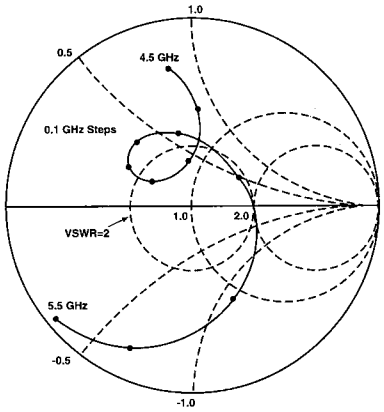
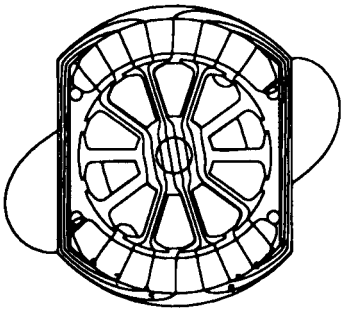
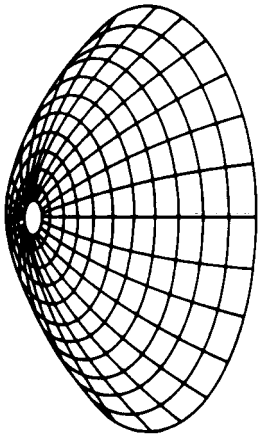
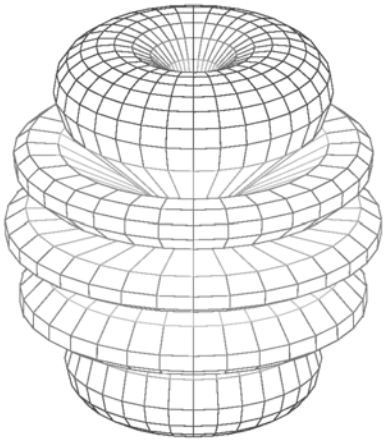






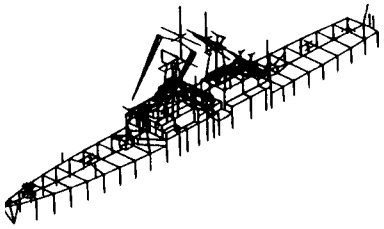


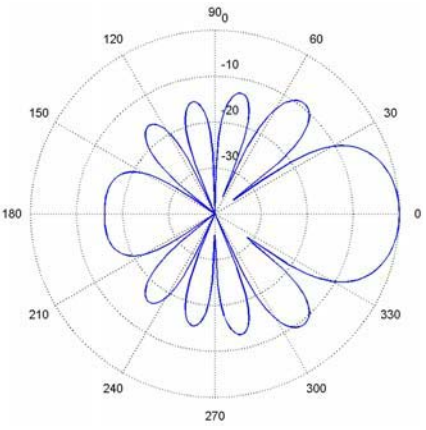
Applied Computational Electromagnetics Society Journal

Special Issue on
Neural Network Applications in Electromagnetics

Guest Editor
Christos Christodoulou

July 2003
Vol. 18 No. 2
ISSN 1054-4887





GENERAL PURPOSE AND SCOPE: The Applied Computational Electromagnetics Society ***(ACES)*** Journal hereinafter known as the ***ACES Journal*** is devoted to the exchange of information in computational electromagnetics, to the advancement of the state-of-the art, and the promotion of related technical activities. A primary objective of the information exchange is the elimination of the need to "re-invent the wheel" to solve a previously-solved computational problem in electrical engineering, physics, or related fields of study. The technical activities promoted by this publication include code validation, performance analysis, and input/output standardization; code or technique optimization and error minimization; innovations in solution technique or in data input/output; identification of new applications for electromagnetics modeling codes and techniques; integration of computational electromagnetics techniques with new computer architectures; and correlation of computational parameters with physical mechanisms.

SUBMISSIONS: The ***ACES Journal*** welcomes original, previously unpublished papers, relating to applied computational electromagnetics. Typical papers will represent the computational electromagnetics aspects of research in electrical engineering, physics, or related disciplines. However, papers which represent research in applied computational electromagnetics itself are equally acceptable.

Manuscripts are to be submitted through the upload system of ***ACES*** web site http://aces.ee.olemiss.edu See "Information for Authors" on inside of back cover and at ***ACES*** web site. For additional information contact the Editor-in-Chief:

Dr. Atef Elsherbeni
Department of Electrical Engineering
The University of Mississippi
University, MS 386377 USA
Phone: 662-915-5382 Fax: 662-915-7231
Email: atef@olemis.edu

SUBSCRIPTIONS: All members of the Applied Computational Electromagnetics Society who have paid their subscription fees are entitled to receive the ***ACES Journal*** with a minimum of three issues per calendar year and are entitled to download any published journal article available at http://aces.ee.olemiss.edu.

Back issues, when available, are $15 each. Subscriptions to ***ACES*** is through the web site. Orders for back issues of the ***ACES Journal*** and changes of addresses should be sent directly to ***ACES*** Executive Officer:

Dr. Richard W. Adler
ECE Department, Code ECAB
Naval Postgraduate School
833 Dyer Road, Room 437
Monterey, CA 93943-5121 USA
Fax: 831-649-0300
Email: *rwa@attglobal.net*

Allow four week's advance notice for change of address. Claims for missing issues will not be honored because of insufficient notice or address change or loss in mail unless the Executive Officer is notified within 60 days for USA and Canadian subscribers or 90 days for subscribers in other countries, from the last day of the month of publication. For information regarding reprints of individual papers or other materials, see "Information for Authors".

LIABILITY. Neither ***ACES***, nor the ***ACES Journal*** editors, are responsible for any consequence of misinformation or claims, express or implied, in any published material in an ***ACES Journal*** issue. This also applies to advertising, for which only camera-ready copies are accepted. Authors are responsible for information contained in their papers. If any material submitted for publication includes material which has already been published elsewhere, it is the author's responsibility to obtain written permission to reproduce such material.

APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY JOURNAL

Special Issue on
Neural Network Applications in Electromagnetics

Guest Editor
Christos Christodoulou

July 2003
Vol. 18 No. 2

ISSN 1054-4887

The ACES Journal is abstracted in INSPEC, in Engineering Index, and in DTIC.

The first, fourth, and sixth illustrations on the front cover have been obtained from the Department of Electrical Engineering at the University of Mississippi.

The third and fifth illustrations on the front cover have been obtained from Lawrence Livermore National Laboratory.

The second illustration on the front cover has been obtained from FLUX2D software, CEDRAT S.S. France, MAGSOFT Corporation, New York.

Special Issue on

Neural Network Applications in Electromagnetics

Guest Editor Introduction

Neural computing and machine learning algorithms have arrived and are here to stay! In the last ten years neural networks have experienced an unbelievable growth, both in terms of novel neural network architectures that have appeared in the literature, and new applications where neural networks have been used successfully. The high-speed capabilities and "learning" abilities of neural networks can be applied to quickly solving numerous complex optimization problems in electromagnetics, and this special issue shows you how. Even if you have no background in neural networks, the papers that appear in this issue will give you a flavor of the different applications that neural networks can be applied to.

In the past, neural networks (NNs) have been applied to modeling and design of antennas, microstrip circuits, embedded passive components, semiconductor and optical devices, and so on. Today, support vector machines (SVM) have also emerged in the area of machine learning and have been used mainly in the area of pattern recognition and classification. In this issue, two of the papers discuss a machine learning approach to solving electromagnetics problems. One of them compares results between classical neural networks and SVM's.

There are basically four main situations in which NNS and SVMs are good candidates for use in electromagnetics.

1. When closed form solutions do not exist and trial and error methods are the only approaches to solving the problem at hand.
2. When the application requires real-time performance.
3. When faster convergence rates and smaller errors are required in the optimization of large systems.
4. When enough measured data exist to train an NN or an SVM for prediction purposes, especially when no analytical tools exist.
5. When they can be used in conjunction with other numerical techniques for enhancement purposes.

This special issue includes 7 papers all of which are very different yet they have one unifying factor which is the use of NNS and SVM in tackling the problem at hand. The 1st paper is an example of how both neural networks and support vector machines can be used to classify buried objects (a classification problem). The second paper shows how neural networks can be used along with signal processing techniques for bio-medical applications and sensors. In the third paper we see an example of how neural networks can be combined with equivalent circuit formulations and other approaches for modeling of multilayer printed circuits. The fourth paper introduces the use of SVM in training adaptive array antennas for determining the direction of arrival of a signal (DOA). The paper includes a brief introduction of machine learning and support vector machines and how results compare with the more classical existing techniques. The fifth paper demonstrates how measured data can be used to train neural networks to predict

resonances for microstrip antennas at different frequencies and for different dimensions. The sixth paper is an example of how neural networks can be used in problems where no closed-form solutions exist such as the estimation of target orientation using measured radar cross section data. The last paper is a unique example of using neural networks with the asymptotic waveform evaluation (AWE) to speed up the analysis of the method of moments. This combined approach is applied to the solution of a microstrip antenna. Also, several references are included in each paper and the hope is that the reader will be exposed to the wide range of applications that are possible today in the area of electromagnetics using neural networks and machine learning!

Finally, I wanted to thank the following reviewers for helping me with this issue: Chaouki Abdallah, Michael Cryssomallis, Said El-Khamy, K. C. Gupta, Kerim Guney, Nafatli (Tuli) Herscovici, Q. J. Zhang, and Ahmed EL Zooghby. Special thanks go to Atef Elsherbeni for coming up with the idea behind this special issue and being patient and very helpful along the way!

Christos Christodoulou

University of New Mexico

THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

JOURNAL

SPECIAL ISSUE ON
NEURAL NETWORK APPLICATIONS IN ELECTROMAGNETICS

Vol. 18 No. 2 July 2003

TABLE OF CONTENTS

ACES COPYRIGHT FORM

This form is intended for original, previously unpublished manuscripts submitted to ACES periodicals and conference publications. The signed form, appropriately completed, MUST ACCOMPANY any paper in order to be published by ACES. PLEASE READ REVERSE SIDE OF THIS FORM FOR FURTHER DETAILS.

TITLE OF PAPER:

AUTHORS(S)

PUBLICATION TITLE/DATE:

RETURN FORM TO:

Dr. Atef Z. Elsherbeni
University of Mississippi
Dept. of Electrical Engineering
Anderson Hall Box 13
University, MS 38677 USA

PART A - COPYRIGHT TRANSFER FORM

(NOTE: Company or other forms may not be substituted for this form. U.S. Government employees whose work is not subject to copyright may so certify by signing Part B below. Authors whose work is subject to Crown Copyright may sign Part C overleaf).

The undersigned, desiring to publish the above paper in a publication of ACES, hereby transfer their copyrights in the above paper to The Applied Computational Electromagnetics Society (ACES). The undersigned hereby represents and warrants that the paper is original and that he/she is the author of the paper or otherwise has the power and authority to make and execute this assignment.

Returned Rights: In return for these rights, ACES hereby grants to the above authors, and the employers for whom the work was performed, royalty-free permission to:

1. Retain all proprietary rights other than copyright, such as patent rights.
2. Reuse all or portions of the above paper in other works.
3. Reproduce, or have reproduced, the above paper for the author's personal use or for internal company use provided that (a) the source and ACES copyright are indicated, (b) the copies are not used in a way that implies ACES endorsement of a product or service of an employer, and (c) the copies per se are not offered for sale.
4. Make limited distribution of all or portions of the above paper prior to publication.
5. In the case of work performed under U.S. Government contract, ACES grants the U.S. Government royalty-free permission to reproduce all or portions of the above paper, and to authorize others to do so, for U.S. Government purposes only.

ACES Obligations: In exercising its rights under copyright, ACES will make all reasonable efforts to act in the interests of the authors and employers as well as in its own interest. In particular, ACES REQUIRES that:

1. The consent of the first-named author be sought as a condition in granting re-publication permission to others.
2. The consent of the undersigned employer be obtained as a condition in granting permission to others to reuse all or portions of the paper for promotion or marketing purposes.

In the event the above paper is not accepted and published by ACES or is withdrawn by the author(s) before acceptance by ACES, this agreement becomes null and void.

AUTHORIZED SIGNATURE — TITLE (IF NOT AUTHOR)

EMPLOYER FOR WHOM WORK WAS PERFORMED — DATE FORM SIGNED

Part B - U.S. GOVERNMENT EMPLOYEE CERTIFICATION

(NOTE: if your work was performed under Government contract but you are not a Government employee, sign transfer form above and see item 5 under Returned Rights).

This certifies that all authors of the above paper are employees of the U.S. Government and performed this work as part of their employment and that the paper is therefor not subject to U.S. copyright protection.

AUTHORIZED SIGNATURE — TITLE (IF NOT AUTHOR)

NAME OF GOVERNMENT ORGANIZATION — DATE FORM SIGNED

PART C - CROWN COPYRIGHT

(NOTE: ACES recognizes and will honor Crown Copyright as it does U.S. Copyright. It is understood that, in asserting Crown Copyright, ACES in no way diminishes its rights as publisher. Sign only if *ALL* authors are subject to Crown Copyright).

This certifies that all authors of the above Paper are subject to Crown Copyright. (Appropriate documentation and instructions regarding form of Crown Copyright notice may be attached).

AUTHORIZED SIGNATURE TITLE OF SIGNEE

NAME OF GOVERNMENT BRANCH DATE FORM SIGNED

Information to Authors

ACES POLICY

ACES distributes its technical publications throughout the world, and it may be necessary to translate and abstract its publications, and articles contained therein, for inclusion in various compendiums and similar publications, etc. When an article is submitted for publication by ACES, acceptance of the article implies that ACES has the rights to do all of the things it normally does with such an article.

In connection with its publishing activities, it is the policy of ACES to own the copyrights in its technical publications, and to the contributions contained therein, in order to protect the interests of ACES, its authors and their employers, and at the same time to facilitate the appropriate re-use of this material by others.

The new United States copyright law requires that the transfer of copyrights in each contribution from the author to ACES be confirmed in writing. It is therefore necessary that you execute either Part A-Copyright Transfer Form or Part B-U.S. Government Employee Certification or Part C-Crown Copyright on this sheet and return it to the Managing Editor (or person who supplied this sheet) as promptly as possible.

CLEARANCE OF PAPERS

ACES must of necessity assume that materials presented at its meetings or submitted to its publications is properly available for general dissemination to the audiences these activities are organized to serve. It is the responsibility of the authors, not ACES, to determine whether disclosure of their material requires the prior consent of other parties and if so, to obtain it. Furthermore, ACES must assume that, if an author uses within his/her article previously published and/or copyrighted material that permission has been obtained for such use and that any required credit lines, copyright notices, etc. are duly noted.

AUTHOR/COMPANY RIGHTS

If you are employed and you prepared your paper as a part of your job, the rights to your paper initially rest with your employer. In that case, when you sign the copyright form, we assume you are authorized to do so by your employer and that your employer has consented to all of the terms and conditions of this form. If not, it should be signed by someone so authorized.

NOTE RE RETURNED RIGHTS: Just as ACES now requires a signed copyright transfer form in order to do "business as usual", it is the intent of this form to return rights to the author and employer so that they too may do "business as usual". If further clarification is required, please contact: The Managing Editor, R. W. Adler, Naval Postgraduate School, Code EC/AB, Monterey, CA, 93943, USA (408)656-2352.

Please note that, although authors are permitted to re-use all or portions of their ACES copyrighted material in other works, this does not include granting third party requests for reprinting, republishing, or other types of re-use.

JOINT AUTHORSHIP

For jointly authored papers, only one signature is required, but we assume all authors have been advised and have consented to the terms of this form.

U.S. GOVERNMENT EMPLOYEES

Authors who are U.S. Government employees are not required to sign the Copyright Transfer Form (Part A), but any co-authors outside the Government are.

Part B of the form is to be used instead of Part A only if all authors are U.S. Government employees and prepared the paper as part of their job.

NOTE RE GOVERNMENT CONTRACT WORK: Authors whose work was performed under a U.S. Government contract but who are not Government employees are required so sign Part A-Copyright Transfer Form. However, item 5 of the form returns reproduction rights to the U. S. Government when required, even though ACES copyright policy is in effect with respect to the reuse of material by the general public.

APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY JOURNAL
http://aces.ee.olemiss.edu

INFORMATION FOR AUTHORS

PUBLICATION CRITERIA

Each paper is required to manifest some relation to applied computational electromagnetics. **Papers may address general issues in applied computational electromagnetics, or they may focus on specific applications, techniques, codes, or computational issues.** While the following list is not exhaustive, each paper will generally relate to at least one of these areas:

1. **Code validation.** This is done using internal checks or experimental, analytical or other computational data. Measured data of potential utility to code validation efforts will also be considered for publication.

2. **Code performance analysis.** This usually involves identification of numerical accuracy or other limitations, solution convergence, numerical and physical modeling error, and parameter tradeoffs. However, it is also permissible to address issues such as ease-of-use, set-up time, run time, special outputs, or other special features.

3. **Computational studies of basic physics.** This involves using a code, algorithm, or computational technique to simulate reality in such a way that better, or new physical insight or understanding, is achieved.

4. **New computational techniques**, or new applications for existing computational techniques or codes.

5. **"Tricks of the trade"** in selecting and applying codes and techniques.

6. **New codes, algorithms, code enhancement, and code fixes.** This category is self-explanatory, but includes significant changes to existing codes, such as applicability extensions, algorithm optimization, problem correction, limitation removal, or other performance improvement. **Note: Code (or algorithm) capability descriptions are not acceptable, unless they contain sufficient technical material to justify consideration.**

7. **Code input/output issues.** This normally involves innovations in input (such as input geometry standardization, automatic mesh generation, or computer-aided design) or in output (whether it be tabular, graphical, statistical, Fourier-transformed, or otherwise signal-processed). Material dealing with input/output database management, output interpretation, or other input/output issues will also be considered for publication.

8. **Computer hardware issues.** This is the category for analysis of hardware capabilities and limitations of various types of electromagnetics computational requirements. Vector and parallel computational techniques and implementation are of particular interest.

Applications of interest include, but are not limited to, antennas (and their electromagnetic environments), networks, static fields, radar cross section, shielding, radiation hazards, biological effects, electromagnetic pulse (EMP), electromagnetic interference (EMI), electromagnetic compatibility (EMC), power transmission, charge transport, dielectric, magnetic and nonlinear materials, microwave components, MEMS technology, MMIC technology, remote sensing and geometrical and physical optics, radar and communications systems, fiber optics, plasmas, particle accelerators, generators and motors, electromagnetic wave propagation, non-destructive evaluation, eddy currents, and inverse scattering.

Techniques of interest include frequency-domain and time-domain techniques, integral equation and differential equation techniques, diffraction theories, physical optics, moment methods, finite differences and finite element techniques, modal expansions, perturbation methods, and hybrid methods. This list is not exhaustive.

A unique feature of the Journal is the publication of unsuccessful efforts in applied computational electromagnetics. Publication of such material provides a means to discuss problem areas in electromagnetic modeling. Material representing an unsuccessful application or negative results in computational electromgnetics will be considered for publication only if a reasonable expectation of success (and a reasonable effort) are reflected. Moreover, such material must represent a problem area of potential interest to the ACES membership.

Where possible and appropriate, authors are required to provide statements of quantitative accuracy for measured and/or computed data. This issue is discussed in "Accuracy & Publication: Requiring, quantitative accuracy statements to accompany data," by E. K. Miller, *ACES Newsletter,* Vol. 9, No. 3, pp. 23-29, 1994, ISBN 1056-9170.

EDITORIAL REVIEW

In order to ensure an appropriate level of quality control, papers are peer reviewed. They are reviewed both for technical correctness and for adherence to the listed guidelines regarding information content.

JOURNAL CAMERA-READY SUBMISSION DATES

March issue	deadline 8 January
July issue	deadline 20 May
November issue	deadline 20 September

Uploading an acceptable camera-ready article after the deadlines will result in a delay in publishing this article.

STYLE FOR CAMERA-READY COPY

The ACES Journal is flexible, within reason, in regard to style. However, certain requirements are in effect:

1. The paper title should NOT be placed on a separate page. The title, author(s), abstract, and (space permitting) beginning of the paper itself should all be on the first page. The title, author(s), and author affiliations should be centered (center-justified) on the first page.

2. An abstract is REQUIRED. The abstract should be a brief summary of the work described in the paper. It should state the computer codes, computational techniques, and applications discussed in the paper (as applicable) and should otherwise be usable by technical abstracting and indexing services.

3. Either British English or American English spellings may be used, provided that each word is spelled consistently throughout the paper.

4. Any commonly-accepted format for referencing is permitted, provided that internal consistency of format is maintained. As a guideline for authors who have no other preference, we recommend that references be given by author(s) name and year in the body of the paper (with alphabetical listing of all references at the end of the paper). Titles of Journals, monographs, and similar publications should be in italic font or should be underlined. Titles of papers or articles should be in quotation marks.

5. Internal consistency shall also be maintained for other elements of style, such as equation numbering. As a guideline for authors who have no other preference, we suggest that equation numbers be placed in parentheses at the right column margin.

6. The intent and meaning of all text must be clear. For authors who are NOT masters of the English language, the ACES Editorial Staff will provide assistance with grammar (subject to clarity of intent and meaning).

7. Unused space should be minimized. Sections and subsections should not normally begin on a new page.

PAPER FORMAT

The preferred format for initial submission and camera-ready manuscripts is 12 point Times Roman font, single line spacing and double column format, similar to that used here, with top, bottom, left, and right 1 inch margins. Manuscripts should be prepared on standard 8.5x11 inch paper.

Only camera-ready electronic files are accepted for publication. The term **"camera-ready" means that the material is neat, legible, and reproducible.** Full details can be found on ACES site, Journal section.

ACES reserves the right to edit any uploaded material, however, this is not generally done. It is the author(s) responsibility to provide acceptable camera-ready pdf files. Incompatible or incomplete pdf files will not be processed, and authors will be requested to re-upload a revised acceptable version.

SUBMITTAL PROCEDURE

All submissions should be uploaded to ACES server through ACES web site (http://aces.ee.olemiss.edu) by using the upload button, journal section. Only pdf files are accepted for submission. The file size should not be larger than 5MB, otherwise permission from the Editor-in-Chief should be obtained first. The Editor-in-Chief will acknowledge the electronic submission after the upload process is successfully completed.

COPYRIGHTS AND RELEASES

Each primary author must sign a copyright form and obtain a release from his/her organization vesting the copyright with ACES. Copyright forms are available at ACES, web site (http://aces.ee.olemiss.edu). To shorten the review process time, the executed copyright form should be forwarded to the Editor-in-Chief immediately after the completion of the upload (electronic submission) process. Both the author and his/her organization are allowed to use the copyrighted material freely for their own private purposes.

Permission is granted to quote short passages and reproduce figures and tables from and ACES Journal issue provided the source is cited. Copies of ACES Journal articles may be made in accordance with usage permitted by Sections 107 or 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying, such as for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale. The reproduction of multiple copies and the use of articles or extracts for commercial purposes require the consent of the author and specific permission from ACES. Institutional members are allowed to copy any ACES Journal issue for their internal distribution only.

PUBLICATION CHARGES

ACES members are allowed 12 printed pages per paper without charge; non-members are allowed 8 printed pages per paper without charge. Mandatory page charges of $75 a page apply to all pages in excess of 12 for members or 8 for non-members. Voluntary page charges are requested for the free (12 or 8) pages, but are NOT mandatory or required for publication. A priority courtesy guideline, which favors members, applies to paper backlogs. Authors are entitled to 15 free reprints of their articles and must request these from the Managing Editor. Additional reprints are available to authors, and reprints available to non-authors, for a nominal fee.

ACES Journal is abstracted in INSPEC, in Engineering Index, and in DTIC.