

Warsaw University of Technology

Institute of the Theory of Electrical
Engineering, Measurement and Information
Systems

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Chapter 1

SCIENTIFIC ACTIVITY OF THE INSTITUTE

1.1 Computational bioelectromagnetism

S. Wincenciak, J. Starzyński, J. Korytkowski, B. Sawicki, R. Szmurło, M. Chojnowski (PhD Student), P. Płonecki (PhD Student)

Various magnetic formulations for biomedical applications; pre- and post-processing for data and results (visual presentation including animation); electric thermal coupled fields and eddy current problems (3D). Synthesis, efficient techniques for sensitivity analysis; the optimization algorithms for nonlinear problems; identification of source functions and boundary conditions (application for electroencephalography); optimal shape design; material structure identification. Computer modeling of the bio-effects of electromagnetic fields on the human body; simulation of magnetic and electrical stimulation of the brain. Effective algorithms of realistic models creation for bioelectromagnetism. Problem oriented scientific software development.

1.2 Average models of active power filters

K. Mikołajuk, A. Toboła

Two time-varying models for single phase voltage source structure of active power filter have been developed. The first model adopts the time-varying transformer. The second proposed model adopts a time varying capacitor. The relation between time-varying transformer and time-varying capacitance has been established. Average models simplify analysis and make easier to understand the system's behaviour under steady state and transient conditions. Such models speed up simulation and can be used for control and design purposes. The numerical examples of third order and reactive fundamental harmonic generation illustrate the proposed method.

1.3 Research in the area of neural networks

S. Osowski, A. Cichocki, K. Siwek, T. Markiewicz, M. Warowny (PhD Student)

Study of the properties and applications of neural networks (n.n.) of MLP, SVM and RBF type, application of n.n. in synthesis and design of electrical circuits, location of faults, predictive properties of neural networks - application to load prediction of power electro-energetic system. Self-organizing neural networks of Kohonen type and their applications. Neuro-fuzzy systems - study of self-organizing and supervised learning rules and application in identification and prediction. Blind separation and deconvolution of signals - development of new effective learning rules and its applications. PCA neural networks - learning algorithms and applications. Support Vector Machines (SVM) networks for classification and regression and their applications. Biomedical signal processing, arrhythmia recognition on the basis of ECG, EEG signal processing for epilepsy recognition and prediction, recognition and classification of blood cells in leukemia on the basis of bone marrow aspirate, computer aided support for cancer cell recognition on the medical images, data mining of biomedical signals and images, ensemble of classifiers.

1.4 Optical, electrical impedance tomography

S. Filipowicz, T. Grzywacz (PhD Student)

Implementation of piecewise constant level set framework in electrical impedance tomography

The problem of the image reconstruction in Electrical Impedance Tomography is a highly ill-posed inverse problem. The iterative algorithm is based on a combination of the level set methods and the finite element method. The shape representation of the boundary and its evolution during an iterative reconstruction process is achieved by the level set method. The Mumford-Shah algorithm sets the formulation and minimization problem in the image processing, to compute piecewise-smooth optimal approximations of a given object. The proposed model follows and fully generalizes work, where there was proposed an active contour model without edges based on a 2-phase segmentation. The idea of the level set method is merely to define a smooth function, that represents the interface.

Quality of imaging in multipath tomography

Today tomographic measurement techniques allow fairly accurate monitoring of the test objects. The work presents the problem of obtaining high quality tomography images and of simulation researches of the complex shape objects. This discusses an application of ultrasonic tomography in construction the velocity images of flowing gas in circular pipe. An ultrasonic flowmeter was assumed for measuring the average velocity of the gas in the

axial direction inside the pipe. Chosen methods made it possible to obtain tomographic images that accurately map tested phantoms.

1.5 Singular multivariable and parameter distributed systems

Z. Trzaska

Effective algorithms and computational procedures for analysis, synthesis, identification and design of singular dynamical multivariable systems; analysis and design of manipulators; studies of systems with distributed parameters; cryogenic systems, fault diagnostic systems, geometrical approaches to dynamical system problems, electrical car drives; fundamentals and applications of the Fibonacci hyperbolic trigonometry and Fibonacci polynomials; direct and inverse problem solutions for 2-D and N-D systems.

1.6 Simulation of power system loaded by the high power nonlinear load

W. Brociek

Modeling of the elements of power system, interaction of the system and nonlinear load of quickly changing parameters (arc furnaces, traction substations), electromagnetic compatibility of the high power nonlinear load and power system in dynamic conditions, analysis of higher harmonics using simulation languages including PCNAP and PCSPICE, quality of the delivered energy under non-sinusoidal conditions.

1.7 Software modeling group (SMoG)

M. Śmiątek, S. Drejewicz, W. Nowakowski, A. Ambroziewicz, J. Bojarski, T. Straszak

The main area of interest of the SMoG is modeling of software. The group is mostly engaged in research around object-oriented software development methods and their applications. SMoG's area of concern are also CASE tools that try to realize the ideas of MDD (Model Driven Development) and which enhance the possibility of using UML (Unified Modeling Language) as a universal "lingua franca" of software engineering. SMoG research activities are often related to the field of meta-modeling, such as issues which pertain to the creation of MOF-based definitions of languages. Other SMoG's research interests include scenario-based requirements engineering, model transformations and software reuse.

Throughout 2009, SMOG has realized the ReDSeeDS project. The main objective of the project was to create a system (language, tool, reuse process) where software reuse is based on building and retrieving of so-called software cases (large compound artifacts) that can be reused between domains. This work was partially funded by the EU: Requirements-Driven Software Development System (ReDSeeDS) (contract no. IST-2006-33596 under 6FP). The project was coordinated by Infovide, Poland with technical lead of Warsaw University of Technology and with University of Koblenz-Landau, Vienna University of Technology, Fraunhofer IESE, University of Latvia, HITeC e.V. c/o University of Hamburg, Heriot-Watt University, PRO DV, Cybersoft and Algoritmu Sistemas.

1.8 Research in the area of methods and systems for testing magnetic materials

S. Tumański, J. Olędzki, T. Winek

Parameter identification approach to magnetic material testing, adaptive techniques in testing magnetic materials, e.g. adaptive control of demagnetization, of measurement process, adaptive digital synthesis of magnetizing current waveform. Methods of identification of two- and three-terminal networks in the harmonic current circuits when model accuracy in a frequency range is specified, computer parameter identification supplemented with an automatic selection of a model structure of adequate accuracy. Sensors of magnetic fields, magnetic fields measurements, construction of magnetometers, measurements of power frequency magnetic and electric fields, nondestructive testing of electric steel sheets. Computer controlled measurement system of magnetic fields. Computer aided processing of measurement data.

1.9 Large area, distributed measurement systems as a tools for environment protection

A. Michalski, Ł. Makowski, A. Kalicki, Z. Staroszczyk. B. Dziadak

The main stream of scientific works contains to main groups: flow meters in open channels and monitoring of the concentrations of petroleum derivatives in fresh water or drainage. Study of the features of electromagnetic method, development of new generation of electromagnetic flow meter dedicated for industrial open channels, optimization of primary transducer (coil, electrodes) based on the finite element idea and generalized Newton algorithm, designing small measurements systems based on one chip microcomputers. Measurement algorithms and signal processing for electromagnetic flow meters. One of the most important problems in environmental pollution

protection is the monitoring of drinking water quality. The aim of the proposed system is to protect sensitive country areas from this kind of pollution with the use of GSM/GPRS accessed mobile observation points (MOP). The basic version of the MOP is equipped with the GPS position locator, sensitive hydrocarbon contamination probe and a GSM/GPRS connection with a central www accessible server. The dedicated system server collects data from mobile GSM/GPRS accessed observation points, and delivers it through the Internet the information on potential pollution to the authorised www clients. The moving observation indicates property, and the countrywide GSM operator coverage makes the system flexible and universal, allowing for “on request” installations of MOPs in pollution sensitive areas.

1.10 Time-frequency and time-scale analysis of signals

R. Rak, A. Majkowski, A. Jósko

Traditional frequency analysis is not appropriate for the observation of properties of non-stationary signals. It is for the fact that the time resolution of the Fourier series representation is not very good. Thus, there is a need for an analysis implementing the joint time-frequency signal representations. The time-frequency representation family is very large. In this project practical aspects of some representative methods are implemented including short time Fourier transform, Gabor transform, Wignera-Ville transform, Cone-shaped transform and also the wavelet transform. What makes the wavelet analysis interesting is that individual wavelet functions are quite localized in time scale (or space) and simultaneously in frequency (or characteristic scale). Unlike sine and cosine, which define a unique Fourier transform, there is not one single unique set of wavelets. In fact there are infinite variety of possible sets. Which one is the best it depends on a particular application. Wavelet analysis owes its efficiency to the fast pyramid algorithm described by Mallat.

1.11 Human computer interaction and visual perception

D.Sawicki, mgr inż. Ł.Stelmach (PhD Student), mgr inż. M.Augustynowicz (PhD Student), mgr inż. B.Neuman (PhD Student)

New methods of data presentation and modern interface design in human computer interaction. Development and future of HCI. Human vision and visual perception. Color perception and its influence on interface. Ray tracing application. Simulation of the wave properties of light using ray tracing.

Material appearance and optical properties of the shape. Description of the light reflection.

1.12 Virtual laboratory and distributed measurement systems

R. Rak, A. Majkowski, T. Winek, M. Godziemba-Maliszewski

The main purpose of the investigations is to develop a remote measurement laboratory as a Virtual Laboratory operating by Internet with simplifications deriving from the requisites of distance learning. It includes the features of a complete Learning Management System (LMS) with experiments on actual measurement instrumentation. The primary objective of a LMS is to manage learners, keeping track of their progress and performance across all types of training activities. The LMS manages and allocates learning resources such as: registration, classroom and instructor availability, instructional material fulfilment, online learning delivery.

1.13 Features extraction, selection and classification of EEG signal for brain-computer interface design

R. Rak, A. Majkowski, M. Kołodziej, A. Jóska, Ł. Oskwarek

The main aim of the investigation is to introduce a new method of feature extraction from EEG signal for brain-computer interface (BCI) design. In recent years, we can observe a growing interest in brain-computer interfaces. The main advantage of the communication between brain and computer is its “directness”. The brain activity is processed into information understandable by a computer, omitting all indirect factors such as muscles. The application of BCI is primarily to allow contact with paralyzed people. At present the main factors that restrict the wider use of brain-computer interfaces are: low speed of information conveyed by brain-computer technology and problems with acquisition of EEG signals. Although there are many ways of the brain activity examination, the most widely used is electroencephalography (EEG). To enable brain-computer interface construction an efficient method of feature extraction from EEG signal is needed. We propose a feature extraction method based on higher order statistics (HOS) calculated for the details of discrete wavelet transform (DWT) of EEG signal. The next aim of the research is to check whether the efficient brain-computer interface can be build using only 2 channels of EEG signal. Limiting the number of electrodes is supposed to simplify the use of the interface and reduce the cost of the

EEG signal amplifier. This would also facilitate the analysis, processing and classification of signals.

1.14 Power system time-frequency properties investigations: LTI/LPTV modeling, impedance and transfer functions identification and measurements

Z. Staroszczyk, P. Figoń (Ph.D. student), P. Irzmański (Ph.D. Student)

The research concerns multiphase power grid time and frequency domain description in the acoustic frequency range, oriented to system voltage harmonic and non-harmonic distortions limitation. Classical LTI (linear time invariant) and LPTV (linear periodically time variant) models are used for grid modeling, and parameters of such models are experimentally identified with the use of developed instrumentation. That way valuable, useful models of the grid are obtained, which are used in simulations serving for proper system conservation and modernization. DSP methods and algorithms oriented to accurate power system transfer functions measurements in the noisy, natural conditions are developed. The focus of research is on invasive methods of the large and multipoint active power system treatment.

Chapter 2

Publications

The results of the scientific activity of the Institute of the Theory of Electrical Engineering and Electrical Measurements, Warsaw University of Technology have been published in 46 journal papers (20 in international journals of Journal Citation Reports list, 19 papers in journal of Philadelphian list and 7 in other, either national or international journals), and 35 contributions of the proceedings of the national (17) and international (18) conferences. Below there is a list of papers published in 2009 as well as list of books and book chapters published by the scientific staff of the Institute in the year 2009.

Following you will the following lists of publications:

- Papers in international journals of Journal Citation Reports list,
- Papers in international journals of Philadelphian list (journals with no impact factor),
- Papers in other journals,
- Works published in conference proceedings,
- Books,
- Books parts and chapters

Papers in international journals of Journal Citation Reports

- [1] Bartłomiej Grala, Wojciech Kozłowski, and Tomasz Markiewicz. Primary cns meningiomas treated with neurosurgery in the military institute of health services in Warsaw recognition of tumor cells by image analysis. *Virchows Archives*, 455:441, 2009.

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- [6] Michał Kruk, Stanisław Osowski, and Robert Koktysz. Recognition and classification of colon cells applying the ensemble of classifiers. *Computers in Biology and Medicine*, 39:156–165, 2009.
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- [12] Stanisław Osowski and Artur Wiliński. Gene selection for cancer classification. *Compel*, 2009, vol. 28, pp. 231-241

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Chapter 3

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Chapter 5

International cooperation

- Computational Problems of Electrical Engineering – cooperation with Lviv Technical University (Ukraine) and University of West Bohemia (Czech Republic)
- Bioelectromagnetism – cooperation with Instituto de Biofísica e Engenharia Biomédica da Faculdade de Ciências da Universidade de Lisboa (Portugal)
- Software engineering – Technical Coordination of the VI Frame European Program Requirements Driven Software Development System (ReDSeeDS) coordinated by dr Śmiałek. The cooperation with Technical University of Vienna, University of Koblenz-Landau, University of Hamburg, University of Riga, Fraunhofer Institute, University of Herriot-Watt in Edinburgh, and some industrial companies from Turkey, Germany and Lithuania.