Silesian University of Technology
Faculty of Automatic Control, Electronics
and Computer Science

Annual Review 2014

Institute of Electronics

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Edyta Kawa

Institute of Electronics, March 2015

FOREWORD

The Institute of Electronics is a part of the Faculty of Automatic Control, Electronics and Computer Science, one of the 13 faculties of the Silesian University of Technology, founded in 1945. The University is located in Gliwice and has almost 25,000 students at present. The Faculty of Automatic Control was founded in 1964, and after a few reorganisations it changed its name to the Faculty of Automatic Control, Electronics and Computer Science. The total number of students is about 3,000 now. Since its creation in 1974 the Institute of Electronics has undergone a number of reorganisations. It has over 70 members of academic staff and consists of six divisions:

- ***Division of Electronics Fundamentals and Radio Engineering***
- ***Division of Digital and Microprocessor Systems***
- ***Division of Circuit and Signal Theory***
- ***Division of Telecommunication***
- ***Division of Biomedical Electronics***
- ***Division of Microelectronics and Nanotechnology***

The Institute specialises in such advanced fields of engineering as analogue and digital electronic systems, including biomedical systems, production of telecommunication and electronic systems etc. Research in these areas ranges from component to system level, encompassing practical and theoretical investigations with the application of both hardware and software techniques. Research groups are supported by a wide range of test and instrumentation equipment together with computer facilities, which can run with programming languages of all levels and offer various application software. Many of the Institute's research programmes are carried out in close co-operation with industry in order to satisfy the needs of the region, which is the main industrial centre of Poland.

The Institute offers 3.5-year courses leading to the degree of BSc in the general field of Electronics and Telecommunication and 1.5-year MSc courses in the following specialisations:

- Electronic Apparatus
- Biomedical Electronics
- Microelectronics
- Radio Engineering
- Telecommunication

Both degrees are obtained on the basis of a project and a report, presented during a final examination. In addition, the Institute participates in a joint macro-course in Automatic Control, Electronics and Computer Science, run by the Faculty, in which all teaching is in the English language. In the academic year 2013/2014 a completely new course in Information and Communication Technology was started together with the Institute of

Informatics. The courses normally consist of lectures, laboratories, seminars and projects, and are followed by examinations. The curricula of the courses run by the Institute are designed for people who want to achieve both theoretical knowledge and practical skills in electronics. Other didactic activities include postgraduate and PhD studies.

The following pages provide detailed information regarding the research carried out as well as the subjects taught in each division.

CONTENTS

DIRECTORS OF THE INSTITUTE

Director of the Institute:
Prof. Edward HRYNKIEWICZ

Vice Director of the Institute for Research:
Prof. Zdzisław FILUS

Vice Director of the Institute for Teaching:
Asst. Prof. Jacek KONOPACKI

DIVISION OF ELECTRONICS FUNDAMENTALS AND RADIO ENGINEERING

Head of Division: Prof. Zdzisław Filus, PhD, DSc

Research staff

Prof. Zdzisław FILUS, PhD, DSc

Prof. Andrzej KARWOWSKI, PhD, DSc
Andrzej BŁONAROWICZ, PhD
Jacek CHĘCIŃSKI, PhD
Jerzy FIOŁKA, PhD
Zenon KIDOŃ, PhD
Adam KRISTOF, PhD
Sławomir LASOTA, PhD
Mirosław MAGNUSKI, PhD
Andrzej MALCHER, PhD
Artur NOGA, PhD
Wojciech OLIWA, PhD
Maciej SURMA, PhD
Tomasz TOPA, PhD
Grzegorz WIECZOREK, PhD
Dariusz WÓJCIK, PhD

PhD Students

Krzysztof BERNACKI, MSc

Research fields

- Electronic circuits synthesis
- Symbolic methods of electronic circuits analysis
- Electronic circuits for automotive applications
- Power electronic circuits
- Microprocessor-based measurement systems
- Computational electromagnetics
- Numerical modelling of radiating and scattering wire objects
- Linear antenna theory
- Electromagnetic compatibility
- Optoelectronics, Fiberoptics

Courses

- Semiconductor Devices
- Analogue Electronic Circuits
- Analogue Circuits Design
- Fundamentals of Measurements
- Electronic Measurement Techniques
- Switching Circuits
- Special Semiconductor Devices and Circuits
- Materials Technology and Electronic Equipment Design
- Field and Wave Electromagnetics
- Introduction to Radiocommunication
- Radio Engineering Systems
- Fields, Waves and Antennas
- Wireless Computer Networks
- Design of Radio Electronic Devices
- High-Frequency Engineering Fundamentals
- Electromagnetic Compatibility
- Optoelectronics
- Optical Fiber Techniques

DIVISION OF DIGITAL AND MICROPROCESSOR SYSTEMS

Head of Division: Prof. Dariusz Kania, PhD, DSc

Research staff

Prof. Dariusz KANIA, PhD, DSc

Prof. Edward HRYNKIEWICZ, PhD, DSc
Mirosław CHMIEL, PhD
Robert CZERWIŃSKI, PhD
Tomasz GARBOLINO, PhD
Krzysztof GUCWA, PhD
Józef KULISZ, PhD
Adam MILIK, PhD
Adam PAWLAK, PhD
Krzysztof PUCHER, PhD
Tomasz RUDNICKI, PhD
Wojciech SAKOWSKI, PhD
Dariusz STACHAŃCZYK, PhD
Krzysztof TABOREK, PhD
Bernard WYRWOŁ, PhD
Dariusz POLOK, MSc

PhD Students

Jarosław Wrotniak, MSc

Research fields

- Testing and testability of digital systems
  - Test and diagnostics of connections
  - Built-in self-test
  - Generation of test patterns and analysis of test responses
  - Specific linear registers
  - Design for testability
  - Digital systems compliant with IEEE 1149 and IEEE 1500 standards
  - On-line testing
- Design of systems with programmable devices and controllers
  - Design of support software
  - Logic synthesis
  - Technology mapping in CPLDs, FPGAs and pSoCs
  - Fast operating CPU structures of programmable controllers and methods of PLC programming
  - Distributed structures of PLCs
  - PLC applications

- Embedded control system design
- Frequency multipliers based on digital techniques
- Multiprocessor systems
  - Pipelining and parallel processing
  - Systems with global memory and arbitration
  - Statistical analysis of performance for pipelining processing
- ASIC design
  - High level design methodologies
  - System modelling and simulation (using VHDL and Verilog)
  - IP-core design
  - Distributed design methodologies based on the Internet
- Cyber-physical systems
- Field oriented control (FOC) dedicated for a permanent magnet synchronous motor (PMSM)

Courses

- Digital Systems Fundamentals
- Design of Digital Devices
- Microprocessors Fundamentals
- Microprocessor Systems
- Reliability and Testing of Electronic Devices
- Computer Aided Design of Integrated Circuits
- Programmable Logic Devices
- Programmable Controllers
- Hardware Description Languages

DIVISION OF CIRCUIT AND SIGNAL THEORY

Head of Division: Prof. Jerzy Rutkowski, PhD, DSc

Research staff

Prof. Jerzy RUTKOWSKI, PhD, DSc

Damian GRZECHCA, PhD, DSc
Jacek KONOPACKI, PhD, DSc
Andrzej PUŁKA, PhD, DSc
Tomasz GOLONEK, PhD
Jan MACHNIEWSKI, PhD
Katarzyna MOŚCIŃSKA, PhD
Łukasz CHRUSZCZYK, PhD
Andrzej KUKIEŁKA, PhD

Research fields

- Computer-aided electronic circuits analysis and design
  - Test and diagnosis for analogue and mixed-signal electronic circuits
  - Application of sensitivity methods to the analysis and synthesis of electronic circuits
  - Modelling and simulation of digital and mixed analog-digital circuits in VHDL language
  - System level design in System C
  - Application of artificial intelligence methods and genetic algorithms to circuit theory and electronics
  - Common-sense reasoning modelling and application of AI techniques to circuits models generation and verification
- Digital signal processing focused on digital filters design and application
- Signal processing and basic research into neural networks (analysis, synthesis and optimisation) and their application to engineering practice
  - Application of neural networks to image processing and recognition, including texture images
  - Application of wavelet techniques to signal processing
- Technology Enhanced Learning (IC-TEL) Web based Education (WBE)
- Indoor location and navigation methods

Courses

- Circuit Theory
- Systems and Signals
- Fundamentals of Electrical Engineering
- Information Theory and Coding
- Computer-Aided Design of Electronic Circuits
- Digital Signal Processing
- Neural Networks
- LabView – Graphical Programming Language
- Computer-Based Measurements with NI Lab View

DIVISION OF TELECOMMUNICATION

Head of Division: Asst. Prof. Jacek Izydorczyk, PhD, DSc

Research staff

Asst. Prof. Jacek IZYDORCZYK, PhD, DSc
Leszek DZICZKOWSKI, PhD, DSc
Piotr ZAWADZKI, PhD, DSc
Adam DUSTOR, PhD
Maria DZICZKOWSKA, PhD
Grzegorz DZIWOKI, PhD
Piotr KŁOSOWSKI, PhD
Marcin KUCHARCZYK, PhD
Wojciech SUŁEK, PhD
Jerzy WOJTUSZEK, PhD

Research fields

- Digital commutation in modern telecommunication systems
  - Construction of telephone exchanges
  - Supervisory software for telephone exchanges
  - Special services (e.g. teleconferences)
  - Implementation of digital networks with integrated services (ISDN, B-ISDN, ATM)
- Application of digital signal processing to telecommunication
  - Compression of speech signal with the application of DSPs
  - Speech synthesis
  - Speech and speaker recognition
  - Application of artificial neural networks to signal processing
  - Design, testing and implementation of error correcting and modulating codes
  - Design of modern local area networks
  - Implementation and testing of new services in the Internet
  - xDSL technology
  - Efficient hardware implementation of decoder of LDPC code.
- Modems

Courses

- Fundamentals of Analogue and Digital Communication
- Fundamentals of Commutation
- Switching Nodes and Exchanges
- Principles of Transmission
- Communication Systems
- Signal Theory
- Information Theory and Coding
- Digital Signal Processing
- Computer-Aided Analysis of Electronic Circuits
- Digital Signal Processors (DSP)
- Neural Networks
- Computer Networks
- Internet
- Modems
- Introduction to Cryptography

DIVISION OF BIOMEDICAL ELECTRONICS

Head of Division: Prof. Jacek Łęski, PhD, DSc

Research staff

Prof. Jacek ŁĘSKI, PhD, DSc

Marian KOTAS, PhD, DSc
Ewa STRASZECKA, PhD, DSc
Robert CZABAŃSKI, PhD
Norbert HENZEL, PhD
Jerzy IHNATOWICZ, PhD
Michał JEŻEWSKI, PhD
Michał KOZIELSKI, PhD
Tomasz PANDER, PhD
Stanisław PIETRASZEK, PhD
Tomasz PRZYBYŁA, PhD

Research fields

- Biocybernetics and biomedical engineering - processing of information in medicine
  - Processing of biomedical signals
  - Image processing and analysis
  - Fuzzy sets and systems, neuro-fuzzy systems
  - Pattern recognition
  - Cybernetics
  - Computer assisted medical diagnosis
  - Hospital information systems
  - Picture archiving and communications systems
  - Medical information systems integration
  - Expert systems in medicine
  - Time-frequency analysis of biomedical signals
  - Multirate signal processing
  - Evolutionary computations
  - Artificial neural networks
  - Data mining
  - Artificial intelligence
- Design, construction and testing of electronic medical equipment
  - Design and construction of amplifiers for biological signals and data acquisition systems co-operating with computers
  - Testing of electromedical equipment
  - Design of electronic devices for data acquisition

Courses

- Electromedical Metrology
- X-ray and Nuclear Imaging
- Medical Information Systems
- Cybernetics
- Artificial Intelligence
- Electromedical Equipment
- Pattern Recognition
- Principles of Knowledge Engineering
- Diagnostic Imaging Systems
- Biocybernetics
- Computers in Medicine
- Diagnostic Cardiological Systems
- Computer Aided Medical Diagnosis
- Probability Theory and Mathematical Statistics
- Optimization Methods
- Bionics
- Principles of Digital Signal Processing
- Numerical Methods
- Biomedical Information Processing
- Digital Signal Processing
- Artificial Intelligence in Engineering Applications

DIVISION OF MICROELECTRONICS AND NANOTECHNOLOGY

Head of Division: Prof. Jacek Szuber, PhD, DSc

Research staff

Prof. Jacek SZUBER, PhD, DSc

Prof. Zbigniew RYMARSKI, PhD, DSc
Wojciech FILIPOWSKI, PhD
Weronika IZYDORCZYK, PhD
Piotr Kościelniak, PhD
Piotr KOWALIK, PhD
Monika KWOKA, PhD
Jerzy ULJANOW, PhD
Krzysztof WACZYŃSKI, PhD
Edyta WRÓBEL, PhD

PhD Students
Aleksander MIERA, MSc
Michał SITARZ, MSc (till 30.09.2014)

Research fields

- Design of electronic devices for data acquisition
- Technology of doped semiconductor glasses based on organosilicon compounds
- Special hybrid circuits made in thick (thin) film technology
- Solar cells and photovoltaic systems
- Passivation of semiconductor surfaces for application in microelectronics
- Nanotechnology of transparent conductive oxides and organic semiconductors for application in photovoltaics and gas sensors

Courses

- Design of Thick/Thin-Film Circuits
- Fundamentals of Physics
- Hybrid Circuit Technology
- Electronic Devices, Semiconductor Structures and Circuits
- Materials Science and Principles of Construction of Electronic Equipment
- Microelectronics
- Nanotechnology in Microelectronics
- Solid State Electronics
- Sensors and Actuators
- Thick-Film Technology
- Thin-Film Technology

SECRETARIAL AND TECHNICAL STAFF

Secretarial staff

Beata BIELAWNY, MBA
Edyta KAWA, MSc
Maria LANGIER
Tatiana NIEDZIELA, BBA

Technical staff

Andrzej CZYŻ, MSc
Łucja LEWANDOWSKA
Szymon PARA, MSc
Tomasz SZYMAŃSKI, BSc
Natalia WACZYŃSKA–NIEMIEC, MSc
Jarosław WROTNIAK, MSc
Piotr ZAJĄC
Czesław ZIOBER

STATUTORY ACTIVITIES OF THE INSTITUTE OF ELECTRONICS

TITLE OF PROFESSOR

1. The President of Poland conferred the title of professor on **Dariusz Kania**, PhD, DSc, on 19 February 2014.
2. The President of Poland conferred the title of professor on **Edward Hrynkiewicz**, PhD, DSc, on 28 July 2014.

PhD DEGREES CONFERRED ON STAFF MEMBERS AND PhD STUDENTS OF THE INSTITUTE OF ELECTRONICS

1. **Andrea Ehrmann** (Germany), Examination and simulation of new magnetic materials for the possible application in memory cells, PhD advisor: Prof. Tomasz Błachowicz, 18 March 2014 (with honours)
2. **Adam Popowicz**, Detection, classification and correction of non-linear generation processes of dark current in CCD matrices, PhD advisor: Prof. Zdzisław Filus, 14 July 2014 (with honours)
3. **Błażej Kwiecień**, Algorithms for detection of redundant link failure in industrial real-time distributed systems with continuous transmission of data by two buses, PhD advisor: Prof. Edward Hrynkiewicz, 27 October 2014
4. **Marcin Szelest**, Automatic formal verification of an electronic circuit on the basis of its circuit diagram for design of electronic devices with high reliability, PhD advisor: Asst. Professor Jacek Izydorczyk, 18 November 2014
5. **Damian Modrzyk**, Coder Motion JPEG2000 in the form of a GALS structure, PhD advisor: Prof. Dariusz Kania, 12 December 2014
6. **Krzysztof Walczak**, Application of evolutionary computations to the processing of electrocardiographic signals, PhD advisor: Prof. Jacek Łęski, 19 December 2014

RESEARCH GRANTS

Research activities of the Institute of Electronics are mainly financed by the Ministry of Science and Higher Education within the frames of a general research programme:

- ***Development of new research areas in electronics, telecommunication and signal processing***

Apart from this, each division of the Institute carries out its own research in the following general areas, which are further subdivided into individual research projects:

Division of Electronics Fundamentals and Radio Engineering:

- *Electronic components, circuits and systems - development of measurement methods, analysis and synthesis*

Division of Digital and Microprocessor Systems:

- *Multiprocessor systems, application specific integrated circuits, programmable logic devices and systems - analysis, design and testing*

Division of Circuit and Signal Theory:

- *Computer-aided methods of analysis, synthesis and testing of electronic systems and their selected applications*

Division of Telecommunication:

- *Development of methods and applications of digital channel commutation and transmission of digital signals, theoretical and experimental methods of examination of bodies radiating and dissipating electromagnetic waves*

Division of Biomedical Electronics:

- *Acquisition and processing of biomedical information*

Division of Microelectronics and Nanotechnology:

- *Advanced technologies in microelectronics and nanoelectronics*

In total, forty individual research projects were completed in 2014.

GRANTS AWARDED BY THE COMMISSION OF EUROPEAN COMMUNITIES OR OTHER INTERNATIONAL SOURCES

1. European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability – EuNetAir within European Cooperation in the Field of Scientific and Technical Research (COST)
Grant: OC-2011-1-9706; Period: 2011-2014
Coordination: Dr. Michele Penza, ENEA, Brindisi, Italy; National Coordination: Dr. M. Kwoka
The project deals with the development of new sensing technologies including new materials and systems for air-pollution control and environmental sustainability. It has a form of an international network with the contribution of 12 European scientific centres from academia and industry.

2. Innovation Technology of Multifunctional Materials and Structures for Nanoelectronics, Photonics, Spintronics and Sensoric Techniques (InTechFun); Structural project within Operational Programme of Innovative Economy: POIG.01.03.01-00-159/08, Period: 2009-2013; Prolongation: 30.06.2014
Coordination: prof. A. Piotrowska, Institute of Electron Technology, Warsaw, Contribution of the Institute of Electronics: Prof. J. Szuber - Head of group PSl-2
The project deals with the development of a new innovative technology of multifunctional materials and structures for nanoelectronics, photonics, spintronics and sensoric techniques in the form of a national network with the contribution of 6 Polish partners from academia and industry. The Institute of Electronics is responsible for 5 Workpackages dealing with technology and characterization of novel materials, structures and demonstrators. In 2014 several scientific tasks were realized within the new materials and new technological modules, together with the development of infrastructures for new materials characterization.

3. Dependable Cyber-Physical Systems. Project DAAD (Deutscher Akademischer Austausch Dienst) No. 56268155
Coordination: Dr. A. Pawlak
Collaboration with Brandenburg University of Technology in Cottbus (Prof. H.T. Vierhaus) is realised in a frame of the DCPS (Dependable Cyber Physical Systems) project. DCPS is a network project of the German DAAD-Program „Strategic Partnerships and Thematic Networks“ (2013-

2016). The project supports organisation of doctoral workshops and exchange of PhD students and professors doing research in the area of dependable cyber physical systems. Information on DCPS network activities is available on the following web pages:
http://www.iele.polsl.pl/~pawlak/DCPS/index.htm
http://www.iele.polsl.pl/~pawlak/DCPS/index-DCPS.htm
These web pages are accessible from the Institute's home page (Bookmark: *Projects*).

4. Innovative speaker recognition methodology for communications network safety. A structural project financed by the European Fund for Regional Development within the Operational Programme of Innovative Economy in a consortium formed by Silesian Technical University and Samsung: POIG.01.03.01-24-107/12, Period: 2013 – 2015
Coordination: J. Izydorczyk, PhD, DSc
The objectives of the project are: 1) Determination how certain parameters affect the process of speaker identifying. 2) Comparative studies of solutions produced in Task 1. 3) The effect of speaker model for speaker identification process. 4) Different approaches to the optimization of the system created in Task 2. 5) Tests of the identification system in Matlab environment. 6) Verification and optimization of the computer code provided by the research unit within the task 3.

5. Increasing the professional competence of students studying Electronics and Telecommunication at Silesian University of Technology. A project financed by the European Social Fund and The National Centre for Research and Development within the Operational Programme - Human Capital - Measure 4.1 Strengthening and Development of Didactic Potential of Universities and Increasing the Number of Graduates from Faculties of Key Importance for Knowledge-Based Economy. Grant Number: POKL.04.01.01-00-073/14 Period: 1.10.2014-30.09.2015
Coordination: Damian Grzechca, PhD, DSc
The main objective of the project is to prepare graduates for entering the labour market by offering certified courses and national/international internships.

INTERNATIONAL CO-OPERATION

1. University of Brescia, Italy (Prof. J. Szuber, Dr M. Kwoka)
2. University of L'Aquila, Italy (Prof. J. Szuber, Dr M. Kwoka)
3. California University, Department of Electrical Engineering and Computer Science, Berkeley, USA (Dr A. Pułka)
4. Technical University of Ostrava, Department of Measurements and Control, Czech Republic (Prof. E. Hrynkiewicz)
5. Tomas Bata University, Department of Computer and Communication Systems, Zlín, Czech Republic (Prof. E. Hrynkiewicz)
6. Brandenburg University of Technology, Cottbus, Germany (Dr A. Pawlak, Prof. E. Hrynkiewicz)
7. TIMA Laboratory, Grenoble, France (Dr D. Grzechca)

STAFF MEMBERS PARTICIPATING IN SCIENTIFIC AND ORGANISING COMMITTEES OF CONFERENCES AND SYMPOSIA

International

1. **Prof. Z. Filus**, Scientific and Program Committee of 4th International Scientific and Technical Conference: Application of Data Exchange Networks to Military and Civilian Technology, 18-19 September 2014, Chorzów, Poland
2. **Dr T. Garbolino**, Steering Committee and Program Committee, 17th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, DDECS 2014, 23-25 April 2014, Warsaw, Poland
3. **Dr T. Garbolino**, Program Committee, 17th Euromicro Conference on Digital System Design (DSD), 27 -29 August 2014, Verona, Italy
4. **Prof. E. Hrynkiewicz**, Program Committee, The International Scientific Conference: Computer Networks - CN`14, 23-27 June 2014, Brunów Palace, Poland
5. **Prof. E. Hrynkiewicz**, Steering Committee and Program Committee, 17th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, DDECS 2014, 23-25 April 2014, Warsaw, Poland

6. **Prof. E. Hrynkiewicz**, Programm Committee of IEEE International Conference Beyond Databases, Architectures and Structures, 27-30 May, 2014, Ustroń, Poland
7. **Prof. E. Hrynkiewicz,** Programm Committee of International Conference on Signals and Electronic Systems, 11-13 September 2014, Poznań, Poland
8. **Prof. E. Hrynkiewicz**, Scientific and Program Committee of 4th International Scientific and Technical Conference: Application of Data Exchange Networks to Military and Civilian Technology, 18-19 September 2014, Chorzów, Poland
9. **Dr J. Izydorczyk,** Program Committee of 7th International Multi-Conference on Engineering and Technological Innovation: IMETI 2014, July 15 - 18, 2014 – Orlando, Florida, USA
10. **Dr J. Izydorczyk**, Program Committee, Special Track on Engineering Education and Educational Technologies: EEET 2014 in the context of The 7th International Multi-Conference on Engineering and Technological Innovation: IMETI 2014, July 15 - 18, 2014 – Orlando, Florida, USA
11. **Dr J. Izydorczyk**, Program Committee, The International Science Conference Computer Networks - CN2014, June 23-27, 2014, Brunów Palace, Poland
12. **Prof. D. Kania,** Program Committee of 18th International Conference Electronics 2014, 16-18 June 2014, Palanga, Lithuania
13. **Prof. D. Kania**, organizer of a session, 10th International Conference of Computational Methods in Science and Engineering, ICCMSE 2014, 4-7 April 2014, Athens, Greece
14. **Prof. A. Karwowski**, Steering Committee, EMC Europe 2014, 1-4 September 2014, Gothenburg, Sweden
15. **Prof. A. Karwowski,** Scientific Advisory Committee, Advanced Electromagnetics Symposium AES 2014, 7-10 December 2014, Hangzhou, China
16. **Dr P. Kłosowski**, Program Committee, International Symposium on Engineering Education and Educational Technologies, July 15 - 18, 2014, Orlando, Florida, USA
17. **Dr A. Pawlak,** Program Committee, 17th Euromicro Conference on Digital System Design, DSD14, 27-29 August 2014, Verona, Italy

18. **Dr A. Pawlak,** Program Committee, 17th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, 23-25 April 2014, Warsaw, Poland
19. **Dr A. Pawlak,** Program Committee, 15th International Working Conference on Virtual Enterprises, PRO-VE 2014, 6-8 October 2014, Amsterdam, Netherlands
20. **Dr A. Pawlak,** Technical Program Committee, 9th IEEE International Conference on Computer Engineering and Systems, ICCES 2014, 21-23 December 2014, Cairo, Egypt
21. **Dr E. Straszecka,** Program Committee, 20th International Conference Medical Informatics & Technologies, 22-24 October 2014, Szczyrk, Poland
22. **Prof. J. Szuber** Scientific Committee, XI International Scientific Conference on Optical Sensors and Electronic Sensors – COE2014, 22-24 June 2014, Łódź, Poland
23. **Dr K. Waczyński,** Scientific Committee, 38th International Microelectronics and Packing IMAPS – CMPT Poland Conference, 21-24 September 2014, Rzeszów – Czarna, Poland

National

1. **Prof. Z. Filus,** member of the Scientific Committee of 13th National Electronics Conference, 9-13 June 2014, Darłowo
2. **Prof. E. Hrynkiewicz,** member of the Scientific Committee of 17th National Conference Reprogrammable Digital Circuits, RUC 2014, 29-30 May 2014, Szczecin
3. **Prof. E. Hrynkiewicz,** member of the Scientific Committee of 13th National Electronics Conference, 9-13 June 2014, Darłowo
4. **Prof. E. Hrynkiewicz,** member of the Scientific Committee of Scientific Conference „Informatics – Art. or Craft?" and Training Workshop of the Institute of Computer Science and Electronics of the Zielona Góra University, 9-12 June 2014, Karpacz
5. **Prof. D. Kania**, member of the Scientific Committee of 17th National Conference Reprogrammable Digital Circuits, RUC 2014, 29-30 May 2014, Szczecin

6. **Prof. D. Kania**, member of the Scientific Committee of Scientific Conference „Informatics – Art. or Craft?" and Training Workshop of the Institute of Computer Science and Electronics of the Zielona Góra University, 9-12 June 2014, Karpacz
7. **Prof. A. Karwowski**, member of the Scientific Committee of National Conference on Radiocommunications and Broadcasting, Warsaw, 11-13 June 2014
8. **Dr A. Milik**, member of the Scientific Committee of 17th National Conference Reprogrammable Digital Circuits, RUC 2014, 29-30 May 2014, Szczecin
9. **Prof. J. Rutkowski**, member of the Scientific Committee of 13th National Electronics Conference, 9-13 June 2014, Darłowo

REVIEWERS

1. **Dr Ł. Chruszczyk,** Circuits, Systems & Signal Processing (CSSP), Journal of Electronic Testing: Theory and Applications (JETT)
2. **Dr R. Czabański**, 19th International Conference on Methods and Models in Automation and Robotics MMAR 2014
3. **Dr R. Czerwiński,** Elektronika IR Elektrotechnika
4. **Dr L. Dziczkowski,** IEEE Transactions on Instrumentation and Measurement
5. **Dr W. Filipowski**, Elektronika - Konstrukcje Technologie Zastosowania
6. **Prof. Z. Filus**, International Journal of Electronics, Szybkobieżne Pojazdy Gąsienicowe, National Electronics Conference
7. **Dr. T. Garbolino,** Microelectronics Reliability, Microprocesors and Microsystems, Conferences: IEEE DDECS 2014, Euromicro DSD 2014 (special session)
8. **Dr D. Grzechca,** Journal of Electronic Testing: Theory and Applications, Circuits, Systems & Signal Processing, Metrology and Measurement Systems, Elektronika - Konstrukcje Technologie Zastosowania, Przegląd Elektrotechniczny, projects in the EU Operational Programme Innovative Economy 1.4

9. **Prof. E. Hrynkiewicz,** Journal of Applied Logic, Journal of Circuits, Systems and Computers; International Journal of Electronics and Telecommunication, IEEE DDECS Symposium, International Science Conference on Computer Networks, International Conference on Artificial Intelligence and Soft Computing, Scientific Conference „Informatics – Art or Craft?", National Electronics Conference, National Conference on Reprogrammable Digital Circuits, Szybkobieżne Pojazdy Gąsienicowe

10. **Dr J. Izydorczyk**, Physica B - Condensed Matter; PIER & JEMVA (Progress In Electromagnetics Research, Journal of Electromagnetic Waves and Applications), Micro & Nano Letters from the Institution of Engineering and Technology (IET), IEEE Transactions on Circuit and Systems I, IEEE Transactions on Magnetics, Journal of Applied Physics from American Institute of Physics (AIP), International Journal of Electronics and Telecommunications, Studia Informatica

11. **Prof. D. Kania,** Bulletin of the Polish Academy of Sciences – Technical Sciences, International Journal of Electronics and Telecommunication, Journal of Circuits, Systems and Computers; Electronics and Electrical Engineering, Pomiary Automatyka Kontrola, Przegląd Elektrotechniczny, International Conference Information Technology Interfaces, International Conference Electronics, International Conference of Computational Methods in Science and Engineering, International Conference on Human System Interaction, National Conference Informatics – Art. or Craft?, National Conference on Reprogrammable Digital Circuits

12. **Prof. A. Karwowski**, Journals: IET Proceedings Microwaves, Antennas & Propagation (London), Electronics Letters; IEEE Transactions on Antennas and Propagation; IEEE Transactions on Microwave Theory and Techniques; Progress in Electromagnetics Research, International Journal of Microwave and Wireless Technologies; COMPEL: The International Journal for Computation and Mathematics in Electrical and Electronic Engineering; Conferences: European Microwave Conference, EMC Europe, International Conference on Microwaves, Radar & Wireless Communications (MIKON)

13. **Dr P. Kłosowski**, 17th IEEE Mediterranean Electrotechnical Conference (MELECON2014), International Symposium on Engineering Education and Educational Technologies, EEET 2014, Orlando, Florida, USA, International Conference on Renewable Energies for Developing Countries 2014 (REDEC2014)

14. **Dr J. Konopacki**, International Conference on Artificial Intelligence and Soft Computing

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ABSTRACTS OF SELECTED RESEARCH PROJECTS

DIVISION OF ELECTRONICS FUNDAMENTALS AND RADIO ENGINEERING

M. Magnuski (PhD), M. Surma (PhD), D. Wójcik (PhD), *Broadband Input Block of Radio Receiver for Software-Defined Radio Devices*

Presently, trends in the development of RF systems and circuits leading towards increasing their versatility by means of their ability of flexible operation in various frequency bands and with numerous modulations could be observed. Flexibility of RF systems is achieved thanks to the application of configurable circuitry whose properties are programmable. Reconfigurability is the main feature of devices built in the SDR technology. RF devices built in the SDR technology have many of their intrinsic functions, which have been realized so far by analogue blocks, such as filtration, modulation, demodulation or signal conditioning realized as effects of algorithms implemented on signal processors or PLD circuits. This way some properties of the SDR devices can be easily changed or modified without any circuitry modifications. The ability of reconfiguration of RF devices without recomposition of their circuitry is an objective of modern RF engineering. In the RF and microwave SDR devices DSP blocks often cooperate with programmable high frequency analogue blocks realizing frequency conversion, preselection or filtration and amplification. The application of the SDR technology has simplified the construction of tuned-in narrow band receivers whose properties such as the operating frequency band and selectivity are determined by means of an input filter having appropriate electric parameters. In tuned-in broad band microwave SDR receivers the achievement of desired selectivity and dynamic range is related to the application of analogue signal processing blocks in their front-ends and SDR technology in their IF blocks. In case of tuned-in broad band microwave SDR receivers the main designers' objectives are achievement of assumed selectivity and good rejection of image channels. This aim could be realized thanks to the application of double-conversion technique.

The reported requirements are fulfilled by the frond-end block of SDR receiver designed by the authors. The device is designated for 900 MHz to 2.4 GHz frequency band as a full double-conversion receiver dedicated to cooperation with a broadband antenna. The device consists of a two-stage tuned input amplifier, solid state Gilbert's double balanced mixer, three-stage selective AGC controlled first IF, quadrature second mixer and two output low pass filters. As the mixers, IAM81008 (first) and two ESMD-C1 (second) have been used. As gain blocks, ERA1 and ERA3 MIMIC amplifiers were implemented. Input filters were realized according to the authors' concept shown in their patent application No. P.407888, selectivity of the receiver is established by two SAW filters Sawtek 856490. As the first and the second local oscillator, ADF4350

wideband synthesizers with integrated VCO have been applied. According to the authors, the designed front-end is a low cost versatile broadband device that can be integrated with a wide number of radiocommunication and measurement systems working over UHF L and S bands.

Prof. A. Karwowski, A. Noga (PhD), T. Topa (PhD), *Development of full-wave methods of computational electromagnetics. Performance evaluation and selected applications of the method of moments implemented on multicore CPUs and GPUs*

The performance of the full-wave MoM-based numerical simulations of radiating and scattering structures can be noticeably increased by extending a traditional CPU-based computation model through adoption of the General-Purpose computing on Graphics Processing Unit (GPGPU) paradigm. The main purpose of the study was to examine the performance and scalability of a hybrid OpenMP/CUDA parallelization technique in the context of electromagnetic simulation of wire-grid models of antennas and scatterers. A single-CPU sequential code based on the discretized frequency-domain Electric Field Integral Equation (EFIE) was ported using OpenMP and CUDA to heterogeneous multi-core/multi-GPU platform. The parallel implementation of a MoM code involves parallel assembling of the MoM-generated system matrix and the solution of the system of linear equations. Since the size of the problem being considered fits the GPU memory, the assembly of the impedance matrix has been carried out by a single, in-house CUDA kernel. For the solution of a linear equations, an off-the-shelf approach is followed, that is, the routine from a library CULA Tools providing a subset of LAPACK's functionality has been employed. Numerical results are given for a quadrifilar spiral antenna for a satellite-mobile handset. On a quad-core Intel Core i7-920 host with three NVIDIA GTX 590 devices, the measured speedup of about 104x over a reference single-thread implementation is demonstrated.

W. Oliwa (PhD), G. Wieczorek (PhD), *Time Delay Measurement Method for Range Finders*

In this research work a novel, accurate method for measuring signal delay was proposed. The method was also analysed and numerically simulated. The idea of this method may be implemented in various pulse range finders, including acoustic, radio frequency and, especially, laser range finders. The method involves generation of a series of pulses delayed with respect to the clock signal. The delay is changed during the measuring time in a controlled manner by a controller, for example, software implementation of the PID controller in a microcontroller. The delayed signal is presumably to be converted to a non-electric signal and transmitted in the direction of an object to which the distance is to be measured. The received non-electric signal, i.e. optical, RF or acoustic, is transformed to an electric signal, amplified and converted by a comparator to the form of a series of pulses. These series of pulses are counted by two counters. Each counter responds only when an appropriate enable signal is active. Enable signals are generated by a shift register with a multi–input OR gate. The role of

the controller is to choose such a delay time of the transmitted signal that the values counted by both counters are more or less the same over the measuring time. On the basis of this delay time the microcontroller estimates the distance to the object.

DIVISION OF DIGITAL AND MICROPROCESSOR SYSTEMS

R. Czerwinski (PhD), T. Rudnicki (PhD), *Control system for PMSM motor*

Permanent magnet motors with sinusoidal back-EMF play an increasingly important role in modern industry, including automotive industry. High efficiency of the motor, the biggest power in the overall dimensions and smooth regulation make it often used to build electric vehicles. Due to the lack of a classical commutator an electronic inverter carries out motor control. The well-known method, called field oriented control, is used. The purpose of the control system is suitable control over the power module (based on IGBT transistors) based on a winding current and shaft angle position measurements. On the basis of the measurements, transformations to the 'dq' model are performed (using Clarke and Park transformations). New values of flux and torque are calculated. Then the reverse transformation and adequate control of the transistor keys using pulse width modulation are performed. The engine speed and the angle of the shaft must also be determined. The electromagnetic distortions play an important and negative role in the system. The impact of those distortions can be reduced using filters, e.g. digital filters.
Due to the complexity of calculations in the field oriented control, a CPU with adequate computing power must be used as a DSP designed for motor control. A complete laboratory set was built to measure motor characteristics. A PMSM motor with rated values: 500W, 5Nm and 1000rpm has been tested. Performance analysis has been performed in two control zones. The operation of a PMSM above the base speed is possible by weakening the permanent-magnet excitation through a demagnetising field component supplied by the stator winding. However, the motor efficiency decreases. Experiments show, that in the second control area speed can be increased by about 30% in relation to nominal speed (overspeed).

Prof. E. Hrynkiewicz, A. Milik (PhD), M. Chmiel (PhD), R Czerwiński (PhD), Prof. D. Kania, J. Mocha (PhD student), M. Kobylecki (PhD student), *Fast Logic Controllers programmed according to IEC61131-3 standard*

An efficient execution of a control program written according to the IEC61131-3 standard is a subject of our multi domain research program. The main goals of the project are reduction of a response time and increase in a throughput of the control system. There are two paths to achieve these goals. The standard approach proposes the implementation of highly specialized central processing units and entire controllers that closely adhere to the IEC61131-3 standard. A multicore central processing unit with extended support of time and counting operations has been proposed. The hardware architecture is evaluated with the use of FPGAs and supported with a respective

compiler. The compiler uses enhanced data flow graphs for extracting the parallel task and distributing it among the processing units. The experience gained in program compilation has encouraged for developing a unique hardware supported event driven execution concept.
The other approach proposes synthesis of the custom hardware structure of the control program implemented in FPGA. There have been developed different methods of control program synthesis to hardware structure. The graph and set analysis are employed for this purpose. The controller implemented from a ladder description limited to Boolean operations requires only two clock cycles to complete the calculation process independently of program complexity. The developed representation method based on the enhanced data flow graph enables synthesis, scheduling and mapping not only logic but also arithmetic operations. The mapping procedure enables arithmetic resource sharing and use of highly dedicated DSP FPGA cores (e.g. DSP48E). The obtained hardware structures are able to operate as extremely fast feedback controllers.

K. Taborek (PhD), Prof. E. Hrynkiewicz, *Probabilistic elements in analysis of performance of multiprocessor systems*

The work presents important probabilistic elements that should be taken into consideration in the analysis of performance of classical multiprocessor systems. These elements are the following quantities: modified arrival rate for processor requests and a few probabilities, which determine the frequency of certain events when a multiprocessor system is working. There are four peculiar events: service of another job, existence of the queue, a processor request while the given task is waiting into the queue and the return of another task into the queue while the given task is waiting in the queue. The first three events happen more often when a system consists of a smaller number of processors, whereas the fourth event happens more often when more processors work in a system. Including (or not) the probabilities of these events into the analysis of performance of multiprocessor systems exerts much influence on the precision of computations. All the mentioned quantities were described in detail. Formulas for these quantities were derived. Examples of applications of the formulas to the prediction of performance of various multiprocessor systems were presented.
All the analytically obtained results of performance of multiprocessor systems were verified in a real multiprocessor system. This real system was equipped with a special measuring circuit. Thanks to this circuit we could measure execution times of programs in this system. Of course, for the purpose of verification of the analytical results proper test programs were written, so that we ensured the same conditions as for the analytical computations. The results which were obtained from measurements confirmed that the analytically obtained results were characterized by their high precision. For the results presented in the work the maximum error is not greater than 3.5 %. Programs destined to the analysis or simulation of queueing networks usually achieve accuracy of between ten or twenty per cent.
Thanks to the modified formulas we can more precisely analyse multiprocessor systems in various hardware configurations. For instance, we may analyse multiprocessor

systems that are equipped with various arbitration circuits, this means such arbitration circuits which may differ from their algorithms of request service of processors. It is very important that it is not necessary to build real multiprocessor systems with their equipment in all hardware configurations. On the basis of computations we can already say which of the considered multiprocessor systems achieve higher performance.

DIVISION OF CIRCUIT AND SIGNAL THEORY

D. Grzechca (PhD, DSc), Ł. Chruszczyk (PhD), *The use of data fusion for localization of objects in supervised areas*

There is an increasing demand for indoor localization and tracking objects with high accuracy. The GPS system is not efficient for positioning in such areas. Since WLAN infrastructure exists in many buildings, many researchers and companies are looking for methods for indoor localization and positioning. More, smartphones and other pocket devices are very popular and their prices are falling down. Such devices are also equipped with multiple sensors such as: accelerometer, gyroscope and magnetometer. Usage of the mentioned sensors can help to eliminate localization errors occurring in the pattern method. RSSI (Radio Signal Strength Index) is commonly applied but it is limited to pattern matching methods. A map called fingerprint is created at the first stage. However, its accuracy is low and very often not satisfying. The authors propose a method for indoor localization based on smartphone available sensors and the RSSI system. The onstructed pre- and post-processing algorithms take into account the mobile phone orientation with respect to AP (Access Points), acceleration and RSSI. The first results show positioning improvement and better accuracy with respect to the commonly used RSSI map. Experiments in real environment on localization of a static and in-motion object prove better accuracy comparing to the pure RSSI system.

A. Pułka (PhD, DSc), A. Milik (PhD), *Heuristic methodologies for satisifability checking of complex logical functions*

The research has been divided into two sub-tasks: the first, the modification of the FUDASAT algorithm and analysis of different searching strategies and scenarios of the proving process; and the second, a new approach to the SAT solving technique based on WalkSAT philosophy which tries to find the assignment to all variables. In comparison with the previous works of the team, the modified FUDASAT algorithm introduces new mechanisms: hypergraph analysis, multiple variable assignments and search space pruning algorithms. The approach considers only 3-SAT class functions, although a generalization of the method is discussed as well. The approach has been tested on various benchmarks and compared with the original FUDASAT algorithm as well as with other algorithms known from the literature and the authors have formulated a set of rules controlling the reasoning process of the FUDASAT inference engine.
The new methodology, called JumpSAT, represents an alternative approach to satisfability checking problems, where all variables are assigned at once. The presented

algorithm introduces fuzzy default logic and searching space pruning techniques based on cliques analysis into the heuristic variable flipping. Instead of single variable flipping, the presented method introduces multi-variable flipping, which can be compared to the jumping between possible combinations. The first experiments in the field proved the efficiency of the approach.

DIVISION OF TELECOMMUNICATION

P. Kłosowski (PhD), A. Dustor (PhD), J. Izydorczyk (PhD, DSc), J. Kotas , J. Slimok, *Speech Recognition Based on Open Source Speech Processing Software*

The creation of a speech recognition application requires advanced speech processing techniques realized by specialized speech processing software. It is very possible to improve the speech recognition research by using frameworks based on open source speech processing software. The article presents the possibility of using open source speech processing software to construct an own speech recognition application.
Division of Telecommunication, a part of the Institute of Electronics and Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, has been specializing in advanced fields of telecommunication engineering for many years. One of them is speech signal processing. The main research areas in this field are: speech synthesis, speech recognition and speaker verification and identification.
Creating of a speech recognition application requires advanced speech processing techniques realized by specialized speech processing software. Which software should be used for speech recognition application development ? There are many possibilities. To create an own speech recognition application we can use programming languages such as C++, Java, Python, high level commercial computing environment for implementation of speech recognition algorithms such as MATLAB with Signal Processing Toolbox, or open source speech processing software.
A hypothesis can be formulated as follows: It is possible to improve the speech recognition research by using frameworks based on open source speech processing software. The article focuses on open source applications that can be used to construct their own speech recognition system.
The most important elements of each speech recognition system are speech features extraction and classification. The paper presents examples how open source speech processing software can be used for speech features extraction. Similarly, the open source software can be used to test and create efficient classifiers that are the basis for designing effective speech recognition applications. For testing and construction of the various classifiers we can use e.g. the Hidden Markov Model Toolkit (HTK) or an open source platform for biometrics authentication called ALIZE. The use of open source speech processing software can significantly improve the construction and testing of modern speech recognition application.

P. Zawadzki (PhD, DSc), *Study of the effect of noise on the security of quantum cryptographic protocols*

Quantum direct communication (QDC) protocols provide confidentiality of sensitive information without any encryption. Messages are encoded in the states of quantum objects which are further exchanged over the quantum channel. Protocols of this type frequently use entanglement to physically protect transmitted data and offer asymptotic security in perfect quantum channels. However, it has been shown [Phys. Rev. Lett., vol. 90, pp. 157901, 2003] that they do not hold asymptotic security in the presence of losses. Moreover, an undetectable eavesdropping is possible even in perfect channels as long as legitimate parities use dense information coding [Phys. Rev. A, vol. 87, pp. 042326, 2013].
QDC protocols operate in a control or a message mode. The former serves for an eavesdropping detection and it checks whether legitimate parties share components of the same entangled system, while the latter is used for information transfer. We have identified the source of the above mentioned weaknesses as the incomplete check of coherence in the control mode. We have proposed improved version of the control mode. The relation of our contribution to main attacks which undermine QDC security has been thoroughly investigated. It follows that the new control mode detects these attacks with high probability and independently of the quantum channel type. As a result, an asymptotic security of QDC communication can be maintained in imperfect quantum channels. The proposed solution has desired properties also in the regime of dense information coding. It is worth noting that invention of quantum communication protocols which behave well in imperfect channels is of key importance because the noise is rather a rule than an exception in a quantum world.

G. Dziwoki (PhD), J. Izydorczyk (PhD, DSc), *Time domain estimation of mobile radio channels for OFDM transmission*

Time Domain Synchronous Orthogonal Frequency Division Multiplex (TDS-OFDM) transmission belongs to the broad family of orthogonal multicarrier modulation schemes that use IFFT/FFT as the key processing method. The specific feature that distinguishes it from the other OFDM techniques is a pseudorandom noise sequence with good autocorrelation property inserted between consecutive information symbols. This sequence can be used both for synchronization and channel estimation. The standard approach used in most OFDM systems utilizes some subcarriers as the pilot tones for efficient estimation of the transmission channel. The high estimation quality is substantial for the transmission throughput, but undoubtedly, every irrecoverable pilot consumes some part of the system capacity on its own. Therefore, the pilot reduction is a serious challenge, especially in case of the mobile radio environment, that usually requires more training information for the channel recovery, because of its dynamic properties both in the time and frequency domains.

The research has concerned a new estimation procedure for mobile channel recovery that was based on the time domain training sequence and utilized the compressive sensing approach. The proposed solution does not require any additional help from any deliberately deployed training information in the frequency domain (pilot tones). The method was experimentally explored in a simulated, doubly selective sparse transmission environment. The sparse channel has only several isolated propagation paths which are essential for information transfer. The quality metrics, obtained for an uncoded OFDM transmission system with implementation of the proposed estimation method, were compared to the ones that were obtained in case of ideal channel state information as well as the time-frequency training method. The simulation results with the OMP algorithm demonstrate fine estimation accuracy for mobile channels, even better than for the time frequency training method implemented in TFT-OFDM. The method was investigated for the fully implemented frequency domain channel matrix. Next research plans cover the issues of an improvement of the paths delay estimation and system analysis with error correction codes.

DIVISION OF BIOMEDICAL ELECTRONICS

Prof. J. Łęski, *Fuzzy (c+p)-Means Clustering And Its Application To A Fuzzy Rule-Based Classifier: Towards Good Generalization And Good Interpretability*

This work introduces a new classifier design method that is based on a modification of the classical fuzzy c-means clustering. A new fuzzy c-means clustering with p constant prototypes is proposed. This method can be considered as a generalization of the concept of the conditional fuzzy clustering with some prototypes a priori known. A special initialization of the prototypes is introduced. The proposed clustering method is used to construct the premises of an if-then rules based classifier. Generally, to obtain the antecedents part of the if-then rules for both TSK and MA classifiers, the fuzzy clustering of the training data in the input space is most commonly applied. To obtain antecedents for one class, the data from the training set that belong to this class are selected and undergo clustering, and the data from the other class(es) are not taken into consideration. This approach is effective for non-overlapping classes. But almost always the classes overlap. Thus, for more effective determination of antecedents, the operation of clustering should find a structure of the data from one class while taking into account the structure of the other class(es). For this purpose, a new conditional clustering method (fuzzy (c+p)-means — FCPM) is proposed. This method is used to find antecedents of the if-then rules and then Iteratively Reweighted Least Squares (IRLS) procedure is used to obtain consequents of these rules with the certainty factors. With the IRLS procedure, we can achieve better approximation of the misclassification error than with the use of the square function. The procedure can also be used for relaxation (when the misclassified data are analysed, only). The conjugate gradient algorithm is used to minimize the proposed criterion function. Each if-then rule is represented in the Mamdani-Assilan form that has good interpretability. An extensive experimental

analysis on 14 benchmark datasets is performed to demonstrate the validity of the classifier introduced. Its competitiveness to the state-of-the-art classifiers, with respect to both performance and interpretability, is also shown.

Prof. J. Łęski, M. Kotas (PhD, DSc), *On Robust Fuzzy C-Regression Models*

The unsupervised classification of data into groups is called clustering. The method plays an important role in many engineering fields, such as pattern recognition, computer vision, machine learning, image analysis, communication, knowledge discovery, data mining and so on. In the traditional, so called hard clustering, the groups (clusters) are disjoint. Each data item belongs to one cluster only. Zadeh introduced the notion of a fuzzy membership function. It allowed to associate with each data item and each cluster a real number in the interval [0,1] representing the "grade of membership" of this item in the cluster considered. This way Zadeh formed the basis for the development of fuzzy (or soft) clustering. However, the idea itself has been introduced by Ruspini and generalized by Bezdek, who developed an approach based on criterion function minimization. One of the most popular clustering methods based on criterion function minimization is the Fuzzy C-Means (FCM) method which has successfully been applied to a wide variety of problems. Many modifications of the FCM method have been proposed in the literature. Most of them rely on an inclusion of additional information into the clustering process. In an important group of FCM modifications, the information about the shapes of clusters prototypes is exploited. This information is relayed to the algorithms as the constraints on these shapes: the prototypes were constrained to linear varieties or linear elliptotypes in a feature space, to hyperellipsoidal ones and into hyperspheres in a feature space. Our goal in this work is to modify the method of fuzzy c-regression models, which are also called switching regression models, where the prototypes are constrained to functions (usually but not necessarily the linear ones). In the second group of FCM modifications, the information about the data non-Gaussian distribution and the presence of noise and outliers is taken into account. This group includes: possibilistic clustering, fuzzy noise clustering, Lp ($0<p<1$) norm clustering, L1 and $L\infty$ norm clustering, fuzzy c-ordered-means clustering, time-domain-constrained clustering, ε-insensitive fuzzy clustering and ε-insensitive fuzzy c-regression models clustering. Two different approaches to clustering algorithms robustifying against outliers are worth emphasizing. They are: application of reweighting scenario based Huber's M-estimators and the use of the ordered weighted averaging (OWA) operation. In our previous work both approaches were combined for the first time (the aim was to robustify a modification of the FCM method). In this work we propose to use the same idea to improve the method of the fuzzy c-regression models. We will first present fuzzy c-ordered-regression models method, which exploits both approaches to be more robust. The algorithm is compared with the traditional fuzzy c-regression models based one. The experiments on synthetic data with various types of noise and different numbers of outliers are carried out. We investigate the methods performance in the conditions that can be encountered in signal analysis. Large-scale simulations demonstrate the competitiveness and usefulness of the method proposed.

M. Kotas (PhD, DSc), Prof. J. Łęski, *Averaging of time-warped signal cycles for noise suppression*

Dynamic time warping (DTW) is a technique that uses dynamic programming to determine the best alignment of two time series (or sequences of vectors) and to provide a measure of their morphological similarity. This similarity measure was developed for spoken words recognition, and later applied in a variety of pattern recognition problems, e.g. to ECG beats clustering, to knee joint sound classification, to sleep stage classification and more generally to different biomedical time series clustering.
In our research, we focus on the application of the DTW technique to noise suppression. Averaging of time-warped signal cycles is an important method for suppressing noise of quasi-periodical or event related signals. Among important examples of such signals are the so-called evoked potentials. They respond to a stimulus with a series of positive and negative deflections from the baseline. The time between a stimulus and a particular deflection is called latency. The latencies convey important information on physiological mechanisms evolving in the brain. Unfortunately, the evoked potentials are mixed with the spontaneous EEG signal and can be of low signal-to-noise ratio. However, time warping and averaging of these signals can help to improve their quality.
In our study we show that the operation of time warping introduces unfavourable correlation among the noise components of the summed cycles. Such correlation violates the requirements necessary for effective averaging and results in poor suppression of noise. To limit these effects, we redefine the matrix of the alignment costs.
To improve results of averaging in cases of variable energy noise, we apply weighting of the summed signal samples. The derived formula gives smaller weights for more noisy signal cycles and this way limits their influence on the constructed template. The proposed modifications result in significant increase of the noise reduction factor in the experiments on different types and levels of noise.

DIVISION OF MICROELECTRONICS AND NANOTECHNOLOGY

M. Kwoka (Ph.D), P. Koscielniak (Ph.D), Prof. J. Szuber, *XPS, TDS and AFM studies of surface chemistry and morphology of Ag-covered L-CVD SnO_2 nanolayers*

This is well known that the selectivity and sensitivity of SnO_2 thin film sensors for the detection of low concentration of volatile sulfides such as H_2S in air can be improved by a small amount of Ag additives. In this paper we present the results of comparative X-ray Photoelectron Spectroscopy (XPS), Thermal Desorption Spectroscopy (TDS), and Atomic Force Microscopy (AFM) studies of the surface chemistry and morphology of SnO_2 nanolayers obtained by Laser Chemical Vapour Deposition (L-CVD),

additionally covered with 1 ML of Ag. For tin dioxide SnO_2 nanolayers deposited this way a mixture of tin oxide SnO and tin dioxide SnO_2 with the [C]/[Sn] ratio of ~1.3 was observed. After dry air exposure the [O]/[Sn] ratio slightly increased to ~ 1.55. Moreover, an evident increase of C contamination was observed with [C]/[Sn] ratio ~ 3.5. After the TDS experiment the [O]/[Sn] ratio goes back to 1.3, whereas C contamination evidently decreases (by factor 3). Simultaneously, Ag concentration after the air exposure and TDS experiment subsequently decreased (finally by factor ~2), what was caused by the diffusion of Ag atoms into the subsurface layers related to the grain-type surface morphology of Ag-covered L-CVD SnO_2 nanolayers, as confirmed by XPS ion depth profiling studies. The variation of surface chemistry of the Ag-covered L-CVD SnO_2 after air exposure observed by XPS was in a good correlation with the desorption of residual gases from these nanolayers observed in TDS experiments.

W. Izydorczyk (PhD), K. Waczyński (PhD), J. Uljanow (PhD), N. Waczyńska-Niemiec (MSc), W. Filipowski (PhD), *Research on the influence of technological parameters on the optical and sensory properties of layer structures, in terms of their potential applications in microelectronics*

Tin dioxide is a direct transition wide bandgap n-type semiconductor (Eg = 3,6 eV at 300 K) with a tetragonal crystal structure. SnO_2 due to its unique properties has been widely used for gas sensing, various photocatalytic applications, as optical coatings and liquid crystal displays.
The aim of this work was to study the effect of annealing temperature and molar concentration of tin (IV) chloride pentahydrate solution in isopropanol on the structural and optical properties of SnO_2 thin films. The examined thin films were prepared by the spin-coating method on silicon and quartz substrates, previously covered with a thin layer of gold. It was shown that the concentration of the precursor solution, annealing temperature and heating rate have a significant effect on the structural, optical and electrical properties of the studied thin films. The authors also proposed an equivalent circuit used for analysis of the impedance plots for one of the films. The prepared SnO_2/Au nanolayers may find applications in gas sensors.
The results of the qualitative X-ray phase analysis revealed that the SnO_2 film was deposited on the Au/SiO_2/Si substrate which was proved by the identification of reflexes originating from crystallographic planes (110), (101), (200), (211), (112) and (321). The intensities of the SnO_2 (110) peaks were found to vary with the different molar concentrations of the precursor solution.
The SEM analysis revealed that the surface is tightly and homogeneously covered with nanoparticles, whose dimension varies in the 17-46 nm range and they accumulate into bigger agglomerates of an elongated shape. The SEM analysis showed that the SnO_2 nanoparticles have a tendency to grow with increasing the annealing temperature. Optical transmission of SnO_2/Au films in the visible region improved with increasing the annealing temperature due to improved crystallinity of SnO_2 nanoparticles.
The average SnO_2 nanoparticle size increased from 22 to 38 nm with respect to the annealing temperature of 700 and 900 °C, respectively. The corresponding optical

bandgap was calculated to be 3.99 and 3.97 eV, which are larger than the value of 3.6 eV for the bulk of SnO_2. It was shown that for SnO_2/Au films a lower optical bandgap (Eg = 3.83 eV) could be obtained by increasing the initial thickness of the gold layer (dAu = 16.5 nm) and the annealing temperature (1.5 M solution, 900 °C).