[7] Dr. Michael Tsuk,[8] Dr. Jiqing Xia[9]

Graduate Students

Jerome J. Akerson, Robert G. Atkins, William W. Au, Hong Tat Ewe, Tza Jing Gung, Chih-Chien Hsu, Gregory T. Huang, Joel T. Johnson, Jenn-Huei Kuan, Kevin Li, Christina Manolatou, John H. Oates, Ante Salcedo, Shih-En Shih, Prathet Tankuranun, M. Ali Tassoudji, Murat E. Veysoglu, Li-Fang Wang, Jun Yan, Chen-Pang Yeang, Yan Zhang, William W. Zhou

Undergraduate Students

William Lee, Grant Smith

Technical and Support Staff

Kit-Wah F. Lai

1.1 Remote Sensing of Earth Terrain

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    Jet Propulsion Laboratory
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Project Staff

Professor Jin Au Kong, Dr. Francesca Scire-Scappuzzo, Dr. Leung Tsang, Dr. Kung Hau Ding, Dr. Robert T. Shin, Dr. Jean-Claude Souyris, Robert G. Atkins, William W. Au, Hong Tat Ewe, Chih-Chien Hsu, Joel T. Johnson, Ante Salcedo, Shih-En Shih, Murat E. Veysoglu, Li-Fang Wang, Jun Yan, Yan Zhang

In this project area, we investigate the active and passive remote sensing of forest, vegetation canopy, snow, sea ice, and ocean wind directions. Vegetation canopy can be modeled as either a mixture of multiple-species discrete scatterers described by a certain size, shape, and orientation

distributions, or as a continuous random medium characterized by correlation functions. A layer model is developed and applied to interpret radar backscattering coefficients and radiometric brightness temperatures collected from forest and vegetation fields.

For sea ice data interpretation and inversion, we have developed a random medium model using radiative transfer theory. An optimization approach is used for inversion. The discrepancy between the data and the results of the forward model is minimized by changing the inversion parameters according to a nonlinear programming scheme. Reconstruction of correlation lengths in the horizontal and vertical dimensions has been accomplished using the polarimetric backscattering coefficients at different angles of incidence as input data. Effects of data diversity and noise on the reconstruction of the physical parameters of sea ice from the backscattering coefficients are being investigated.

Polarimetric passive remote sensing of wind-generated ocean surfaces is investigated with emphasis on the third Stokes parameter. A numerical study of the polarimetric thermal emission from ocean surfaces randomly rough in one dimension using a Monte Carlo technique is carried out. A set of finite length surface profiles with desired statistics is generated using a spectral method. Each surface is extended periodically to create an infinite rough surface, and the thermal emission is computed using the extended boundary condition method (EBC) and the method of moments (MOM). The results of the study show that the third Stokes parameter is sensitive to the azimuthal angle between the surface periodicity and the looking angle, the rms height of the surface, and the surface power law spectrum slope. The results also show that this parameter is insensitive to variations in polar angle, permittivity, and surface spectrum high frequency content.

1.2 Electromagnetic Waves in Multilayer Media

Sponsors

Project Staff

Professor Jin Au Kong, Dr. Lars H. Bomholt, Dr. Robert T. Shin, Dr. Michael Tsuk, Dr. Jiqing Xia, Dr. Y. Eric Yang, Robert G. Atkins, Hong Tat Ewe, Chih-Chien Hsu, Gregory T. Huang, Joel T. Johnson, Kevin Li, Christina Manolatou, John H. Oates, Prathet Tankuranun, M. Ali Tassoudji, Murat E. Veysoglu

In this project area, we apply both analytical and numerical methods to the solution of electromagnetic wave problems in layered media and microstrip structures. The analytical technique included the double deformation method performed on complex planes and the numerical technique include the integral equation methods and the finite difference time domain (FDTD) methods together with the absorbing boundary conditions (ABC).

The electromagnetic radiation from a VLSI chip package and heatsink structure is analyzed by means of the finite-difference time-domain (FDTD) technique. The dimensions of a typical configuration calls for a multizone gridding scheme in the FDTD algorithm to accommodate fine grid cells in the vicinity of the heatsink and package cavity and sparse gridding in the remainder of the computational domain. The issues pertaining to the effects of the heatsink in influencing the overall radiating capacity of the configuration are addressed. Analyses are facilitated by using simplified heatsink models and by using dipole elements as sources of electromagnetic energy to model the VLSI chip. The potential for enhancement of spurious emissions by the heatsink structure is illustrated. For heatsinks of typical dimensions, resonance is possible within the low gigahertz frequency range. The exploitation of the heatsink as an emissions shield by appropriate implementation schemes is discussed and evaluated.

The media that we studied included electrically and magnetically anisotropic material, superconductors, and chiral media made of helical elements. For helical chiral media, we derived the constitutive relations and studied their potential use as absorbing material. Anisotropic media are also investigated for applications as modulators in microstrip configurations.

1.3 Simulation of Electromagnetic Wave Scattering

Sponsors

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Project Staff

Professor Jin Au Kong, Dr. Kevin O'Neill, Dr. Y. Eric Yang, Hong Tat Ewe, Tza Jing Gung, Chih-Chien Hsu, Jenn-Huei Kuan, William Lee, Grant Smith, M. Ali Tassoudji, Li-Fang Wang, Chen-Pang Yeang, Yan Zhang, William W. Zhou

In this project area, we concentrate on the development of the computer simulation software for electromagnetic modeling of scattering applied to remote sensing and applied to landing systems for airplanes. This is a long-term project for the development of comprehensive theoretical model for the computer simulation of three-dimensional microwave and millimeter wave scattering and emission phenomena. Major tasks include (1) Simulation Program—development of baseline simulation that include the effects of environments, hard targets, atmospheric absorption and scattering, and ground reflection; (2) Validation and Documentation—generation of synthetic scene for comparison with real data and production of user manuals and validation reports; and (3) Upgrade Assessment—studies into models that can be added to the baseline simulation and the ways to integrate them.

The goals are (1) to assemble available physical models that satisfy the minimum requirement defined above and (2) to build a preliminary simulation package using these models to demonstrate the process of generating scenes from standard input data sets and possibly of direct or indirect comparison with recorded images. We have developed a baseline simulation package with X-window/Motif graphical user interface. This program (1) first accesses GIS feature map and elevation map and create displays of both, (2) allows a user to identify and highlight particular terrain features in the map region from a menu, and then (3) interfaces with background terrain scattering coefficient database, which has been created by EMSARS program and a clutter statistics model to generate simulated radar images. A simple terrain shadowing effect is included. The current database is created using the random medium volume scattering model and composite rough surface scattering model.

A study is also underway to model the effects of interference on the safety of ILS Category III operations. The intention is to gain a full understanding of radio interference on aircraft performance and to determine an acceptable level of interence for use in autoland certification. Previously a computer package had been developed to assess the electromagnetic compatibility in ILS/MLS channel planning. It is proposed that this model be enhanced to include the industrial, scientific, and medical (ISM) sources in the interference study. The aircraft automatic flight control system (AFCS) model will be integrated with the receiver model to simulation the effect of interference on autoland performance. Ultimately a standard on acceptable exposure time of FM broadcast interference will be developed from the study.

1.4 Publications

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1.4.1 Meeting Papers

Hsu, C.C., J.A. Kong, T. Le Toan, S. Paloscia, and P. Pampaloni. "Microwave Emission and Backscattering from Crops." Paper presented at the 1994 Progress in Electromagnetics Research Symposium, Noordwijk, The Netherlands, July 11-15, 1994.

Johnson, J.T., J.A. Kong, Shin, and L. Tsang. "Theory and Experiments in Polarimetric Passive Remote Sensing." Paper presented at the National Radio Science Meeting, Boulder, Colorado, January 5-8, 1994.

Nghiem, S.V., R. Kwok, S.H. Yueh, J.A. Kong, M.A. Tassoudji, C.C. Hsu, A.J. Gow, and D.K. Perovich. "Polarimetric Backscattering from Thin Saline Ice Related to Ice Physical and Morphological Characteristics." Paper presented at the International Geoscience and Remote Sensing Symposium, Pasadena, California, August 8-12, 1994.

Nghiem, S.V., R. Kwok, S.H. Yueh, J.A. Kong, M.A. Tassoudji, C.C. Hsu, A.J. Gow, and D.K. Perovich. "Polarimetric Backscattering Signatures from Thin Saline Ice under Controlled Laboratory Conditions." Paper presented at the International Geoscience and Remote Sensing Symposium, Pasadena, California, August 8-12, 1994.

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Yang, Y.E., H.T. Ewe, C.C. Hsu, L. Wang, S.E. Shih, K.H. Ding, J.A. Kong, R.T. Shin, H. Nguyen, T. Nguyen, J.Y. Ho, K. O'Nell. "A GIS Driven Interactive Radar Simulation using EMSARS Model." Paper presented at the International Geoscience and Remote Sensing Symposium, Pasadena, California, August 8-12, 1994.

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