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

Institute of Informatics

ACTIVITY REPORT
2014-2015
Contents

General information .............................................. 5

Organisational structure of the Institute ......................... 8

Divisions of the Institute ........................................ 23
Division of Computer Graphics, Vision and Simulation (DCGVS) ........ 23
Division of Computer Networks and Systems (DCNS) .............. 24
Division of Informatics Devices (DID) ................................ 25
Division of Microinformatics and Automata Theory (DMAT) .......... 26
Division of Software (DS) ........................................... 27
Division of Theory of Informatics (DTI) ............................ 28

Teaching activities ............................................... 31
Bologna declaration ............................................... 31
Cycles of studies .................................................. 32
Undergraduate 1st level studies .................................... 32
Graduate 2nd level studies ........................................ 33
Doctoral 3rd level studies ......................................... 34
Postgraduate studies ............................................... 35
Current curricula .................................................. 35
Full-time, undergraduate studies .................................... 35
Full-time, graduate studies ........................................ 38
Part-time, undergraduate studies ................................... 45
Part-time, graduate studies ........................................ 46
Courses Description ............................................... 46
Courses taught for students of other faculties ...................... 64
Other possibilities for students to improve their qualification .. 68
Ph.D. studies ...................................................... 76
Ph.D. studies in Data Mining ...................................... 77
'Scientists of the Future': the Scholarship Program .............. 78
Postgraduate studies ............................................... 78
Computer Networks and Systems, Databases ....................... 78
Methods of Exploration of Enterprises’ Databases ................ 79
Internet and Mobile Technologies in Information System Design and Realisation .................................................. 79
Teleinformatics in Aviation ........................................ 80
Production Management ........................................... 81
### Scientific activities

- Research areas .......................................................... 82
- International research projects ................................... 91
- Development and goal-oriented projects supported by Ministry ......................................................... 97
- Grants awarded by the Ministry of Science and Higher Education ......................................................... 98
- Grants awarded by the National Centre for Research and Development ..................................................... 100
- Grants awarded by the National Science Centre .......................................................... 100
- Rector’s grants .......................................................... 103
- Co-operation in grants .................................................. 104
- General statutory research projects ................................ 108
- Individual statutory research projects ................................ 115

### Statutory activities of the Institute

- D.Sc. degrees (habilitations) conferred on staff members of the Institute .................................................. 117
- D.Sc. degrees (habilitations) conferred on non-staff members of the Institute ........................................... 117
- Ph.D. degrees conferred on staff members of the Institute .......................................................... 118
- Ph.D. degrees conferred on non-staff members of the Institute .......................................................... 119

### Scientific journal issued by the Institute

- Man-Machine Interaction ............................................. 123
- Beyond Databases, Architectures and Systems ......................... 123
- Computer Networks .................................................. 124

### Scientific conferences organised by the Institute

- Participation in international projects ................................ 126
- International faculty and student exchange ................................. 127
- Visits of Polish researchers abroad ......................................... 127
- Co-operation in research .................................................. 129
- Long-term cooperation agreements ........................................ 130

### Cooperation with foreign institutions

- Cooperation with foreign institutions .................................. 132

### Cooperation with Polish or Poland-based institutions

- Laboratory and research equipment and software ................. 136

### Other achievements

- Other achievements .................................................. 155

### D.Sc. theses descriptions

- D.Sc. theses descriptions ............................................. 166

### Ph.D. theses descriptions

- Ph.D. theses descriptions ............................................. 170

### Monographs, books, and textbooks

- Monographs, books, and textbooks ...................................... 176

### Complete list of publications

- Complete list of publications .......................................... 178

### Index

- Index .......................................................... 203
General information

The Institute of Informatics is a part of the Faculty of Automatic Control, Electronics and Computer Science, one of the thirteen faculties of the Silesian University of Technology (SUT). The Institute consists of six divisions: Computer Graphic, Vision and Simulation (DCGVS), Computer Networks and Systems (DCNS), Informatics Devices (DID), Microinformatics and Automata Theory (DMAT), Software (DS), and Theory of Informatics (DTI).

The origins of the Institute can be found in the former Chair of Electrical Engineering Fundamentals at the Faculty of Electrical Engineering, where in 1956 a Division of Control Theory was created, headed by Dr Stefan Węgrzyn. The Division conducted research in the theory of automatic control and fundamentals of control and system design measurement. On October 18, 1961, the Division was transformed into the Chair of Control Theory and, at the same time, at the Faculty of Electrical Engineering a unit of Automatic Control was formed. That set the basis for the new Faculty of Automatic Control, formally established on December 30, 1963.

Originally, the research addressed automation, control theory and dynamics of electric circuits, but with time it evolved to new areas such as: analogue and digital technologies, digital systems, peripheral devices of digital systems, programming of digital systems, and many others. The worldwide and domestic regional developments in the area of computer science and industrial automation caused the issues of control systems design and programming for digital systems to become the main target of scientific and educational activities of the Chair, which in turn led to renaming the Faculty to the Faculty of Automatic Control and Computer Science on June 26, 1972, and starting a new course programme in computer science.

On September 18, 1975, the Institute of Real-Time Computer Science was founded, which performed its teaching and research activities until 1977, when the Faculty of Automatic Control and Computer Science was reorganised once again through the integration of the Institute (Professor S. Węgrzyn as the Director) with part of the Institute of Industrial Automatic Control and Measurement (Professor Jerzy Siwiński as the Director).

In 1984 the Faculty changed its name into the Faculty of Automatic Control, Electronics and Computer Science, and the Institute of Real-Time Computer Science into the Institute of Informatics, which better corresponded to their research areas.

From 1994 until 2000 Professor Andrzej Grzywak was the Director of the Institute and during this time the scientific research topics widened, including computer networks, databases, multimedia systems, and computer systems security. This was in turn reflected in the changes of teaching programmes, curricula and the introduction of specialisations. Since the year 2000 the Director of the Institute has been Professor Stanisław Kozielski, who is specialising in databases and computer architecture.
In May 2009, the Faculty of Automatic Control, Electronics and Computer Science obtained accreditation for the following five years entitling the Faculty to lead the studies in the field of informatics which are within the range of responsibility of the Institute of Informatics. The accreditation was issued by the State Accreditation Committee which is the state body evaluating the quality of teaching and verifying compliance with the requirements for higher education degree programmes.

In 2013, the Faculty of Automatic Control, Electronics and Computer Science received the highest possible evaluation from the Polish Accreditation Committee. The evaluation covered Faculty development strategy, an internal system of quality assurance, the level of scientific research, national and international cooperation, training of Ph.D. and postgraduate students, material resources and a system of financial support for students and doctoral students. This is another extremely high evaluation of the activities of the Faculty, following recently granted scientific category (A) by the Research Units Evaluation Committee.

The educational activity of the Institute comprises several types of studies: undergraduate or 1st level (B.Sc.), graduate or 2nd level (M.Sc.), and postgraduate or 3rd level (Ph.D.), led either as stationary full-time or part-time studies. At present the number of students of computer science at the 1st and 2nd level, for both full-time and part-time studies, reaches almost 1,400.

Thanks to the modern curriculum of studies and modern equipment of laboratories, a graduate of the Computer Science faculty is prepared for construction, design and research works in all industry branches that use computers, in particular in the electronic computer industry and its various applications, especially those which require deep knowledge of computer science. The studies give scientific, theoretical and experimental foundations needed for the software design, construction and exploitation of microcomputers, computers, large computer systems and computer networks. Graduates can be employed in research centres, in institutions and firms that create and use computer hardware or software, in design companies that develop projects on the computerisation of certain aspects of life, in specialised computer science domains of the majority of modern institutions, in computing centres, and in scientific research institutions of various industrial branches. They may also find jobs in secondary schools and posts in the Polish Academy of Sciences leading work in the field of construction, programming, and new applications of computers.

In the year 2007 teaching activities performed by the Institute of Informatics underwent a significant change in order to make them follow the Bologna Declaration principles, which required reorganisation of existing programmes which were valid for students who started their education before October 1, 2007. This date symbolically divides programmes of teaching into two categories: with partial concordance with Bologna strategy (for students starting their education before that date) and fully concordant with Bologna Declaration (for students starting in 2007 and after). Obviously the older programmes lost their validity with graduation of students following them.

The Institute of Informatics organises two international scientific conferences each year, which are: Conference Beyond Databases, Architectures and Structures and Com-
puter Networks. Additionally, since 2009, there is organised biannually the International Conference on Man-Machine Interactions.

The Institute of Informatics is active in cooperation with other institutions, both domestic, such as significant companies of the southern Poland like Comarch, and international like IBM and Microsoft. The scientific staff of the Institute takes part in the European projects. The exchange programme and scientific cooperation with various universities abroad is also kept and developed.

Over the last two years there were performed research works within six international research projects, there was conveyed works concerning ten grants awadred by Polish Ministry of Higher Education (two grants), National Centre for Research and Development (one grant), National Science Centre (four grants), and three Rector’s grants. Moreover, there was co-operation within nine grants led by other Polish institutions. There were also executed research activities within general and individual statutory projects. The total number of publications by staff members of the Institute was 368. The number of the Ph.D. degrees conferred was twenty-one, seventeen out of this number being staff members of the Institute. There was also conferred nine D.Sc. degrees.
Organisational structure of the Institute

The structure of the Institute can be presented in a diagram as follows:

Director of the Institute:
Stanisław Kozielski, Ph.D., D.Sc., Professor
Vice-Director of the Institute for Research:
Tadeusz Czachórski, Ph.D., D.Sc., Professor
Vice-Director of the Institute for Teaching:
Krzysztof Tokarz, Ph.D.
Director of the Institute
and Head of Division of Theory of Informatics

Stanislaw Kozielski received his M.Sc., Ph.D., and D.Sc. degrees from the Faculty of Automatic Control, Silesian University of Technology in 1971, 1977, and 1988 respectively. His D.Sc. monograph concerns the design of relational databases. He received the title of Professor of technical sciences in 1997.

He had been a Vice-Dean and then the Dean of the Faculty of Automatic Control, Electronics and Computer Science at SUT. He has been the Head of Theory of Informatics Division for many years and the Director of the Institute of Informatics at SUT since 2000. He is a member of two research councils and a member of Informatics Committee of Polish Academy of Sciences. He is the Chair of the Programme Committee of the international conference Beyond Databases and Systems (BDAS). He was an editor for Silesian University of Technology Press (Wydawnictwo Politechniki Śląskiej) for the Institute of Informatics.

Professor Kozielski conducts research in the areas of databases, computer architecture, and parallel and distributed processing. He is an author, co-author and editor of four books, five academic books, and over sixty scientific papers on these subjects.

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Tadeusz Czachórski received his M.Sc., Ph.D., D.Sc. degrees in informatics respectively in 1972, 1979, 1988, and Professor title in 1999. Currently he is a Professor at the Silesian University of Technology (Division of Computer Systems Theory and Design) and the Director of the Institute of Theoretical and Applied Informatics of Polish Academy of Sciences, Gliwice.

He spent more than five years at several French universities and research institutes (IRISA, University of Versailles, Paris-Sud, Paris-Nord, National Institute of Telecommunication) and still maintains scientific cooperation with these centres. He also participates in Next Generation Internet European project concerning such issues as multiservice-multimedia, mobility, services convergence, quality of service and variable connectivity, where he is co-responsible for the work package concerning analytical, numerical and simulation methods to model performance of the Internet.

Professor Czachórski is a member of programme committees of some periodic international and national conferences, e.g., Heterogeneous Networks HET-NETS, EuroNGI Next Generation Internet Design and Engineering, Polish Symposium of Teletraffic, Computer Networks, Internet in the Information Society. 1990 – 2007 he was scientific secretary of the Committee of Informatics of Polish Academy of Sciences, 2007 – 2011 vice-president of this committee, currently he is a member of presidium and head of the section of computer networks of the committee.

His scientific interests are in mathematical methods and software related to modelling and performance evaluation of wide area computer networks, especially the Internet. The methods include diffusion approximation and fluid flow approximation, which are well suited to analyse behaviour of networks and are applied to study the performance of control mechanisms. Another approach adapts Markov chains to model computer networks. These and other methods are used to model the traffic and control mechanisms assuring proper transmission parameters and quality demanded by users. Professor Czachórski is the author of over a hundred articles concerning these issues.

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Vice-Director of the Institute for Teaching and Vice-Dean of the Faculty of Automatic Control, Electronics and Computer Science and Head of Division of Microinformatics and Automata Theory

Krzysztof Tokarz received his M.Sc. and Ph.D. degrees in computer science from the Silesian University of Technology in 1996 and 2005 respectively. Currently he is an Assistant Professor and from September 1, 2006, Head of Division of Microinformatics and Automata Theory. From April 1, 2012 he is Vice-Director of the Institute for Teaching and from September 24, 2013 Vice-Dean for Organisation and Development of the Faculty of Automatic Control, Electronics and Computer Science.

His Ph.D. dissertation addresses the issues of IrDA protocol characteristics in the environment of microcontrollers. His research interests are in programming microprocessors and embedded systems, GNSS navigation systems, in-door navigation systems, wireless computer networks, infrared data transmission, implementation of wireless communication protocols and e-Learning. He is the author and co-author of many projects and successful implementations as well as around thirty publications including articles in journals and conference proceedings. Doctor Tokarz has supervised almost fifty M.Sc. theses.

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Head of Division of Computer Graphic, Vision and Simulation

**Andrzej Polański** received his M.Sc., Ph.D., and D.Sc. degrees in technical sciences from the Silesian University of Technology, in 1982, 1990, and 2000 respectively. In 2003 he received the Professor title. From 1990 to 2006 he worked as an Associate Professor and then Professor at the Institute of Automatic Control. In 2006 he has joined the Institute of Informatics (Division of Computer Systems Theory and Design).

From 2007 he has been the head of the Ph.D. studies at the Faculty of Automatic Control, Electronics and Computer Science, SUT. He also holds a position at the Polish-Japanese Institute of Information Technology, Faculty of Informatics, Bytom. Professor Polański in 2013 together with Professor Konrad Wojciechowski formed a new division in the Institute of Informatics (Division of Computer Graphics, Vision and Simulation).

He spent more than three years at scientific institutions and universities in Houston, US, where he worked as a Postdoctoral Fellow at the University of Texas, Health Science Centres at Houston, Graduate School of Biomedical Sciences, Genetics Centres and a Visiting Professor at the Department of Statistics, Rice University.

His main area of scientific interest is bioinformatics. His ongoing scientific research includes normalisation and preprocessing of DNA microarray and proteomic data, problems of clusterisation and classification based on DNA microarray data and proteomic spectra, pattern search in biological sequences, mathematical modeling in population genetics including genetic drift, mutation, selection and recombination, and methodologies of analysis of transcriptome dynamics. He is maintaining scientific collaboration with scientific groups in bioinformatics, clinical medicine, biology and biochemistry, in Poland and also Germany, the Netherlands, France, the UK, US. He is the author and co-author of more than a hundred scientific publications including the book: A. Polanski and M. Kimmel, *Bioinformatics*, Springer-Verlag, Berlin Heidelberg, Germany, 2007.

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Head of Division of Computer Networks and Systems

Andrzej Chydzinski received his M.Sc. degree (with honours) in mathematics in 1997, and his Ph.D. and D.Sc. degrees in informatics in 2002 and 2008, respectively. In 2015 he received the Professor title from President of the Republic of Poland and he is currently the youngest professor with the title at the Faculty. Currently he is a professor at the Institute of Informatics and the head of new division: Division of Computer Networks and Systems. His scientific interests are in computer networking, particularly in mathematical modelling and performance evaluation of computer networks, Future Internet design, queueing models, discrete event network simulators and active queue management in Internet routers. He has participated in several research projects, in four of them as the project leader. He authored and coauthored four books and about ninety journal and conference papers. His works are widely cited (about 800 times according to Google Scholar).

He serves as a reviewer for several high-quality journals, such as *Telecommunication Systems*, *Performance Evaluation*, *Queueing Systems*, *Mathematical Problems in Engineering*, *Applied Mathematical Modelling*, *Annals of Operations Research*.

In 2007 he received the prestigious award "Stay with us" from POLITYKA magazine.

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Head of Division of Informatics Devices

Andrzej Kwiecien received his M.Sc., Ph.D., and D.Sc. degrees in electrical engineering and informatics from the Silesian University of Technology. He is a Professor at SUT (Division of Informatics Devices).

Professor Kwiecien closely cooperates with many branches of industry. He has more than 30 medium and high scale applications of computer systems in Polish industry. In 1998 he was a leader of research group of a grant Communication networks—bus controller of FIP network. Hardware and Software from the Ministry of Science and Higher Education. The practical results of this grant led to production process in ZEG factory in Tychy. He received an international certificate for FIP board from ALSTOM (CEGELEC) Company. Together with his team he won the first place on International Software Fair Softarg’94 (Computer control system of treatment water station for electricity plant in Czech Republic).

Professor Kwiecien is a member of programme committees of 4 scientific conferences. He has made numerous presentations at the scientific and technical conferences. He cooperates with foreign universities as well as some companies. He has presented some lectures (Industrial Computer Networks, Distributed Industrial Systems) at the University of Ingolstadt, Germany. He has participated in many international seminars at General Electric and ALSTOM (CEGELEC) Company.

His current interests are in distributed real-time systems, visualisation of technological industry processes, deterministic industrial computer networks and methods of design of computer industrial systems. He is an author of a monograph Analysis of information flow in industrial computer networks (Studia Informatica, Silesian University of Technology Press (Wydawnictwo Politechniki Śląskiej), Gliwice, 2002), a book titled Time data flow analysis in industrial computer networks (PKJS Publishers, Gliwice, 1999), co-author, editor and co-editor of 9 books, 3 other academic books and many scientific articles.

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Przemysław Szmal received his M.Sc. and Ph.D. degrees in informatics from the Silesian University of Technology respectively in 1973 and 1984. His Ph.D. thesis was devoted to problems of syntax error correction in computer software. In 1992 he was for 3 months a Visiting Professor at the University of Sciences and Technologies of Lille, France. He is the author or co-author of over fifty technical papers in journals and conference proceedings.

His research interests are related to software visualisation, software engineering, and natural language engineering. He also has experience in compiler construction. He has been involved in numerous statutory projects conducted at the Institute of Informatics and several scientific projects financed by the former State Committee for Scientific Research and - directly or indirectly - by the Ministry of Science and Higher Education. His most significant project has been Thetos, focused on translation of Polish texts into the Polish Sign Language.

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Faculty Professors

Apart from Professor Stanisław Kozielski (the Director of the Institute and Head of the Division of Theory of Informatics, see page 9), Professor Tadeusz Czachórski (Vice-Director for Research, see page 10), Professor Andrzej Polański (Head of Computer Graphic, Vision and Simulation, see page 12), Professor Andrzej Chydzinski (Head of Division of Computer Networks and Systems, see page 13) and Professor Andrzej Kwiecień (Head of the Division of Informatics Devices, see page 14), within the Institute of Informatics seven other Professors or Associate Professors work and perform their scientific and educational activities, which together accounts to the total of twelve faculty Professors.
Krzysztof A. Cyran has received at the Silesian University of Technology (SUT) his Ph.D. degree (with honors) in technical sciences (2000) and his D.Sc. degree (habilitation) in technical sciences with speciality in computer science (2012). His Ph.D. dissertation addresses the problem of image recognition with the use of computer generated holograms applied as ring-wedge detectors and his D.Sc. dissertation concerns, among other, various methods of artificial intelligence and machine learning in knowledge acquisition and processing. He has been an author and co-author of more than 100 publications, including technical papers in journals (several of them indexed by Thomson Scientific), conference proceedings and monographs with total number of citations exceeding 200. Since 2012 he is an Associate Professor in the Institute of Informatics at SUT. Prof. Cyran (in 2003–2004 and 2012–2013) was a Visiting Scholar in Department of Statistics at Rice University in Houston, USA. He was the Vice-Head of the Institute of Informatics at SUT, currently he is the Director of Virtual Flying Laboratory created at SUT as his initiative. His experience and current research interests include image recognition and processing, artificial intelligence and knowledge acquisition, decision support systems, bioinformatics, aviation and aeronautics. Prof. Cyran has been involved in numerous scientific grants awarded in Poland as well as European projects within the 7th Framework Program (7FP) of the European Union. In particular, he is the researcher in the ArSInformatiCa project, and coordinator in the EGALITE project, funded under Industy - Academia Partnership and Pathways scheme and implemented in a collaboration of SUT with commercial companies from Barcelona and Vienna. He is also local coordinator and Scientist in charge in SHERPA and HEDGE NEXT, the two others 7FP projects related to application of ICT in aviation, implemented in large European Consortia.

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Zbigniew J. Czech received his M.Sc., Ph.D., and D.Sc. degrees respectively in 1970, 1974, and 1985 in computer science from the Silesian University of Technology. In 1996 he received Professor title in technical sciences. Since 1970 he has been a member of the Faculty of Automatic Control, Electronics and Computer Science at SUT (Division of Software).

In 1983–84 he was a Visiting Scholar at the University of York in the UK; in 1988 - a Visiting Professor at the University of California, Santa Barbara, US; in 1988–89 - a Visiting Professor at the Indiana-Purdue University in Indianapolis, US; in 1994 - a Visiting Professor at the University of Queensland, Australia; in 1995 - a Visiting Professor at the University of Kent, Canterbury, the UK.

His current educational and scientific interests are in analysis and design of algorithms (with issues of computational complexity and visualisation) and parallel computing. He is the author and co-author of over a hundred papers and books and a member of programme committees of several international conferences. Over ten Ph.D. theses have been prepared under his supervision.

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Sebastian Deorowicz received his M.Sc., Ph.D., and D.Sc. degrees in computer science from the Silesian University of Technology in 1998, 2003 and 2011 respectively. Currently he is a Professor at the Silesian University of Technology in the Division of Software. His scientific interests are in sequence analysis, textual algorithms, data compression, massive parallel computations, and bioinformatics. He has participated in several research projects. He has authored and co-authored four books and more than forty journal and conference papers, about 30 of them indexed in Journal Citation Reports. His works are widely cited—about 200 times in ISI-listed journals. He has served as a reviewer for several high-quality journals, such as *Theoretical Computer Science, Information Processing Letters, BMC Bioinformatics, Fundamenta Informaticae*.

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Bolesław Pochopień received the M.Sc. degree in automatic control from the Silesian University of Technology in 1970. His Ph.D. and D.Sc. degrees in automatic control and theory of switching circuits were also conferred by the SUT, in 1974 and 1988 respectively. He received the Professor title in 2005. He is a staff member of Automatic Control, Electronics and Computer Science Faculty of the SUT (Division of Microinformatics and Automata Theory).

From 1990 till 1996 Professor Pochopień was the Vice-Rector for Education of the SUT, and later from 1996 until 2002 he was the Rector of the University. Since 2003 he has also been a Professor at the Academy of Business in Dąbrowa Górnicza.

His current educational and scientific interests are in informatics and automatic control, in particular theory and implementation techniques of logic circuits and arithmetic of logic systems.

He is the author and co-author of numerous monographs, books and handbooks, such as: Digital systems (Silesian University of Technology Press (Wydawnictwo Politechniki Śląskiej), Gliwice, 1980), Switching circuits in industrial automatic control (WNT, Warsaw, 1981), Industrial automatic control for electronic engineers (WNT, Warsaw, 1987), Automatic control elements and devices. Guidebook for automatic control technician (WNT, Warsaw, 1987), Automatic control of industrial processes (WNT, Warsaw, 1988), Modular microcomputer systems (WNT, Warsaw, 1989), Arithmetic processors (WNT, Warsaw, 1993), Digital circuits. Theory and examples (Silesian University of Technology Press (Wydawnictwo Politechniki Śląskiej), Gliwice, 1995), Arithmetic in digital systems (EXIT Publishers, Warsaw, 2004), Theory of Logic Circuits (Silesian University of Technology Press (Wydawnictwo Politechniki Śląskiej), Gliwice, 2007). He is also a co-author of many publications in journals and conference proceedings. Under his supervision several doctoral theses have been written.

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Marek Sikora received his M.Sc. Degree in mathematics in 1993, and his Ph.D. and D.Sc. degrees in informatics in 2002 and 2014, respectively. Currently he is an associate professor at the Silesian University of Technology, Gliwice (Institute of Informatics - Division of Computer Networks and Systems) and associate professor at the Institute of Innovative Technologies EMAG, Katowice.

His scientific interests are in data mining, machine learning, decision support systems, particularly in rule induction and evaluation, application of classification and regression models in industry (e.g. mining industry).

He has participated in several R&D projects, in three of them as the project leader. He authored and co-authored about eighty scientific papers. His works are cited over 250 times according to Google Scholar (60 by Web of Science). He serves as a reviewer for several high-quality journals, such as Information Sciences, Applied Soft Computing, Computational Intelligence, Knowledge Based Systems. Professor Sikora is a member of programme committees of some periodic international and national conferences e.g. International Symposium Advances in Artificial Intelligence and Applications (FedCSIS conference), Joint Rough Set Symposium, Beyond Databases Architectures and Structures. He is also editor-in-chief in Mining - Informatics, Automation and Electrical Engineering journal.

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Katarzyna Stąpor received her M.Sc. degree in technical and mathematical sciences (1992, 2002), Ph.D. D.Sc. and Professor degrees in computer science from Silesian University of Technology, Gliwice, Poland (1994, 2001 and 2006, respectively). Since 1992 she has been working at the Institute of Informatics, Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology in Gliwice. She has published over 80 publications including one book on the Prolog programming language (E. Gatnar, K. Stąpor: Prolog - a language of artificial intelligence, in Polish, PLJ Publishers, Warsaw, 1992), one book on software engineering methodologies (P. Fuglewicz, K. Stąpor, A. Trojnar: CASE for people, in Polish, LU-PUS, Warsaw, 1995), one monograph on pattern recognition (K. Stąpor: Pattern Classification Methods in Computer Vision, in Polish, PWN, Warsaw, 2011) and handbook Statistical methods for students of computer science, in Polish, Silesian University of Technology Press, Gliwice, 2008. She is the co-author of the integrated information management systems and the classification system supporting glaucoma diagnosis in ophthalmology. Her current research focuses on statistical pattern recognition, machine learning, computer vision and bioinformatics. Prof. Stąpor is the member of Advisory Board of the Machine Graphics and Vision journal published by Polish Academy of Sciences and the member of Editorial Board of Bio-Algorithms and Med-Systems journal edited by Medical College, Jagiellonian University. Prof. Stąpor is the member of program committees of several conferences and the supervisor of six doctoral dissertations.

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Konrad Wojciechowski received the M.Sc. degree in electrical engineering from the AGH University of Science and Technology, Cracow, in 1967 and his Ph.D. and D.Sc. degrees in control theory from the Silesian University of Technology in 1976 and 1991 respectively. He joined the Faculty of Automatic Control, Electronics and Computer Science, SUT in 1968 as a Ph.D. student, in 1976 he became an Assistant Professor, Professor of the SUT in 1991, and received the Professor title in 1999. In 1995 he joined the Institute of Theoretical and Applied Informatics, Polish Academy of Sciences, Gliwice, and in 2003 Polish-Japanese Institute of Information Technology. In 1996–2002 he was a Vice-Dean of the Faculty of Automatic Control, Electronics and Computer Science. In 2004 he joined the Institute of Informatics, (Division of Computer Systems Theory and Design). Professor Wojciechowski in 2013 together with Professor Andrzej Polański formed a new division in the Institute of Informatics (Division of Computer Graphics, Vision and Simulation). Professor Wojciechowski is the Head of Laboratory of Computer Vision and Laboratory of Geoinformatics and the Chair of postgraduate studies in “Spatial Information Systems”. He has been a director of Summer School on Morphological Image and Signal Processing, a member of programme committees of numerous conferences and the Chair of International Conference on Computer Vision and Graphics in 2002, 2004, and 2006. He is on the board of Association for Image Processing, a member of International Association for Pattern Recognition and a member of Polish Electrical Engineering Society.

His research interests are in linear and nonlinear control theory, adaptive control, image processing and pattern recognition, neural networks, computer vision, spatial information systems and computer graphics, animation and games. He has been awarded by the Rector of SUT for scientific results and received an Award of the Ministry of Science and Higher Education. He has published 170 papers in refereed journals and conference proceedings on control theory, image processing and computer vision. He was a supervisor of 20 Ph.D. dissertations in field of computer vision and graphics and a reviewer of 38 dissertations.

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Divisions of the Institute

The Institute of Informatics consists of six divisions:
- Computer Graphic, Vision and Simulation (DCGVS),
- Computer Networks and Systems (DCNS),
- Informatics Devices (DID),
- Microinformatics and Automata Theory (DMAT),
- Software (DS),
- Theory of Informatics (DTI).

Division of Computer Graphics, Vision and Simulation (DCGVS)

At the end of the year 2015 the research staff of the Division of Computer Graphics, Vision and Simulation (total of 18) consisted of 2 Professors, one person with D.Sc., 5 people with the Ph.D. degree, and 10 with the M.Sc. degree. They conduct research and projects in the fields of advanced computer graphics, digital geometry processing, bioinformatics, and artificial intelligence. The general statutory research projects concerned development of appropriate algorithms related to the topic of acquisition, storage, analysis and synthesis of multimedia data. Processed data are used in games, virtual and augmented reality. There were also 5 statutory projects for young scientists. The total number of publications in journals and on international and national conferences in 2014 and 2015 accumulates to more than 80.

Research staff

- **Head of the Division**: Andrzej Polański, Ph.D., D.Sc., Professor
- Konrad Wojciechowski, Ph.D., D.Sc., Professor
- Adam Świtoński, Ph.D., D.Sc.
- Henryk Josiński, Ph.D.
- Ewa Lach, Ph.D.
- Przemysław Skurowski, Ph.D.
- Ewa Starzewska-Karwan, Ph.D. (till September, 2014)
- Agnieszka Szczeńsna, Ph.D.
- Przemysław Pruszowski, M.Sc.
Ph.D. students

- Mateusz Garbulowski, M.Sc. (since October, 2014)
- Kamil Lebek, M.Sc.
- Wojciech Łabaj, M.Sc.
- Daniel Krasnokucki, M.Sc.
- Agnieszka Michaczuk, M.Sc. (since October, 2014)
- Damian Pęszor, M.Sc.
- Marcin Paszkuta, M.Sc.
- Karol Trzcionka, M.Sc. (since October, 2015)
- Kamil Wereszczyński, M.Sc. (since October, 2014)

Division of Computer Networks and Systems (DCNS)

In September 2015 the Division of Computer Systems Theory and Design, DCSTD, has transformed and take a new name: Division of Computer Networks and Systems (DCNS). The research staff (total of 11) of the Division of Computer Networks and Systems at the end of 2015 consisted of 3 Professors, 6 people with the Ph.D. degree, and 2 with the M.Sc. degree. They conduct research and projects reflected in publications in journals and on international and national conferences in the fields of bioinformatics, computer networks, wireless networks, performance evaluation of computer networks, queueing systems, traffic modeling, advanced computer graphics, multimedia systems, rough sets and data mining.

Research staff

- **Head of the Division**: Andrzej Chydziński, Ph.D., D.Sc., Professor
- Tadeusz Czachórski, Ph.D., D.Sc., Professor
- Marek Sikora, Ph.D., D.Sc., Professor at SUT
- Błażej Adamczyk, Ph.D.
- Arkadiusz Biernacki, Ph.D.
- Agnieszka Brachman-Piotrowska, Ph.D.
- Aleksandra Gruca, Ph.D.
- Marcin Michalak, Ph.D.
- Michał Staniszewski, Ph.D. (till July, 2015)
- Ryszard Winiarczyk, Ph.D. (till September, 2015)
- Robert Wójcicki, Ph.D.

Ph.D. students

- Monika Nycz, M.Sc.
- Dominik Samociuk, M.Sc. (since October, 2014)
Technical and administrative staff

- Krzysztof Głuch, M.Sc.

Division of Informatics Devices (DID)

At the end of the year 2015 the Division of Informatics Devices consisted of one Professor, 12 people with Ph.D. degree, and 5 with M.Sc. degree. The DID realizes and encourages research, applied projects and courses through publications, conferences, joint research, international cooperation and student exchange. The Division carries on didactic and scientific activities in such areas as industrial informatics (design of systems, devices, and software), computer networks, embedded systems, computer peripherals and mobile technology.

The Division participates in European projects: IAPP Project 'AutoUniMo' and 'MEDUSA', completed grant awarded by the Ministry of Science and Higher Education: 'Compatibility Laboratory at Silesian University of Technology'. The Division again started Postgraduate Studies: Computer Networks and Systems, Databases.

Within the students programme framework of international faculty exchange there were arranged visits of teachers and students to the University of Applied Sciences Ingolstadt, Germany.

With the participation of members of the Division two scientific conferences were organized: the 21st and 22nd Conference on Computer Networks (2014, 2015).

Research staff

- **Head of the Division**: Andrzej Kwiecień, Ph.D., D.Sc., Professor
  - Dariusz Caban, Ph.D.
  - Rafał Cupek, Ph.D.
  - Adam Domański, Ph.D.
  - Jarosław Flak, Ph.D.
  - Piotr Gaj, Ph.D.
  - Michał Maćkowski, Ph.D.
  - Wojciech Mielczarek, Ph.D.
  - Krzysztof Skoroniak, Ph.D. (till June, 2014)
  - Mirosław Skrzewski, Ph.D.
  - Piotr Stera, Ph.D.
  - Jacek Stój, Ph.D.
  - Stanisław Widel, Ph.D.
  - Adam Ziębiński, Ph.D.

Ph.D. students

- Łukasz Herb, M.Sc.
- Łukasz Huczała, M.Sc. (since September, 2014)
• Damian Karbowiak, M.Sc.
• Filip Kłębczyk, M.Sc. (till September, 2014)
• Damian Kusnik, M.Sc.
• Michał Sawicki, M.Sc.

Technical and administrative staff
• Piotr Brzoza, M.Sc.
• Aleksander Cisek, M.Sc.
• Małgorzata Gladysz

Division of Microinformatics and Automata Theory (DMAT)

Staff members of the Division at the end of 2015 included two Professors, one person with D.Sc. degree, 7 people with the Ph.D. degree, and 2 with the M.Sc. degree. The Division carries on didactic and scientific activities presenting and publishing results of performed research. Within the total number of 36 publications of the years 2014—2015 there were edited monographs with articles presented at conferences, one book, and some number of articles in journals as well as conference proceedings, dedicated to logic circuits fundamentals and arithmetic (2), robotics (3), computer assisted learning and design of logic and microprocessor systems (1), computational intelligence (14), bioinformatics (5), transmission and protocols in wired and wireless networks (2), virtual reality (2), aviation (7). In 2014 and 2015, the Division participated in two projects cofinanced by European Union Seventh Framework Programme, general statutory projects concerned deployment of systems using computational intelligence, computer simulations in population genetics research, computer-based analysis and synthesis methods of digital and microprocessor systems, remote monitoring and control systems, and deployment of wireless segments in computer networks. There was also one individual statutory project.

Research staff

• **Head of the Division**: Krzysztof Tokarz, Ph.D.
• Bolesław Pochopień, Ph.D., D.Sc., Professor
• Krzysztof A. Cyran, Ph.D., D.Sc., Professor at SUT
• Bartłomiej Zielinski, Ph.D., D.Sc.
• Grzegorz Baron, Ph.D.
• Piotr Czekalski, Ph.D.
• Gabriel Drabik, Ph.D.
• Henryk Malysiak, Ph.D.
• Adam Opara, Ph.D.
• Tomasz Płuciennik, Ph.D. (till September, 2015)
Division of Software (DS)

At the end of 2015 the staff of the Software Division consisted of 2 professors, one person with D.Sc. and 14 people with the Ph.D. degree. There were also 12 Ph.D. students assigned to the Division. Didactic and scientific activities of the Division were dedicated to complex problem solving algorithms and optimization methods, data compression, software development methods, techniques, and tools, knowledge engineering, bioinformatics, natural language processing and communication, computer graphics and animation, computer vision and image recognition, as well as to methods of information representation. In 2014 and 2015, the Division participated in 2 research grants awarded by the Ministry of Science and Higher Education and in 4 grants awarded by the National Centre for Research and Development. The general statutory research projects concerned complex computational problems, software visualization, computer analysis and translation of inflective languages, software for the Internet, and problems of computer graphics. There were also 7 statutory projects for young scientists.

Research staff

- **Head of the Division**: Przemysław Szmal, Ph.D.
- Zbigniew J. Czech, Ph.D., D.Sc., Professor
- Sebastian Deorowicz, Ph.D., D.Sc., Professor at SUT
- Michał Kawulok, Ph.D., D.Sc.
- Agnieszka Danek, Ph.D. (since May 2015)
- Agnieszka Debudaj-Grabysz, Ph.D.
Ph.D. students

- Maciej Długosz, M.Sc.
- Adam Dyrek, M.Sc. (since October, 2014)
- Tomasz Drosik, M.Sc.
- Tomasz Herud, M.Sc.
- Tomasz Jastrząb, M.Sc.
- Marek Kokot, M.Sc.
- Grzegorz Kwiatkowski, M.Sc.
- Łukasz Lipka, M.Sc.
- Jakub Michulec, M.Sc. (till September, 2014)
- Jakub Nalepa, M.Sc.
- Krzysztof Pawelczyk, M.Sc. (since October, 2014)
- Daniel Pokusa, M.Sc. (till September, 2014)
- Paweł Sadowski, M.Sc.
- Piotr Sroczyński, M.Sc. (since October, 2014)
- Janusz Zientek, M.Sc. (till December, 2014)

Technical and administrative staff

- Katarzyna Chałubiec, M.Sc. (till June, 2014)
- Aleksandra Skórczyńska
- Helena Ślusarczyk (since July, 2014)

Division of Theory of Informatics (DTI)

At the end of the year 2015 the staff of the Division of Theory of Informatics consisted of 27 academic teachers, including 2 Professors (S. Kozielski, K. Stąpor), 1 person with D.Sc. degree (M. Gorawski), 17 workers with Ph.D. degree, and 7 with M.Sc. degree.
Scientific activity of the DTI members focused on the following research areas: distributed and parallel processing, cloud computing, diverse types of databases: object-oriented, distributed, multimedia, XML, NoSQL, in-memory, mobile, spatial and bioinformatic, data warehouses, data mining, query optimization, database structure design, integration of databases in heterogeneous computer network environment, modeling and simulation of dynamical systems, molecular systems of informatics, multi-agent systems, heuristic optimization algorithms, artificial intelligence, biometrics and computer vision.

In period 2014—2015 the DTI workers carried out several general statutory research projects addressing new methods, technologies and software tools for databases and data warehouses, taking the class of protected data warehouses into special consideration. The Division members also led or participated in three research grants cooperating in some cases with Polish and foreign companies. The research workers of the DTI prepared about 90 publications including articles in refereed journals as well as conference proceedings. Three scientific conferences were organised with the cooperation of the DTI members: 10th and 11th Conference on Databases: Applications and Systems (BDAS), and International Conference on Man-Machine Interactions (ICMMI).

Research staff

- **Head of the Division**: Stanisław Kozielski, Ph.D., D.Sc., Professor
- Katarzyna Stąpor, Ph.D., D.Sc., Professor
- Marcin Gorawski, Ph.D., D.Sc., Professor at Wroclaw University of Technology
- Dariusz Augustyn, Ph.D.
- Małgorzata Bach, Ph.D.
- Piotr Bajerski, Ph.D.
- Robert Brzeski, Ph.D.
- Adam Duszeńko, Ph.D.
- Jacek Frączek, Ph.D.
- Katarzyna Haręzłak, Ph.D.
- Paweł Kasprowski, Ph.D.
- Bożena Małysiak–Mrozek, Ph.D.
- Alina Momot, Ph.D.
- Dariusz Mrozek, Ph.D.
- Ewa Płuciennik, Ph.D.
- Jerzy Respondek, Ph.D.
- Robert Tutajewicz, Ph.D.
- Aleksandra Werner, Ph.D.
- Łukasz Wyciślik, Ph.D.
- Hafedh Zghidi, Ph.D.
Ph.D. students

- Marek Drewniak, M.Sc.
- Michał Drzewiecki, M.Sc.
- Anna Gorawska, M.Sc.
- Jakub Guziur, M.Sc.
- Krzysztof Pasterak, M.Sc.
- Grzegorz Powała, M.Sc.
- Szymon Ziemek, M.Sc. (foreign apprenticeship)

Technical and administrative staff

- Dorota Huget, M.Sc. in economics
- Jacek Pietraszuk, M.Sc.
Teaching activities

Teaching activities performed by the Institute of Informatics follow the Bologna Declaration principles. It was achieved by reorganisation of previously existing programs in academic years starting from October 1, 2007. Due to assure the highest standards of education, demanded by the Ministry of Science and Higher Education, the current curricula of studies are modified every few years and fulfil the National Qualifications Framework for Higher Education defined by the Ministry in 2011.

Bologna declaration

Joint declaration of the European Ministers of Education convened in Bologna on June 19, 1999, signed by 29 countries, is the basis for so-called Bologna process defining the European space for higher education. This is the document which has become very important for the organisation of studies in European countries. The following text defining briefly the goals of the Bologna Process is cited from the original declaration:

While affirming our support to the general principles laid down in the Sorbonne declaration, we engage in co-ordinating our policies to reach in the short term, and in any case within the first decade of the third millennium, the following objectives, which we consider to be of primary relevance in order to establish the European area of higher education and to promote the European system of higher education world-wide:

- Adoption of a system of easily readable and comparable degrees, also through the implementation of the Diploma Supplement, in order to promote European citizens employability and the international competitiveness of the European higher education system;

- Adoption of a system essentially based on two main cycles, undergraduate and graduate. Access to the second cycle shall require successful completion of first cycle studies, lasting a minimum of three years. The degree awarded after the first cycle shall also be relevant to the European labour market as an appropriate level of qualification. The second cycle should lead to the master and/or doctorate degree as in many European countries;

- Establishment of a system of credits - such as in the ECTS system- as a proper means of promoting the most widespread student mobility. Credits could also be acquired in non-higher education contexts, including lifelong learning, provided they are recognised by the receiving universities concerned;

- Promotion of mobility by overcoming obstacles to the effective exercise of free movement with particular attention to:
  - for students, access to study and training opportunities and to related services;
for teachers, researchers and administrative staff, recognition and valorisation of periods spent in a European context researching, teaching and training, without prejudicing their statutory rights;

- Promotion of European co-operation in quality assurance with a view to developing comparable criteria and methodologies;
- Promotion of the necessary European dimensions in higher education, particularly with regards to curricular development, inter-institutional co-operation, mobility schemes and integrated programmes of study, training and research.

We hereby undertake to attain these objectives - within the framework of our institutional competencies and taking full respect of the diversity of cultures, languages, national education systems and of University autonomy - to consolidate the European area of higher education. To that end, we will pursue the ways of intergovernmental co-operation, together with those of non governmental European organisations with competence on higher education.

We expect Universities again to respond promptly and positively and to contribute actively to the success of our endeavour.

Convinced that the establishment of the European area of higher education requires constant support, supervision and adaptation to the continuously evolving needs, we decide to meet again within two years in order to assess the progress achieved and the new steps to be taken.

Cycles of studies

In accordance with the fundamental principles of Bologna Declaration which constitutes basis for harmonic system of European Higher Education, the Institute of Informatics of the Silesian University of Technology like other prestigious European Universities offers three level studies in Computer Science:

- Undergraduate B.Sc. studies (i.e. 1st level studies),
- Graduate M.Sc. studies (i.e. 2nd level studies),
- Postgraduate or Doctoral Ph.D. studies (i.e. 3rd level studies).

Implementation of Bologna Declaration is reflected also in the following issues:

- Full support for the ECTS system of credits,
- Diploma Supplement for promotion employability on the European market,
- Quality Assurance guarantied by State Accreditation Committee,
- Promotion of mobility of students by conducting English language studies with specialisation in computer science,
- Scientific and research cooperation with European partners.

The current curriculum of computer science studies follows the principles of Bologna Declaration.

Undergraduate 1st level studies

At the undergraduate 1st level the Institute of Informatics offers 7-semester stationary or part-time studies.
7-semester full-time studies

Enrolling is conducted based on the number of points acquired in qualification procedure focused on mathematics skills.

The number of ECTS points for each semester is equal to 30. That makes in total 210 ECTS for the first level studies. The programme of these studies not only satisfies the requirements of programme minima as defined by the Ministry of Science and Higher Education in Poland, but as in other prestigious Universities it goes far beyond these minima giving the students opportunity for excellent education both from theoretical and practical perspectives. The programme offers a considerable number of facultative lectures, classes, laboratories and projects, as well as three specialisations:

- Computer Graphics and Software,
- Databases, Computer Networks and Operating Systems,
- Industrial Informatic Systems.

The choice of specialisation is made by a student after the 5th semester. The laboratory and project activities constitute substantial, and increasing from semester to semester, part of all activities within the programme. Studies are completed with B.Sc. diploma thesis, which together with B.Sc. exam is the ground basing on which the student can become an engineer in computer science. Additionally, it is the basis for the beginning of the 2nd level graduate M.Sc. studies.

7-semester part-time studies

Enrollment process employs qualification procedure in accordance with general requirements for undergraduate technical studies.

The number of ECTS points for each semesters is equal to 30. That makes in total 210 ECTS for first level studies, the same as for full-time studies. The programme of these studies satisfies the requirements of programme minima as defined by the MS&HE. The programme offers also some facultative lectures, laboratories and projects.

The number of hours dedicated to laboratory and project works increases with each semester and takes significant part of the curriculum. To complete the studies students are required to prepare B.Sc. diploma project and pass B.Sc. exam, which forms the basis to become an engineer in computer science. It also constitutes the starting point for the 2nd level graduate M.Sc. studies.

Graduate 2nd level studies

At the graduate 2nd level the Institute offers either 3-semester stationary full-time studies or 4-semester part-time studies. Furthermore, part-time studies are conducted on Friday evenings and Saturdays.

3-semester full-time studies

The number of ECTS points for each semester is equal to 30. That makes in total 90 ECTS for the second level studies. The programme of these studies goes far beyond the
programme minima defined by the MS&HE giving the students opportunity to learn both theoretical background and practical solutions. The programme of these studies offers six specialisations:

- Databases and System Engineering,
- Industrial Computer Systems,
- Information Systems in Aviation,
- Internet and Network Technologies,
- System Software,
- Three-Dimensional Interactive Graphics.

Apart from possibility of the choice of one out of six specialisations students have opportunity to choose according to their interests as much as 180 or more hours from the pool of facultative subjects (lectures, classes, laboratories and projects). Due to this, besides necessary for each computer scientist core curriculum of professional subjects, students can further develop those specialist areas, which they are especially interested in. The graduate studies are completed with M.Sc. thesis and M.Sc. exam.

4-semester part-time studies

The number of ECTS points for each semesters is equal to 30. During the final, fourth semester 20 of required 30 ECTS points are assigned to M.Sc. diploma thesis and seminar. That makes in total 120 ECTS for the second level studies. Apart from the core curriculum in concordance with MS&HE requirements, the programme of these studies offers also facultative courses.

Doctoral 3rd level studies

For both full-time and part-time studies the number of semesters usually varies from 6 to 8. The full-time doctoral students attend lectures one Saturday per month and are encouraged for intense discussion with their supervisors on individual meetings. Additionally, the full-time students take part in the educational process of the lower level studies, for which they receive a scholarship. Doctoral studies are completed with preparation of Ph.D. thesis and doctoral exam.

Scope of the four-year Ph.D. studies in the area of computer science includes three main topics: hardware, methods of development of algorithms and software, and Internet technologies and multimedia. The programme of Ph.D. studies consists mainly of monographic lectures related to the most important directions of development of contemporary informatics, in particular to scientific research carried out in the Institute of Informatics at the Silesian University of Technology.

Ph.D. students have their individual profile of lectures, chosen in consultation with Ph.D. scientific supervisor and the departmental coordinator of Ph.D. studies. Lectures can be chosen from the pool of all Ph.D. level lectures offered at the Faculty of Automatic Control, Electronics and Computer Science, SUT. According to the needs and possibilities new courses can be started. For some courses lecturers are professors invited from other universities or institutions.

34
Presentation of topics during the lectures is organised in such a way that possible developments of results or starting points for new research are highlighted. Ph.D. students are encouraged to join research projects carried out in the Faculty and/or to start their own research projects. Often, during lectures, there are discussed new problems which can become topics of Ph.D. theses.

Apart from lectures the programme of Ph.D. studies in computer science includes seminars. The seminar group for a Ph.D. student is chosen in consultation with Ph.D. supervisor and the departmental coordinator of these studies. During Ph.D. seminar, every Ph.D. student once in a semester should present directions of own research and interests and the advances in scientific work. Ph.D. students are also encouraged to organise journal club meetings devoted to presentation of most recently published scientific results, related to topics of their Ph.D. theses.

Seminars and lectures are obligatorily held in English if at least one participant is a foreign language speaker. However, other classes can be held in English as well based on the agreement between the students and a lecturer, in consultation with the departmental coordinator of Ph.D. studies.

In 2009 there was created a new specialisation for postgraduate studies in Data Mining. The courses include topics such as Artificial Neural Networks, Pattern Recognition and Data Mining Tools. During Ph.D. seminar there are discussed possible areas of research leading to dissertations, supervised within Ph.D. project.

Postgraduate studies

Postgraduate studies are conducted as weekend studies, mainly on Saturdays. They are organised in two semesters of classes and offered in five specialisation areas:

- Computer Networks and Systems, Databases,
- Internet and Mobile Technologies in Information System Design and Realisation,
- Methods of Exploration of Enterprises’ Databases,
- Production Management,
- Teleinformatics in Aviation.

Current curricula

At the time of publication of this Activity Report the curricula on each level of studies were fully concordant with principles of Bologna declaration.

Full-time, undergraduate studies

Within the current curricula 1st level undergraduate full-time studies comprise 7 semesters, including 2685 hours of lectures, table classes, projects, laboratory classes or seminars.

There are offered three specialisations:

- Computer Graphics and Software (CGS),
- Databases, Computer Networks and Operating Systems (DCNOS),
- Industrial Informatic Systems (IIS).
Therefore the curriculum consists of mandatory courses for all students which also include some variant courses of selectable scope, specialisation core curriculum courses, and facultative courses. The choice of a specialisation happens during the 5th semester and depending on that choice different courses are mandatory within the 6th semester. The culmination point of undergraduate studies is preparation of B.Sc. thesis and passing B.Sc. exam.

Courses are led by staff members of the Institute of Informatics or by academic teachers from other institutes or faculties of the Silesian University of Technology.

Facultative courses

Students of a specialisation can treat all courses of another specialisation core curriculum as facultative. Apart from that there are also available strictly facultative courses:

- Analytical Methods for Object-Oriented Design,
- Basics of Natural Language Processing,
- Computer Graphics (mandatory for CGS),
- Cryptography and Data Protection,
- Data Warehouses and Data Exploration Systems (mandatory for DCNOS),
- Design and Implementation of Local Area Networks
- Face Recognition and Biometrics,
- Fundamentals of Programming in LINUX,
- LabVIEW: Engineering Environment,
- Management of Mainframe Systems,
- Microprocessor and Embedded Systems (mandatory for IIS)
- MS SQL Server,
- Multimedia Embedded Systems,
- PLC Drivers (mandatory for IIS),
- Programming in Integrated Data-Processing System,
- Programming JAVA EE,
- Programming Mobile Devices,
- Programming Project (mandatory for CGS),
- Security of Computer Systems,
- Seminar for Solving Programming Problems,

Curriculum

Legend:
- L — Lecture
- T — Table classes
- A — Laboratory classes
- P — Project
- S — Seminar
- E — ECTS—European Credit Transfer System points (E in this column means Exam)
<table>
<thead>
<tr>
<th>Subject</th>
<th>Lectures (L)</th>
<th>Tutorials (T)</th>
<th>Practical/Projects (P)</th>
<th>Total Hours</th>
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<td>Physical Education</td>
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<td>2</td>
<td>7</td>
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<tr>
<td>English Language</td>
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<td>2</td>
<td>2</td>
<td>5</td>
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<tr>
<td>Calculus and Linear Algebra</td>
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<td>2</td>
<td>7</td>
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<tr>
<td>Statistical Methods</td>
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<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Physics</td>
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<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Fundamentals of Computer Programming</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Theory of Computer Science</td>
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<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Electronics and Measurement</td>
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<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Arithmetic of Digital Systems</td>
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<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Computer Organization and Embedded Systems</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Design of Digital Systems</td>
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<td>2</td>
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<td>6</td>
</tr>
<tr>
<td>Operating Systems—various course</td>
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<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Algorithms and Data Structures</td>
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<td>2</td>
<td>6</td>
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**Total Hours / Exams / Credits**

- Lectures: 120
- Tutorials: 120
- Practical/Projects: 120
- Total Hours: 360
- Exams: 120
- Credits: 120
Full-time, graduate studies

The second level graduate full-time studies are conducted within specialisations chosen by students during the last semester of undergraduate level of their studies for those students who want to continue their education by pursuing the M.Sc. degree. For them the preparation of B.Sc. theses and defending them within B.Sc. exam is the primary requirement to be included in enrolling procedures for graduate studies. Prospective students who have obtained their B.Sc. degrees elsewhere (that is from different faculty or university) have to pass successfully the procedure of confirmation of courses and ECTS points with regard to base requirements for graduate studies in computer science.

The whole curriculum for second level studies consists of:

- 495 hours of core curriculum courses, mandatory for all students regardless of their specialisation,
- 375 hours of specialisation core curriculum courses, obligatory for students of a specialisation, which can also be chosen as facultative courses by students from other specialisations,
- 180 hours of facultative courses.

Within the general organisation of courses for specialisation core curriculum and facultative courses only totals are presented as the number of hours, types of classes and ECTS points can vary depending on a particular choice.

The second level graduate full-time studies enable future graduates to broaden and deepen already possessed knowledge and specialization in the chosen field of computer science. It is provided by compulsory subject blocks for each specialisation, a large collection of facultative courses and preparation of Master’s thesis, which together with M.Sc. exam completes the studies. A subject of M.Sc. thesis can be chosen from those proposed by faculty members of the Institute of Informatics, or first proposed by a student and next confirmed by some faculty member who agrees to supervise it. Topics usually address these areas of science that students choose as their specialisation.

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Full-time, graduate studies curriculum
Core curriculum for all specialisations

Core curriculum of graduate studies comprises nine courses mandatory for all students regardless of their specialisation.

Specialisations

Second level graduate full-time studies are conducted within six available specialisations:

- Databases and System Engineering,
- Industrial Computer Systems,
- Information Systems in Aviation,
- Internet and Multimedia Systems,
- Internet and Network Technologies,
- System Software.

Each of these specialisations is characterised by a different focus of attention and profile of conducted courses. The detailed descriptions for all are given, specifying areas of knowledge and skills acquired by graduate students.

Specialisation core curricula courses

Each specialisation has some number of courses obligatory for students of this particular specialisation.

Facultative courses

Students of a specialisation can treat all courses of another specialisation core curriculum as facultative. Apart from that there are also available strictly facultative courses:

1. Business Project Management,
2. Coding Practice—Python,
3. Data Analysis Techniques in Statistica,
4. Data Compression Algorithms,
5. DBMS Oracle,
6. Development of Measuring–Control Applications in AGILENT VEE and LABVIEW Environments,
7. IBM DB2 Universal Platform for Data Processing,
8. Industrial Ethernet,
9. Organization and Development of Open Source Projects,
10. Programming Mobile Devices II,
11. Programming LEGO Mindstorms NXT Robot,
12. Web Applications Development - PHP, Python, Java Script,
13. Software Design of Control–Measuring Systems,
14. TeX, LaTeX, METAFONT—Typesetting and Text Processing Systems,
15. Utilisation and Programming in IBM POWER,
16. Vision Inspection Algorithms Implemented on Graphical Processors,
17. Wireless Computer Networks.
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Full-time, graduate studies curriculum—spec. Databases and System Engineering

### Databases and System Engineering specialisation

Databases and System Engineering specialisation joins education in two areas. The first area is connected with database management and design while the second concerns the problems of system engineering for large data storage necessary for data warehouses. Combination of these branches is a key issue for development of the information systems using web and mobile technologies commonly used in order to support organisational functioning in various areas of industry at the software and hardware level. The courses which are offered enable presentation of basic and advanced methods and technologies used for the analysis, design and management of both database and computer systems. Students are taught how to deal with the problems arising in medium and large software and hardware projects, issues of configuration, administration and usage of the leading industry database management systems, distributed systems, and advanced methods of data warehouse management.

There are several possible monographic courses to choose by the students of this specialisation:

1. Domain Databases,
2. Enterprise Management Systems,
3. High Performance Computer Systems,
4. Object-Relational Interfaces,
5. XML Technologies.

### Industrial Computer Systems specialisation

Computer systems for control, measuring, visualisation, collecting and processing data are present in many branches of industry and their work in real-time and with territorial
| No. | Subject                                                                 | Total hrs | L | T | A | P | S | E | Sem. 1 L | T | A | P | E | Sem. 2 L | T | A | P | E | Sem. 3 L | T | A | P | S | E |
| 1   | Analysis and Design of Information Systems                              | 60        | 30| 30|   |   |   |   | 2       | 2 | 2 |   |   | 3       |   |   |   |   | 2       | 2 | 2 |   |   | 3       |   |   |
| 2   | Computer Vision and Image Recognition                                    | 60        | 30| 15| 15|   |   |   | 2       | 1 | 3 |   |   | 1       | 2 | 3E |   |   | 2       | 3E |   |   |   |   |
| 3   | Digital Modelling                                                        | 90        | 45| 15| 30|   |   |   | 2       | 1 | 3 |   |   | 1       | 2 | 3E |   |   | 2       | 3E |   |   |   |   |
| 4   | Algorithms and Data Structures II                                       | 45        | 30| 15|   |   |   |   | 2       | 1 | 4E |   |   | 2       |   |   |   |   | 1       | 4E |   |   |   |   |
| 5   | Comp. Systems Performance Evaluation                                     | 30        | 15| 15|   |   |   |   | 2       | 1 | 2 |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 2       |   |   |
| 6   | Comp. Networks Performance Evaluation                                    | 30        | 15| 15|   |   |   |   | 2       | 1 | 2 |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 2       |   |   |
| 7   | Monographic course 1                                                     | 15        | 15|   |   |   |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 2       |   |   |
| 8   | Monographic course 2                                                     | 15        | 15|   |   |   |   |   | 2       |   |   |   |   | 1       |   | 2 |   |   | 1       |   | 2 |   |   | 2       |   |   |
| 9   | Humanities and social sciences                                           | 30        | 30|   |   |   |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |
| 10  | Economics                                                                | 30        | 30|   |   |   |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |
| 11  | Specialisation core curriculum courses                                  | 375       | 160| 30| 155| 30|   |   | 2       | 2 | 1 | 1 | 2 | 8E |   | 4 | 5 | 11E |   | 4 | 2 | 2 | 6 |
| a   | Systems and Control                                                      | 60        | 30| 15| 15|   |   |   | 2       | 1 | 2 |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |
| b   | Microprocessor Measurement Circuits                                      | 30        | 15| 15|   |   |   |   | 2       | 1 | 2 |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 2       |   |   |
| c   | Advanced Programming of Industrial Controllers                           | 60        | 15| 30| 15|   |   |   | 4       | 2 | 3E |   |   | 1       | 1 |   |   |   | 1       |   |   |   |   | 2       |   |   |
| d   | Industrial Processes Visualisation                                      | 30        | 15| 15|   |   |   |   | 2       |   |   |   |   | 1       |   | 1 |   |   | 1       |   | 1 |   |   | 2       |   |   |
| e   | Real-Time Industrial Systems                                            | 60        | 30| 30|   |   |   |   | 6       |   |   |   |   | 2       |   | 6E |   |   | 2       |   |   |   |   | 6       |   |   |
| f   | Embedded Systems Construction and Program                                | 45        | 15| 15|   |   |   |   | 2       |   |   |   |   | 1       |   | 2 |   |   | 1       |   | 2 |   |   | 2       |   |   |
| g   | Electromag. Compatibility of Computer Systems                            | 30        | 15| 15|   |   |   |   | 2       |   |   |   |   | 1       |   | 2 |   |   | 1       |   | 2 |   |   | 2       |   |   |
| h   | Industrial Computer Systems Design                                       | 15        | 15|   |   |   |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 1       |   |   |   |   | 1       |   |   |
| i   | Software Certification                                                   | 18        | 18|   |   |   |   |   | 18      |   |   |   |   | 18      |   |   |   |   | 18      |   |   |   |   | 18      |   |   |
| j   | Real-Time Operating Systems                                              | 45        | 30| 15|   |   |   |   | 2       |   |   |   |   | 2       |   | 1 |   |   | 2       |   |   |   |   | 1       |   |   |
| 12  | Foreign language                                                         | 60        | 60|   |   |   |   |   | 4       |   | 2 |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |
| 13  | Facultative courses                                                      | 180       | 90| 90|   |   |   |   | 12      |   |   |   |   | 6       | 6 | 12E |   |   | 6       | 6   | 12E |   |   | 6       | 6   | 12E |
| 14  | Diploma Thesis                                                           | 18        | 18|   |   |   |   |   | 18      |   |   |   |   | 18      |   |   |   |   | 18      |   |   |   |   | 18      |   |   |
| 15  | Diploma Seminar                                                          | 30        | 30|   |   |   |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |   |   | 2       |   |   |
| Total|                                                                         | 1050      | 525| 120| 330| 45| 30| 90| 15 | 6 | 7 | 1 | 30 | 13 | 2 | 13 | 0 | 30 | 7 | 0 | 2 | 2 | 30 |
| Total hours / Exams / Credits                                            |           | 29 | 3E | 9C |   | 28 | 3E | 5C |   | 13 | 0E | 7C |

Full-time, graduate studies curriculum—spec. Industrial Computer Systems

distribution is usually at the same time the fundamental requirement and a source of many design problems.

Within a project of some industrial system it is necessary to design the structure of distributed real-time system with programmable logic controllers working as nodes, a supervisory station including global access to the system from outside, and communication subsystems using industrial protocols allowing for deterministic access to the network. Furthermore, the project involves developing software for applied industrial embedded systems and all their elements, satisfying safety requirements and ensuring electromagnetic compatibility of equipment.

Graduates of the specialisation are qualified designers of small or large informatics industrial systems applied in different technologies and used within various areas of human activities, capable of finding solutions for both general purpose and customised systems.

### Information Systems in Aviation specialisation

Information System in Aviation specialisation is a response to the growing demand for aviation industry employees, which is currently very dynamically developing sector of the economy and as every modern field requires the support of various computer systems. The specialisation joins education in selected computer science areas with its application in specialized domain of aviation.

Graduates of this specialisation posses knowledge of the fundations of the aircraft, aerodynamics, flight physical basis and avionics theory. They have the skills in design and maintenance of computer networks for aviation needs, administrating such systems.
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Full-time, graduate studies curriculum—spec. Information Systems in Aviation

and working in various environments and on different operating systems. Moreover, the students are familiar with the concepts of aviation-related systems, such as satellite navigation systems (for instance GLONASS, GALILEO, EGNOS), goespatial information technology systems and are capable to exploit the acquired information in computer software they prepare during several project realized within the curriculum. A very important element of the curriculum are classes conducted in the Laboratory of Virtual Flying where on modern flight simulators, students are taught the principles of software development and simulation using three-dimensional graphics.

Internet and Network Technologies specialisation

The goal of this specialisation is to prepare the graduates to create and design software which ensures a desired level of multimedia systems quality working in the Internet environment. It prepares specialist who have the skills to deal with dangers threatening online users.

The block of mandatory subjects presents the knowledge of rules of individual layers of the communication protocols work, network architecture used by the Internet, and the software structure cooperating with the Internet. The audience gets familiar with rules regulating Internet transmission intensities, know how to avoid overloads, measure the transmission rate and interpret the results. The modeling of the network performance knowing its structure, problems arising when different transmission media, like optical networks or wireless, are presented in the courses. Moreover, the students have the skills to implement solutions prone to any dangers that threaten the Internet users. Since the multimedia are used extensively via the network, the techniques to stream multimedia information, design architecture and implement systems ensuring a given level of quality

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42
services, as well as methods of designing and assessing the effectiveness of multimedia systems are presented.

There are several possible monographic courses to choose by the students of this specialisation:

1. Future Internet Solutions,
2. IP Networks Efficiency Evaluation,
3. New Media and the Internet,
4. Online System Administration,
5. Social Networks and Data Mining,
6. Virtual Networks and Cloud Computing,
7. Web Application Technologies.

### System Software specialisation

System software performs functions necessary for a computer system to work. It comprises operating systems, server software, and any software out of direct contact with the end user. The specialisation enables mastering the working principles of system applications and acquiring skills in developing them. There are taken into account operating system mechanisms, techniques and forms of communication with the user, methods used to develop applications and tools serving this purpose, and some branches of algorithmics.

During the courses, modern environments and operating systems such as MS Windows, Unix, XWindow, and Symbian are considered and used and much attention is paid to the Internet as well as to the .NET technology. Among programming techniques, discussion covers object and parallel computing techniques as well as methods used in compiler construction. In the scope of programming languages used to build applications there are presented C++, C#, Java, Visual Basic, and Occam.
| No. | Subject                                                      | Total hrs | L | T | A | P | S | E | Sem. 1 | L | T | A | P | E | Sem. 2 | L | T | A | P | E | Sem. 3 | L | T | A | P | E |
| 1   | Analysis and Design of Information Systems                  | 60        | 30| 30| 3 | 2 | 2 | 3 | 2      | 2 | 1 | 1 | 5E |     |        | 1 | 2 |   | 3E |   |        |     |     |   |   |   |
| 2   | Computer Vision and Image Recognition                       | 60        | 30| 15| 15| 5 | 2 | 1 | 1E     | 4E |     |     | 3E |     |     |   |     |   |     |   |     |   |     |   |
| 3   | Digital Modelling                                           | 90        | 45| 15| 30| 6 | 2 | 1 | 3     | 1 | 2 |   | 3E |     |     |   |     |   |     |   |     |   |     |   |
| 4   | Algorithms and Data Structures II                          | 45        | 30| 15| 4 | 2 | 1 | 4E    |     |     |     |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 5   | Comp. Systems Performance Evaluation                        | 30        | 15| 15| 2 | 1 | 1 | 2     | 1 | 2 |   |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 6   | Comp. Networks Performance Evaluation                       | 30        | 15| 15| 2 | 1 | 1 | 2     | 1 | 2 |   |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 7   | Monographic course 1                                        | 15        | 15| 15| 2 | 1 | 1 | 2     |     |     |     |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 8   | Monographic course 2                                        | 15        | 15| 2 |   |   | 1 | 2     |     |     |     |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 9   | Humanities and social sciences                              | 30        | 30| 2 |   |   | 2 | 2     |     |     |     |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 10  | Economics                                                   | 30        | 30| 2 |   |   | 2 | 2     |     |     |     |     |     |     |     |   |     |   |     |   |     |   |     |   |
| 11  | Specialisation core curriculum courses                     | 375       | 180| 30| 165| 25| 1 | 2 | 5E     | 5 | 1 | 6 | 11E | 3 | 3 | 6     |     |     |     |     |     |     |
| a   | Introduction to Computers                                  | 60        | 30| 15| 15| 4 | 2 | 1 | 4E     |     |     |     |     |     |     | 1 | 2 | 3E |   |     |     |     |     |     |
| b   | Parallel Computing II                                      | 60        | 15| 15| 30| 3 |   | 1 | 2E     | 1 | 1 | 2 |     |     |     |     |   |     |     |     |     |     |
| c   | Methods and Tools of Software Production                   | 30        | 15| 15| 2 |   | 1 | 2     |     |     |     |     |     |     |     |   |     |     |     |     |     |
| d   | Practice of Impl. of Integrated Information Systems         | 45        | 30| 15| 4 | 2 | 1 | 4     |     |     |     |     |     |     |     |   |     |     |     |     |     |
| e   | Facultative monographic courses                            | 180       | 90| 90| 12 | 4 | 4 | 8     | 2 | 2 | 4 |     |     |     |     |   |     |     |     |     |     |
| 12  | Foreign language                                           | 60        | 60| 4 | 2 | 2 | 2 | 2     |     |     |     |     |     |     |     |   |     |     |     |     |     |
| 13  | Facultative courses                                        | 180       | 90| 90| 12 | 6 | 6 | 12E   |     |     |     |     |     |     |     |   |     |     |     |     |     |
| 14  | Diploma Thesis                                             | 0         | 18| 18| 18 | 18 |   |     |     |     |     |     |     |     |     |   |     |     |     |     |     |
| 15  | Diploma Seminar                                            | 30        | 30| 2 |   |   | 2 | 2     |     |     |     |     |     |     |     |   |     |     |     |     |     |
|     | Total                                                       | 1050      | 525| 360| 360| 90 | 14| 14 | 30     | 6 | 0 | 3 | 0 | 2 | 30    | 28 | 3E | 7C | 31 | 3E | 3C | 11 | 0E | 6C |

Full-time, graduate studies curriculum—spec. System Software

Knowledge and skills acquired by the graduates of this specialisation satisfy requirements for a position of system analyst, designer and programmer, system or application software developer, or operating system administrator.

Facultative monographic courses dedicated for students of this specialisation:
1. .NET Platform,
2. Advanced Aspects of Cryptology,
3. Advanced Programming Libraries,
4. Organisation and Management of Informatic Project,

Three-Dimensional Interactive Graphics specialisation

This specialisation is devoted mostly, but not limited to, to computer games. Computer games programming is an extraordinarily intriguing branch of computer science, combining technologies belonging to various fields of informatics: computer graphics, artificial intelligence, algorithms, data structure design, or multimedia. Moreover, as network-oriented games (especially massive multiplayer) are becoming more and more popular, also networking is an important issue.

Worldwide the sales in the market of computer games grow rapidly. In Poland there are several larger companies, more and more small development studios are also founded, working in various stages of computer games production and developing games for both Polish and foreign publishers. Still there are too few experts which results in a higher chance of a fast and successful career.

Courses offered put special emphasis not only on solving individual, single problems, but also on an application design as a single whole. This includes combining various sophisticated subsystems, where the key is not only to create the constituent parts, but also to merge them into an operational whole. Experience and skills acquired can be also
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Full-time, graduate studies curriculum—spec. Three-Dimensional Interactive Graphics

Helpful in other branches of computer science, because computer games and multimedia application programming provide general programming experience, teach team work and give strong background in programming both larger, complex applications and single subsystems designed for working in complex environments.

**Part-time, undergraduate studies**

Part-time 1st level undergraduate studies have classes scheduled on Saturday and Sunday. Within the current curricula undergraduate part-time studies comprise 7 semesters, including 1420 hours of lectures, table classes, projects, laboratory classes or seminars, out of which 1195 are for mandatory, 200 are for specialisations and 25 for facultative courses.

The culmination point of the undergraduate studies is preparation of the B.Sc. diploma thesis. Its aim is to demonstrate the ability of a student to solve a given problem in a creative way, to synthesise known facts from a broader area, to present an extensive scholarly document in writing and to defend it in the review process.

Courses offered for part-time undergraduate students are taught by staff members of the Institute of Informatics or by academic teachers from other institutes or faculties of the Silesian University of Technology.

**Curriculum**

The curriculum consists of mandatory courses for all students which also include some facultative classes of selectable scope, and specialisation core curriculum courses. The choice of specialisation happens during the 4th semester and depending on that choice different
courses are mandatory within 5th and following semesters. Following specialisations are offered:

- Databases and System Engineering (DSE),
- Internet and Computer Systems (ICS).

Each semester is credited with 30 ECTS, where 11 ECTS points of the last semester are appointed for the preparation of the diploma thesis. Gathering 210 ECTS points followed by B.Sc. exam are necessary to graduate.

Facultative courses

Students of a specialisation can treat all courses of another specialisation core curriculum as facultative. Apart from that there are also available strictly facultative courses:

1. Data Warehouses (mandatory for DSE),
2. Database Servers (mandatory for DSE),
3. Embeded Multimedia Systems (mandatory for ICS),
4. Industrial Computer Systems (mandatory for ICS),
5. Internet Engineering (mandatory for ICS),
6. Java and Programming in the Internet (mandatory for DSE),
7. Object-Relational Interfaces (mandatory for DSE),
8. Parallel Computation (mandatory for DSE),
9. Programistic Project (mandatory for DSE),
10. Technologies of Internet Applications (mandatory for ICS).

Part-time, graduate studies

Within the current curriculum 2nd level graduate part-time studies comprise four semesters and are conducted weekend studies regime on Friday evenings and Saturdays. Their four semesters comprise the total of 1080 hours, with 870 mandatory and 210 for facultative courses.

Courses Description

Since the courses thought in full-time and part-time studies regime are similar. The description of course content for both types of studies is given below.

3D Object Modelling  
The guiding idea of the course is to acquaint students with advanced techniques used for modelling of 3D objects and introduce the foundations of real-time computer graphics-based applications. During the lectures the students are taught the theoretical and mathematical basis of various graphics-oriented subjects, which are then implemented during laboratories with use of graphics engines (for example Unity).

Advanced Computer Networks  
The lecture present advanced topics relating to the construction and operation of computer networks, particularly solutions of different access network standards (‘last mile networks’), corporate networks, and the Internet backbone. Students learn the principles of xDSL, cabletv, Radio 802.11 and 802.16 networks, solutions of frame relay, ISDN, B-ISDN networks, methods of shaping QoS, design of MPLS networks and methods of network traffic management.
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Total hours / Exams / Credits:
Total: 1080
21 Diploma Seminar
30 Diploma Thesis
15 Economics
15 Humanities and Social Sciences
15 Foreign Language
11 Computer Networks
11 Advanced Computer Networks
11 Computer Networks
10 Database Systems
8 Computer Programming
7 Advanced Artificial Intelligence
6 Applications of Digital Systems
5 Advanced Artificial Intelligence
4 Advanced Artificial Intelligence
3 Advanced Artificial Intelligence
3 Advanced Artificial Intelligence
2 Artificial Intelligence
1 Advanced Artificial Intelligence
1 Advanced Artificial Intelligence

Part-time, graduate studies curriculum

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The total number of hours, exams, and credits are as follows:

- Total hours: 1080
- Total exams: 21
- Total credits: 18

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The table includes courses and their corresponding hours, exams, and credits for each semester.
**Advanced Data Analysis Methods**  The aim of the course is to present the approaches to practical data mining issue solving. Several data analysis methods, such as: data preprocessing, classification and regression, clustering, association mining, social network analysis are presented during the course. The approaches utilizing the presented methods are implemented and verified by the students in RapidMiner and R environments.

**Advanced Databases and Data Warehouses**  The goal of this course is to present the most actual knowledge on theory and technology of advanced databases and data warehouses. In the context of multiaspect algorithm and performance analysis the course presents new ideas and concepts of data processing algorithms such as spatial, spatio-temporal, stream, grid, or mobile, providing a base for more in-depth studies.

**Advanced Programming of Industrial Controllers**  The course is dedicated to students who know basically what the PLC is and how it should be programmed. It is focused on advanced programming methods including not only typical programming languages but also exploitation of graph and universal languages. Moreover, extended commands lists of typical languages, including sophisticated and specialized blocks, are presented. There are considered various hardware platforms, comprising not only commonly used ones but also brand new families. Additionally, students are familiarized with wide area of useful programming techniques, developing tools and differences in language implementations, interrupt programming and safety solutions, along with problems of remote access and remote diagnostics. Methods of PLC cycle optimization and some possibilities of source code improvements are also discussed together with several examples. All presented content is illustrated based on existing, real industrial systems. Standardization issues are also considered.

**Advanced Techniques of Programming Computer Graphics**  A leading idea of the course is to familiarize students with the sophisticated techniques used for creating multimedia applications (including video games). An additional aim is to introduce the basics of a typical workshop of other members of the project team to enable effective communication and efficient collaboration in heterogeneous teams. The student in a series of laboratory exercises develops an interactive application, complete with studied techniques / issues. Mentioned techniques include in particular the basis of modelling and computer animation, lighting configuration and creation of materials, particle effects, animation, skeleton, collision detection, rendering large and vast terrains, the effects created on the basis of physical engines (e.g. ragdoll), advanced techniques and post casting shadow processing stage.

**Algorithms and Data Structures**  The aim of the course is to introduce the audience into subjects of algorithms and data structures. The issues of computational complexity and basic algorithms for selected problems like sorting, searching, graph computations, are introduced. Students acquire skills necessary for analysis and evaluation of algorithms and selection of data structures meeting set requirements.

**Algorithm and Data Structures II**  The aim of the course is to introduce the audience into advanced subjects of algorithms and data structures. The algorithms for linear sorting, searching in trees and pattern matching are presented.
**Analysis and Design of Information Systems**  The course provides students with the knowledge how to deal with problems arising in medium and large software projects. The lecture covers models of software development, software architecture, and advanced usage of UML and design patterns. Special emphasise is put on requirements for engineering and software architecture, especially by MDA approach. During laboratory activities students analyse and design a software system using RequisitePro and RSA.

**Application of Network Technology in Administration and Business**  The lecture aim is to provide the network technologies of ensuring the security of the transmission, storage and processing of information, that can be applied in the electronic circuit, formation of the contents and certification of documents, electronic execution of financial transactions and methods of providing high reliability and performance of network solutions.

**Arithmetic of Digital Systems**  The course deals with number systems, representation of numbers, arithmetic operations and implementation of arithmetic logic circuits. There are presented methods of conversion, and rules for performing arithmetic operations. Arithmetic for fixed-point numbers is explained for binary and BCD numbers, while arithmetic for floating-point numbers is given by general description with provided numerical examples. Accuracy and correctness of operations are discussed for conversions and other arithmetic operations. Implementations of arithmetic circuits are presented in the context of available circuitry.

**Artificial Intelligence**  The aim of the lecture is to delivery to students the information about artificial intelligence methods, which are inspired by functionality and organisation of biological systems. Students develop their knowledge in the area of computational intelligence which includes topics related to artificial neural networks and evolutorial programming. Methods of artificial intelligence, presented during the lectures and laboratories, inspired by biologically systems are example of non—classical methods of information processing in highly concurrent connectionist systems (artificial neural networks) as well as population systems (genetic and evolution algorithms). As a result student are able to use presented methods of artificial intelligence, in addition perception of computer science is extended at the sciences related to information processing.

**Artificial Intelligence in Computer Games**  The course acquaints students with problems related to the use of artificial intelligence in computer games, with the emphasis on algorithms of motion of AI-driven entities: finding way, realistic group behaviour, and motion optimisation. The course covers the subject of state machines and application of scripting languages and their features in games and includes also graphs and graph algorithms.

**Biologically Inspired Artificial Intelligence Methods**  The goal of the course is to present artificial intelligence methods which are inspired by natural biological processes. One group of such methods is based on the evolution of living creatures and is called evolutionary computing, the other derives from processes observed in nerve systems of organisms and is called artificial neural networks or connectionist approach. These two areas belong to the wider branch of artificial intelligence called computational intelligence.
together with fuzzy and rough set based systems, which are taught in the separate course: *Rule-Based Systems of Artificial Intelligence*.

**Calculus and Linear Algebra** The course gives students familiarity with basic topics in calculus and linear algebra, presenting important definitions and theorems and showing relations between discussed concepts. The lecture is illustrated by examples and includes such topics as functions and their properties, function limit, the derivative, the differential, indefinite integral, differential equations, matrices and determinants, elements of 3-space, derivatives of functions of several variables, series and its sum, necessary condition for the convergence, modulo arithmetic and rings of polynomials.

**Computer Architecture** The objective of the course is to provide a wide yet detailed view of computer architecture with the first part presenting the main trends in processor development. CISC, RISC, superscalar and VLIW processor architectures are explained and the details of pipelining discussed. Second part of the course addresses the parallel computers architecture, with presentation of vector processors and vector supercomputers, as well as array processors and SIMD model in modern superscalar processors. The central topic of this part of the course is MIMD model. Shared-memory multiprocessors, NUMA multiprocessors and distributed-memory multicomputers are presented within the confines of this model. The architecture of clusters is the last topic of the course.

**Computer Games Programming** The aim of the course is to introduce students to a wide range of issues related to the design and development of computer games. Computer games are very complex applications, in which the main problem is to combine a number of separate elements, work with multimedia data and quick orientation in new and still developed tools. Besides, students have to remember about the specifics of the production of software for the entertainment industry and work in a team, where developers are only one (rarely dominant) group. This course presents the various aspects of creating computer games to fully understand the challenges facing a programmer working in the game industry. As part of the lecture issues of design and development of computer games of various types (e.g. serious games, casual game type HOPA), today used tools/engines (e.g. UDK, Unity), as well as industry trends and characteristics are presented. Laboratory exercises involve the use of ready-made tools to create simple games or its components (e.g. materials, special effects, audio). Due to its specific, the course is refreshed in close consultation with partner companies developing games and interactive graphics applications.

**Computer Graphics** The course presents modern practical devices used for computer graphics and methods of image synthesis on these devices. Discussed visualisation methods lead to obtaining an image of increasing complexity until synthetic photo-realistic images are obtained. The lecture allows students to understand practical visualisation algorithms in modern graphic environments and web page presentations, and implementations of these algorithms by equipment in modern graphic systems. The laboratory activities aim at instilling in students the practical skills of creating simple graphics applications and the students check in practice the knowledge gained during the lecture.
Computer Graphics and Human-Computer Interactions  The aim of the course is to provide informations about the computer graphics theoretical basis, 3D computer graphics algorithms and selected aspects of 2D computer graphics. The course is also providing the necessary practical experience acquired as a result of the implementation of algorithms during laboratory exercises. The lecture enables students to make contact with the modern solutions for photorealistic 3D graphics and understanding of basic conditions of modern computer animation. Students also create custom solutions for their projects.

Computer Graphics and Image Recognition  The course provides knowledge of computer graphics, image synthesis and computer vision. The lecture introduces the theoretical basics of presented methods, which are implemented and tested on real datasets during the laboratory classes.

Computer Network Security  The course covers basic principles of computer and information security. The students gain understanding of threats classification, principles of intrusion detection in operation systems, information security attributes, methods how to defend systems against different threats, discussion of various attack techniques and technical and non-technical means of systems and information protection.

Computer Networks  The course is aimed at building the understanding of the principles of computer network operation, protocol stack architectures and networking services. Starting from the principles of point-to-point communication, the main rules of protocol engineering are presented, and the influence of channel technology and properties on protocol operation and media access rules are detailed. Then the basic problems of computer to computer communication over the network are discussed in the framework of ISO OSI Reference Model architecture. The examples of the TCP/IP and the netbios/smb protocols stack are examined in more detailed way, along with the basics of Internet services operation.

Computer Networks in Aviation  The lecture presents communication protocols, hardware and software solutions used for planning, development and validation of communication systems used in aviation and automotive. The laboratory exercises include practical examples of communication with real devices such as lidar, radar and camera using CAN protocol. An object oriented communication approach is illustrated on the IEC 62541 (OPC UA) standard example.

Computer Programming  The aim of the course is to lay a solid foundation of good software engineering and programming language practice and it provides the knowledge and skills required to understand, design and write computer programmes in C and C++. The course programme contains introduction to imperative programming in C/C++ language, basic algorithms and data structures, substantial knowledge on object-oriented programming using C++, and some advanced problems and techniques essential for programmers, exceeding traditional programmes of elementary programming courses by giving some knowledge involving the latest achievements in software technology.
Computer Structure  The course presents the hardware solutions, design methods and software tools applied in the hardware/software co-design and construction of computer modules as well as the digital and analog interface design processes based on various types of logic circuits and technologies.

Computer Systems and Networks Performance Evaluation  Assessing the effectiveness of systems and computer networks performance accompanies designing, production, setup, and development of ADP systems. The course covers the issues of operating models for these systems: the number of sequenced tasks, relationships and limitations in the capacity and the reaction time of the multi-access system, average values analysis, Markovian models of a single desktop and a network of desktops, modeling the ATM networks switch, and the algorithms of avoiding the switch overload. There is also discussed the diffusionproximation and its use in describing the unestablished states of traffic intensity of packet in communication networks.

Computer Systems Interfaces  The course gives the students familiarity with the following topics: standard and specialised interfaces used to connect peripheral devices to computer systems, software aspects of communication with peripherals, selected examples of peripherals, and good practices of communicating with external measurement equipment. The course presents evolution of computer interfaces (ports). The first part explains legacy interfaces like UART and parallel port, the second contemporary “system ports”: USB and IEEE 1394 (FireWire). IEEE-488 (GPIB) interface and SCPI language are also covered, as well as problems connected with data acquisition. The special topic includes system protection against noises.

Computer Vision and Image Recognition  During the course there are presented the ways of processing binary, grayscale, and colour images, and methods of object classification and data clustering. The lecture focuses on mathematical and algorithmic description of methods, while within the laboratories students implement given fragments of the algorithms and test them on real images and different kinds of datasets, analysing effects and influence of different values of parameters. During the project students implement and test chosen, more advanced algorithms. The practical skills acquired are techniques such as contrast improvement of selected regions of images, noise elimination, or extraction of image properties.

Copyrights and Social Problems of Informatics  The course explores copyrights role in the flow of research, teaching and development as well as the way in which information technologies have and are transforming society and how these affect a range of social, political and economic issues from the individual to societal levels.

Database Systems  The purpose of the course is a discussion of principles of relational databases and database management systems. Students are made familiar with the theoretical aspects of hierarchical, network and relational data models as well as architecture and functions of DBMS. The course also covers the theoretical aspects of database design theory and queries in relational algebra. SQL as a standard of query language and its usage in data definition, insert, update and delete statement, basic and complex queries are also presented. The methods of defining referential integrity and transaction processing
are given too. Additionally database security and authorisation, concurrency control and database recovery are discussed.

**Databases III** The course extends the subject area presented during course *Database Systems*, providing students with an understanding of models and physical structures of data, data description methods, query languages and database application areas. There are discussed methods of efficient data access methods, full text search, issues related to data distribution and data integration, object-oriented data model, representation of fuzzy terms in a database, the XML language, multimedia, in-memory and bioinformatic databases.

**Design and Development of the Internet** The course shows the evolution which the Internet is experiencing at present and introduces the tools used by its designers. The evolution of the Internet refers both to its software aspect (changes in communication protocols introducing a guarantee of quality of services), as well as the device aspect (changes in network operating principles). The extent and the complexity degree of the Internet require introducing the self-regulation mechanisms on its different levels, adapting the traffic intensity to the network conditions. These mechanisms use increasingly better knowledge of random intensity properties of observed Internet traffic, treated as a stochastic process which is also discussed.

**Design of Digital Circuits** The goal of the course is to present functional, static and dynamic parameters of digital circuits as well as the principles of their usage in construction of digital devices. The course presents also the comparison of realisation techniques of modern digital circuits, with descriptions of input, control, processing and output circuits of devices. Integrated functional modules, programmable logic devices and principles of their application are discussed with details of transmission of digital information. Noise and interference in digital circuits are addressed as well as some testing modes.

**Digital Modelling** The goal of the course is to present description forms of dynamic systems models, programming resources applied for their construction and algorithms used for solving modelling goals. Students acquire some practice in building digital models of continuous or discrete event systems using a specialised or universal programming resources such as: Simmon program, Matlab-Simulink environment, CSL++ library, GASP package, OMNet++ environment and SimEvents (discrete event simulation tool). Parameter optimisation methods and random number generation algorithms are presented as well.

**Diploma Project** The aim of the diploma project is to demonstrate the ability of a student to solve a given problem in an innovative and creative way, to synthesise known facts from some broader area to produce a new approach, to present an extensive scholarly document in writing and to defend it in the review process. The diploma project constitutes the culmination point of the undergraduate studies. The subject matter of the thesis can be a new or modified solution to a research or development problem in informatics or a related part of mathematics, analysis, design, and implementation of a solution to an applied problem.
Diploma Seminar  The objective of the seminar is to prepare students for writing and presentation of their B.Sc. or M.Sc. theses. During seminar classes students describe the subject matter of their theses and relate their progress in form of a presentation with following plenary discussion.

Diploma Thesis  The diploma project is the culmination point of the graduate studies and its aim is to demonstrate the ability of a student to solve a problem in a new and creative way, to synthesise facts from a broader area, to present an extensive scholarly document in writing and to defend it in the review process. The subject matter of the thesis can be a thorough overview of the state-of-the-art in a particular sufficiently broad area, a new solution to a research or development problem in informatics or a related part of mathematics, analysis, design, and implementation of a solution to an applied problem.

Discrete Mathematics  The aim of the course is to present selected concepts and methods of discrete mathematics which are strictly connected with mathematical foundations of informatics. It encloses such problems as set theory, relations algebra, mathematical logic and automatic theorem proving, mathematical induction, elements of the counting theory, recurrence and selected problems of the graphs theory. There are also included the rough sets theory and decision logic, concepts that in the simple way illustrate application of set theory, relations and logic to tabular data analysis.

Electromagnetic Compatibility of Computer Systems  The electromagnetic environment is becoming more and more polluted due to increased use of electronic technologies, especially wireless communication. Consequently, the electromagnetic disturbances, which electronics can be exposed to, are getting steadily worse. That is why research on the influence of the electromagnetic disturbances on electronic devices and systems is important and aims at increasing safety and reliability of these systems. Within the course the students learn The New Approach Standardisation in Europe and standards harmonised with EMC Directive that apply to the electromagnetic immunity of electronic devices and conduct research on the influence of the electromagnetic disturbances on selected electronic devices.

Electronics and Measurement  The course provides a basic understanding of the operating principles of semiconductor devices and an introduction to the theory and operation of electronic circuits. There are given definitions and basic features of analogue and digital signals and circuits with discussion how to use them efficiently and construct complex systems satisfying set requirements. There are also presented analogue-to-digital and digital-to-analogue converters with basic methods of conversion and their comparison.

Embedded Systems Construction and Programming  The course focuses on techniques and tools used in construction of embedded devices based on microprocessors, which are widely used in modern electronic equipment having different input and output interfaces. There is provided definition of an embedded device and description of internal and peripheral elements, as well as requirements of formal methods for designing hardware and software according to standards. Next, there are discussed communication standards used in automotive and industrial environments and some examples of embedded systems.
**English Language**  The aim of the course follows the description of Foreign Language, where the English Language was chosen.

**Flight Instruments, Avionics**  This course introduces students to the principles of avionics equipment work on an airship board and ground infrastructure. Students are made familiar with avionics systems like: Gyro, VOR, ILS, NDB, DME, radio communications, (without GPS) and technical aspect of military network MIL-STD1553B. Laboratory allows to verify theoretical knowledge in the flight simulator.

**Flight Simulators**  Purpose of the lecture is to present topics in the area of plane simulators, functionality of plane simulators and plane simulators creation. History of plane simulator is specified and key breakthrough technologies are described. Various technologies which are utilized in flight simulators are outlined. During project students practically apply knowledge presented in lectures.

**Foreign Language**  The aim of the course is to enable students to communicate effectively in different situations and settings with native and non-native speakers alike using authentic, appropriate, and correct linguistic forms in subject matter areas in general, and mathematics and computer sciences in particular, to equip them with the requisite linguistic skills for pursuing university education in their fields of specialisation.

**Fundamentals of Aerodynamics**  The purpose of the course is to present: basic knowledge on wings profiles aerodynamics and the impact on a flight of the profile changes, information on the forces acting during the flight, the effect of lift, basics of airframe controlling. The course presents also a description of a helicopter flight systems construction with a comparison to the structure of the aircraft.

**Fundamentals of Circuit Theory**  This introductory course lays down foundations of circuit theory and analysis for subsequent use in more advanced courses. There is performed a revision of some general definitions, such as voltage, node voltage, current, electric power and energy, general classification of circuit elements and their description, Ohm’s law, Kirchhoff’s current and voltage laws, linear and non-linear circuits, current and power calculations for complex circuits, and D.C. and A.C. analysis.

**Fundamentals of Digital Data Transmission Systems**  The course covers the following topics: elements of information theory and channel coding, codes with redundancy, error detection and correction, base band and pass band channel transmission methods, physical properties of transmission channels, spread spectrum systems and synchronisation methods, basic aspects of data transmission in computer networks, and communication protocols.

**Game Programming for Mobile Devices**  The course covers different aspects of game programming for mobile devices. Students learn the selected programming interfaces and game engines for smartphones and tablets. They also develop custom software for non-standard devices such as robot sphere or wireless cubes. In addition, they practice the development of applications using a variety of game controllers, i.e., the controller reading the mind using changes of the brain’s electrical activity, or finger motion sensor controller. Lectures present issues of game design, the user interface, code optimization
and obfuscation, as well as the use of sensors embedded in mobile devices for the purpose of controlling games.

**GIS and Environment Simulations** The main goal of the subject is to present current knowledge on geoinformatics and Earth surface modeling, including buildings, infrastructure, etc. Practical part includes short introduction to the virtual flying on fixed wing aircrafts then programming and providing data extensions for FSX/ESP/Prepar3D simulation systems.

**Graphic API Programming** Within the course there is addressed programming in 3D graphics APIs OpenGL and DirectX, with description and comparison of basic and rendering techniques in the two APIs. There is included basic rendering knowledge on matrices and vectors, perspective, orthogonal projection, projection and model-view matrices, constant and programmable rendering pipelines. There is also discussed lighting by specifying types of light sources, shading techniques, and light effects, as well as textures with mapping, anti-aliasing, and mipmapping. Effective rendering techniques such as buffers, culling, bounding volumes, along with rendering optimisation are given and programmable rendering pipelines as basic use of shaders are explained.

**Industrial Computer Systems Design** In each industrial system it is possible to distinguish several functional levels: the object level associated with the technology, local supervision and control level and process management level. In some systems there are also Manufacturing Execution System and Enterprise Resource Planning levels. Between and in all the levels communication system exists that allows vertical and horizontal data exchange. The Industrial Computer Systems Design course describes not only designing process for each level and the communication system, but also it discusses the equipment that can be used. Large applications are also shown to students participating in field trips to some industrial places like electricity plant or automotive works.

**Industrial Informatic Systems—variant course** The course is one of variant courses of selectable scope. It is to be held as either one of two variants: *Industrial Distributed Systems* or *Industrial Networks*.

**Industrial Networks** The main problems discussed in the lecture are strongly connected with industrial distributed real-time systems. Industrial networks must have deterministic protocols. From this point of view, topics of lectures contain description of protocols: Master-Slave, Token Bus, Producer-Distributor-Consument and Master-Slave on TCP/IP. Also the analysis of time transmission and time efficiency of all protocols are presented.

**Industrial Processes Visualisation** The course presents techniques and tools used in distributed industrial process visualisation systems discussed on a base of the hierarchical approach. Local visualisations, visualisation issues in DCS and SCADA systems, industrial databases and remote access tools are described as well as architecture, communication, and information processing problems commonly encountered in industrial visualisation systems. The course is illustrated with many practical application examples and presentations of contemporarily used industrial process visualisation systems.
**Industrial Real-Time Systems**  The objective of the course is a presentation of fundamental problems in building distributed informatics systems in industry area. Most of important features of almost all industry informatics system work in real-time. From this point of view, knowledge of deterministic networks protocol is most important and fundamental for design process of industrial systems. During the lecture three of basic topics are presented: an idea of distributed informatics system in industry applications, deterministic process of control and monitoring as a goal of real-time systems, time analysis of global informatics system having in mind: architecture of computer node and methods of its programming, analyzing possibilities and features of network co-processors, and time-analyzing of deterministic network protocols. After discussion of all of these problems, students are prepared to answer for question concerning parameters of designed system.

**Interactive and Multimedia Systems**  This course gives a unique insight into all aspects of a multimedia system, from technical compatibility, through layers of software to an appreciation of key issues in human computer interaction. The students gain an understanding of a wide range of technical aspects, such as multimedia and Internet programming, the acquisition and manipulation of digital content, and rendering of final digital components. They also learn about the integration of systems and the way they are presented and used. The course mirrors industry where many commercial installations do not fall neatly into either the computer and network system or digital broadcast area. Therefore, this course is more broadly based and focuses not only on the technology of the systems but also the dynamics of all human-machine interface.

**Internet Engineering**  The purpose of the course is to present students the traffic and transmission control mechanisms. Additionally, the approaches and algorithms for monitoring and measurements performed in computer networks are introduced. During the classes, students are familiarized with the current standards and recommendations for traffic measurement. They are also trained in applying solutions for traffic control, traffic engineering and its maintenance in real environment.

**Introduction to Compilers**  The aim of the course is to address selected problems of compiler construction. The discussion starts with an outline of basic terms related to formal languages, formal grammars and their classification. Then problems of lexical and deterministic syntactic analysis are exposed. Discussion on lexical analysis involves regular expressions and equivalent non-deterministic and deterministic finite-state automata. In the discussion on syntactic analysis, the top-down and bottom-up approaches appear, the former represented by recursive descent and LL, the latter–by precedence-based and LR parsers. With this background, during the laboratory classes the students use lex- and yacc-family tools to build their own text processors.

**Introduction to Computer Programming**  This course introduces students to the principles of computation and teaches how to use computation efficiently in solving some types of problems. The Pascal programming language is discussed as a tool to implement programmes and there are discussed various data structures. Lectures are illustrated with many sample programmes. During laboratories there are discussed the basic concepts
of software engineering like design, documentation, testing and debugging and students create their own programmes.

Java and Programming in the Internet In the framework of the course, the Java programming language is presented with its means, tools, and methods that enable building programmes destined for exploitation both as the Internet and standalone applications. Among others, mechanisms for error handling, multithreading and network protection are exposed, also fundamentals of enterprise applications and application for mobile devices are presented. After completing the course, the students should be able to create their own applets, servlets, and applications.

Methodology of Teamwork The aim of the course is the presentation of strategies for managing information systems lifecycle. Among various approaches plan-driven and agile methods are discussed. Students are taught, how to build a development team, which roles should be represented by its members and how to create positive work environment. They are acquainted with techniques supporting team’s work: pair programming, test-driven development, continuous integration, refactoring and small releases. The attention is focused also on such planning and estimation methods like Planning Poker and Wideband Delphi ones. Students have opportunities to use all the aforementioned mechanisms in practice during design activities with usage of the chosen software supporting agile system development. However, the emphasis is placed on improving team collaboration skills rather than implementing an advanced tool.

Methods and Tools of Software Production The course prepares the students to work as members or team leaders in large computer science projects exposing the business aspects of work organisation and management of the project. During the course, the students cooperate with selected IT companies learning how these methods work in practice.

Microprocessor and Embedded Systems The course presents the hardware issues related to the construction of functional modules and operation of microprocessors and embedded systems. During the course functional elements of a microprocessor are presented along with the structure of microprocessor systems with details about every part such as interrupt unit, direct memory access unit, and input-output units.

Microprocessor Measurement Circuits The course gives students familiarity with the following topics: Data Acquisition Systems (DAS), interfacing DAS to a microcontroller and PC computer, distributed microprocessor measurement systems (fieldbuses), computer controlled measurements systems basing on DAS cards and measurement instruments attached by standard interfaces, Standard Commands for Programmable Instruments (SCPI language), data acquisition and control programming in Agilent VEE and LabView.

Monographic courses Propositions for monographic courses must be accepted by the Director of the Institute of Informatics. The courses have to deal with contemporary and future challenges of informatics. For the current curriculum on the full-time undergraduate studies the topics were Theory of Data-Space and Algorithms and Computer Nanosystems.
**Network Technologies**  The course presents basic issues related to the principles of digital data transmission and computer networks operation. Students learn about the basic properties of communication channels, methods of signals description, frequency and time channels multiplexing, principles of protection against transmission errors, organization of information exchange between systems through communication channel, construction of the standard TCP/IP and assessment of their performance.

**Numerical Methods**  The main objective of the course is to present problems of numerical analysis. There are discussed such notions as theory of errors, interpolation, approximation, numerical differentiation and integration, solving systems of linear and non-linear equations, approximate solving of ordinary differential equations, linear programming, and numerical Monte Carlo methods.

**Object-Oriented Design**  The purpose of the subject is to present the most important topics related to design and analysis of object-oriented applications. During lectures students are familiarized with topics in the area of modelling of business processes, formulation of user requirements, dynamics of the system, architecture of systems, life cycle of the project etc. Realization of the project enables practical application of the knowledge presented on lectures.

**Operating Systems**  The course addresses an operating system as a basic piece of software in every computer system. There are described basic functions and supported services. The first part of the course comprises the theoretical aspects of an operating system related problems, like: the idea of a process, a thread, process queue, mutual process communication and synchronisation, memory management issues, input-output operation handling, data management, file systems and data mass storage systems management. The second part of the course—obligatory for those, who choose System Software specialisation—aims at presenting the network related topics. This part describes the distributed file systems, the directory services, public key infrastructure related topics, some network services and the remote access methods.

**Parallel Computing**  The course introduces students into the basic subjects of parallel computing. The performance measures of parallel algorithms, models of parallel computations and architectures of parallel computers are discussed.

**Parallel Computing II**  The course introduces the audience into the advanced subjects of parallel computing, such as the message passing MPI and OpenMP interfaces.

**Physical Education**  Physical education includes gymnastic classes, swimming lessons or special athletic sections (basketball, volleyball, etc.).

**Physics**  The objective of the course is to acquaint students with main physical concepts and their applications in modern science and technology. The course presents fundamental laws of kinematics and dynamics, inertial and non-inertial motions, conservative principles in motion, energy and power in mechanics, second law of thermodynamics, gravitational, electrostatic and magnetic fields, electromagnetic induction and radiation, thermal radiation, wave-particle duality, electron diffraction, fundamentals of quantum mechanics, Heisenberg uncertainty principle, wave function of matter, classical atomic models, electron spin, and physical basis of microelectronics and nanoelectronics.
**Practical Applications of Design Patterns**  Presentation of basic principles and rules in object-oriented programming. The course teaches students that quality of code is very important in real projects and that it is not enough to write a code that only fulfills requirements. After the course students should be able to create the code according to SOLID principles and they know the classic GoF design patterns and its usages.

**Practice of Implementation of Integrated Information Systems**  The subject of the course is the practical approach to the tasks concerning implementation of typical modules of integrated information systems from the range of commercial-of-the-shelf (COTS) software solutions. The goal of the course is to give participants the background and practical knowledge from the area of implementation of such systems. The program of the course involves general topics concerning management of implementation projects, and also some practical issues associated with widely understood information systems in commercial enterprises and companies. The most common problems and system functionalities of such systems are discussed for areas like financials, logistics, manufacturing and sales. The course includes lectures and the project. In frame of the project students are assigned tasks associated with implementation and configuration of sample integrated systems for sample manufacturing and trading companies.

**Programming in Assembler**  The course presents assembler between other programming languages used in modern information technology. It begins with historical view of processors from 8086 to Pentium4 and details about internal elements and programming models of processors such as registers, flags, memory organisation, addressing modes, interruptions, exclusions, data types and instructions. Next, there are discussed the principles of MASM assembler with details about operators, identifiers, statements, directives and memory models. Advanced programming techniques are described with procedures, macros, modules, and optimisation techniques. Features of modern processors as floating point coprocessor, multimedia units like MMX and SSE are also presented.

**Programming of PLC**  The target of this course is a presentation of programmable logic controllers both from construction and from programming point of view. The aim is to prepare a student to creative work within an industrial environment with computerized equipment. Hardware platforms, internal structures, operating system and its tasks, and programming languages are studied in a basic scope. There are considered typical programming methods and common used languages. There is discussed a construction of devices, their internal and external components, run types, and operating modes. The well-known controllers are considered. However, some new models and more complex programming methods are also given.

**Real-time Operating Systems**  The course consists of presentation of the structure and function of real time operating systems, description of use cases and problems encountered in industrial applications. A detailed discussion of issues: periodic and aperiodic tasks scheduling, stochastic analysis of priority based tasks, resource management in real-time operating systems, reliability, vailability and redundancy, examples of RTOS: VX Works RT Linux, POSIX, RT-Java, distributed real-time operating systems, component based model in IEC 61499, service oriented architecture in IEC 62541.
**Rendering of Realistic Images**  Course focuses on photorealism of resulting image. Photorealistic rendering tries to reproduce as accurately as possible the process of illumination found in nature, which implies the utilization of global illumination methods (such as ray tracing, photon-mapping, radiosity). Student through participation in classes, receive theoretical knowledge and acquire practical skills, allowing to render realistic-looking scenes.

**Rule-Based Systems of Artificial Intelligence**  The course covers selected concepts and methods of artificial intelligence, focusing on so-called symbolic approach in which knowledge is represented by rules. The lecture encloses: basic definitions of artificial intelligence, applications of deductive reasoning (expert systems), methods of inductive reasoning (trees and rules induction), methods of attributes transformation (discretisation), methods of rules evaluation and utilisation during classification process, methods of reasoning in the case of uncertain data (fuzzy logic, fuzzy reasoning, determination of fuzzy models).

**Satellite Navigation Systems GNSS**  The aim of the course is to familiarize students with the issues occurring with the use of modern navigation systems in aviation - including European GNSS EGNOS / Galileo system.

**Selected Mathematical Aspects**  This course is a supplement in the area of data analysis. It provides a background knowledge about methods and tools. After an introduction of classification and regression quality measuring and problems, a review of most popular algorithms is presented. The course presents also elements of linear programming, multivariate optimisation with constraints, time series analysis and interval analysis.

**Selected Operating Systems—variant course**  The course is one of variant courses of selectable scope. It is to be held as either one of two variants: Dedicated Operating Systems or General Purpose Operating Systems.

**Social Media and Data Mining**  The aim of the course is to present the approaches to advanced analysis of the data available on the Internet. Several data analysis methods, such as: data preprocessing, classification, clustering and social network analysis are presented during the course. The approaches utilizing discussed methods are implemented and verified by the students in RapidMiner and R environments.

**Software Certification**  The objective of the course is to show students how certified software production process is strongly connected with safety. One of a group of informatics systems, called Programmable Electronic Systems (PES) is permanently used for realization of some safety functions. PES systems use at least one programmable electronic device. It is absolutely necessary to show students the requirements for electrical/electronic/programmable electronic safety-related systems, software requirements, methods for determination of safety integrity levels and present overview of techniques and measures. Most of examples are prepared for requirements and tested for apparatus using software and/or digital technologies. The course introduces also one of tool for producing software - Management of Software Quality System.
Software Engineering  The aim of the course is to present a review of selected problems in software engineering. Software life-cycle is discussed with reference to software production process management issues. In this context special attention is paid to methods of software production cost and time estimation, to definition of requirements and analytical models building, to the essence, organisation, and ways of performing the design activities, and to concepts and forms of software verification and validation. Structural and object-oriented approaches to software system elaboration are exposed. Elements of the UML are introduced and used at successive steps of systematic sample software system development process.

Statistical Methods  The course is dedicated to probability and statistical theory issues with providing both the theory and its application to practical examples. It focuses on the ways of calculating probability, descriptions of given datasets and populations, estimation by means of given samples of general population—parameters and distribution, verification of statistical hypotheses and evaluating dependencies between random variables. During the laboratories students analyse large datasets with spreadsheet application and using integrated statistical library they implement methods operating on the datasets in spreadsheet dedicated language.

Systems and Control  The course presents control systems theory for both dynamic and static combinatorial systems in multidisciplinary approach. Inputs, outputs, and system state descriptions are presented along with control system classification with continuous vs. discrete control aspects, and system modeling by phenomenal and input-output models. There are also described forward and loopback control aspects of disturbance mineralisation methods, real-time output control, modification of system properties, as well as estimation of non-measurable states. Regulation system modelling and design is detailed by giving its static and dynamic requirements, regulation quality limitations, and control with reference model.

Team Design  The aim of the course is to provide students with general view of the software project management techniques within a team environment. The course is divided into two parts: during the first part, the basic principles of agile software development approach are presented. The second part of the course is focused on distributed and centralized version control systems that supports organization of multi-developer projects.

Team Work Practice in Computer Games Development  The course covers problems related to team work in both small and larger teams. Students are acquainted with methodology and team work-oriented tools and their application during various stages of a project, from the first design documents through postproduction stage. There is also discussed the process of game development as a whole, including not only programming, but also its screenplay, key elements, attractiveness of a game, budget, artistic content in games with hardware limits and tools, team work on source code, version control systems, bugtracking systems, code and project documentation, and automatic build and testing systems.
**The Humanities**  The course gives students essential knowledge and transferable skills that are applicable in their personal and family lives as well as in their studies and in the workplace. The course explores several aspects of human society, thought, culture, individual and collective human behaviour and needs, patterns and trends in society, philosophy, and religion. Students gain experience in researching information from a variety of sources, thinking critically about the ideas and facts they gather, and using that information to solve problems through both independent effort and collaborative work.

**Theory of Computer Science**  The aim of the course is to familiarise students with basic notions and problems in computer science. The course gives foundation for many other monographic lectures. It contains presentation of principles of the algorithms and data structures, problems of serial and parallel algorithms and their efficiency, and structural components of computers. The lecture addresses also the operating system functions and programming in assembler language, the Turing machine, formal languages, and programme translation. The data access methods, statistical models of networks and new trends in computer science like nanosystems are given as well.

**Theory of Digital Circuits**  The course presents Boolean algebra with its theorems that form the background for logic circuit design and analysis. There are discussed digital elements and synthesis and analysis procedures for both combinational and sequential general purpose circuits for hard-wired and microprogrammable logic, as well as specialised circuitry of delay elements, registers, counters and arithmetic units.

**Courses taught for students of other faculties**

The staff members of the Institute of Informatics perform teaching activities for students of other faculties. There is the whole group of courses, prepared and led by the staff members of the Institute of Informatics, and dedicated for the students of Macrofaculty of Automatic Control, Electronics and Telecommunication, and Computer Science. There is another set of courses prepared for the students of Teleinformatics, which is a new profile of studies opened in 2013.

Moreover, there are courses prepared for students of Macrofaculty of Industrial Informatics on the Faculty of Materials Science and Metallurgy in the project "The opening of a new field of study and new specialities and organization of specialized courses in the Silesian University of Technology, together with the system of internships for academic staff of universities" co-financed by the European Union under the Operational Programme Human Capital.

**Full-time, Macrofaculty, undergraduate and graduate studies**

The curriculum of undergraduate Macrofaculty of Automatic Control, Electronics and Telecommunication, and Computer Science combines elements of the three individual faculties offered for students. This studies develop graduates skills in the most desirable
engineering disciplines, in the areas of robotics, electronics, information and communication technologies. Rapid progress in these areas is a challenge of our times. Moreover, the modernized English-taught version of Macrofaculty provides all the necessary professional vocabulary, inevitable in engineers world.

Alumni of Macrofaculty are engineers whose education has interdisciplinary elements based on three technical areas combined with practical experience and specialized knowledge in one of the three branches, chosen as leading in their studies. The following specializations are offered:
1. Automatic Control,
2. Electronics and Telecommunication,

The programme of studies guarantees the presentation of the modern knowledge due to it, it is flexible to changes which reflect dynamic development of scientific processes. Graduates specialized in computer science acquire skills in construction, maintenance and usage of system software and applications development, building systems and computer networks and designing and administrating of databases operating in various environments and operation systems.

The staff members of the Institute of Informatics lead courses belonging to core curriculum courses mandatory for all students as well as dedicated for the specialisation of System Software, Databases, Computer Networks and Operating Systems and facultative courses. The specialisation core curriculum courses start with the 6th semester and continues on the graduated level of studies.

**Full-time, Teleinformatics, undergraduate studies**

The development of telecommunications and information technology in recent years make those filled to relate each other. Telecommunications commonly uses methods and informatics tools for generating, processing, storing and displaying information, and also to manage the network traffic. In the computer science, the advanced communication technologies in local and wide area computer networks are exploited. Due to omnipresent access to the Interned via wireless and wired solutions, the transmission protocols, devices, and network design are familiar to IT sector. Therefore, methods and devices of these two fields form a joint common systems, which is exploited among others in the industry – industrial networks, intelligent buildings, administration or banking. The design, maintenance and further development requires specialized staff with expertise in the field of computer science and telecommunication. To meet this demand, the Faculty launched a new curriculum of undergraduate full-time Teleinformatics.

The 1st level full-time studies last for 7 semesters. Students obtain firstly the theoretical background in mathematics, physics and other technical subjects. Then their knowledge is deepen in problems concerning computer science present in telecommunication and vice versa. In order to obtain the B.Sc. title the students are supposed to prepare the engineering projects and pass the exam. It is planned to prepare 2nd degree full-times studies for graduates of this studies.
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Full-time, Macrofaculty, graduate studies curriculum
The graduates are very well prepared theoretically and practically to take creative work in the telecommunication companies. They have broad knowledge and skills in the design, operation and testing of computer networks (wired and wireless), sensor networks, devices and telemedicine systems, software systems, as well as in telecommunications equipment or systems. These qualifications ensure the achievement of employment in companies engaged in the development and implementation of modern means of telecommunication technology, in the business units creating and exploiting ICT systems, at ICT network operators and telecommunications companies and software developers for these operators, in the Internet service providers, in establishments producing and telecommunication equipment, in educational research.

The staff members of the Institute of Informatics lead courses belonging to core curriculum courses mandatory for all students.

**Full-time, Industrial Computer Science, undergraduate studies**

The curriculum of undergraduate Industrial Computer Science conducted by the Faculty of Automata Control, Electronics, and Computer Science and Faculty of Materials Engineering and Metallurgy combines elements from material and computer science. The staff members of the Institute of Informatics lead courses belonging to core curriculum courses mandatory for all students.

**Other possibilities for students to improve their qualification**

**New trends in computer science**


The aim of this project is to teach prospective participants who already have programming abilities how to create software which not only fulfills functional requirements but has also a sufficient structural quality. The course contains eight independent modules described below. All modules consist mostly of hands-on laboratories during which participants learn by example. They try to develop quality code or try to repair the code provided by a teacher:

- Advanced programming of mobile devices (Lectures: 30, Lab Classes: 30)
- Practical usages of Design Patterns (Lectures: 15, Lab Classes: 30)
- Security of environment with mobile devices (Lectures: 30, Lab Classes: 30)
- Software engineering (Lectures: 30, Lab Classes: 30)
- Spring framework (Lectures: 15, Lab Classes: 30)
- Team collaboration methods (Lectures: 30, Lab Classes: 30)
- Topics in modelling human perception and cognition in computer systems (Lectures: 30, Lab Classes: 30)
- Web application security (Lectures: 15, Lab Classes: 30)

Target audience:

- Programmers with knowledge in object-oriented programming (preferably, but not necessary Java) and in basics of web applications development.
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<td>Wireless Networks</td>
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<td>Programming Languages and Paradigms</td>
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<td>Artificial Intelligence and Robotics</td>
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<td>Embedded Systems</td>
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<td>Internet Technologies</td>
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<td>Industrial Electronics and Metrology</td>
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<td>Industrial Controllers Programming</td>
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Total: 2595 hours / Exams / Credits: 1215 / 1516 / 30
• Students who want to practice skills related to developing software for mobile devices.
• Computer science students from any university with a basic knowledge in programming and software design.
• Computer science students from any university with a basic knowledge in programming design.

Lectures are open for all students (limited by the hall capacity – it is assumed at least 30 students). Laboratory classes are provided for two groups of 15 students (2x15=30 students).

Project’s benefits: The education program for students at the Faculty is subjected to the Ministry of Science and Higher Education in the range of minimum curriculum – scope of the subject. Limited number of hours for all courses does not allow to introduce new and up-to-date specialized topics. The proposal (this course) is developed so that the student after the completion of four semesters of engineering in related fields (eg. computer science, automatic control, electricity) could be a conscious participant in the course. Such need flows from the representatives of international companies who estimate a shortage of systems engineers in the near future. Series of courses conducted at the Faculty of Automatic Control, Electronics and Computer Science is an attempt to solve the above problems.

Dealing with a variety of user experience aspects requires a deep understanding of both human perception and possibility provided by hardware on which the software created by developers is running. Obviously, this is a big challenge. That’s why we intend to launch multidisciplinary courses to teach students how to think holistically about interactions between human users and machines. The course aims at providing the knowledge on modern approach to software engineering. This adjust the educational offer of the University to the needs of the market. Students will be better prepared to their future jobs.

ZIP - Become an engineer of the future
(Project No. POKL-04.01.02-00-133/12, National Centre for Research and Development, Human Capital Operational Programme, Subroutine: Priority IV Higher education and science, Measure 4.1 Strengthening and development of didactic potential of universities and increasing the number of graduates from faculties of key importance to the knowledge-based economy, Measure 4.1.2 Increasing the number of graduates from faculties of key importance to the knowledge-based economy, 2013 – 2015),

The project is implemented under the Human Capital Operational Programme, Priority IV Higher education and science, Measure 4.1 Strengthening and development of didactic potential of universities and increasing the number of graduates from faculties of key importance to the knowledge-based economy, Measure 4.1.2 Increasing the number of graduates from faculties of key importance to the knowledge-based economy.

The project was dedicated to full-time students of Computer Science degree conducted at the Faculty of Automatic Control, Electronics and Computer Science, SUT. The project
involves the participation of people recruited in the academic year 2012/2013 in accordance with the Silesian Technical University Senate Resolution No. XIX / 167/09/10 and the general criteria of recruitment.

Support includes followed forms:

1. Motivational scholarships - 50% of students with the best academic results - semester motivational scholarships awarded on the basis of a separate Regulations. 167 students received the scholarships, total amount of budget spend on this form of support: 2,775,620.44 PLN.

2. Remedial Classes - 30% of students with the weakest results from individual subjects countervailable (acc. competence test results conducted before the start of classes compensatory), which aim is to equalize the level of education directional conducted in secondary schools. 152 students received this form of support, total amount of budget spend on this form of support: 46,980.00 PLN.

3. Mentoring Program - practical subjects problems to solve by students delivered by the cooperating companies. The projects assume the students work in the group from 3 up to 6 person under academic (university tutor) and industrial (company tutor) supervision. It is a pilot version of this form of cooperation. During 3 years (2012–2015) of ZIP project over 90 projects within over 40 topics, in cooperation with 15 companies were conducted. Over 120 students participate in those project, over 5500h of Mentoring Program were run. The participation in those projects were preceded by the workshop of group working. The aim of this workshop was to improve the communication skills in the group, to teach planning, time-organizing, task management, etc. 122 students received this form of support, total amount of budget spend on this form of support: 597,500.00 PLN.

4. Internships and Practices - 87 students took part in local internships, 8 in international internships, 57 have a industrial training, total amount of budget spend on this form of support: 760,800.00 PLN.

5. Summer Schools – summer visits in foreign university, the aim of this form of support was to exchange knowledge and experience during lectures, workshops and visits in local companies. 38 students received this form of support, total amount of budget spend on this form of support: 263,025.00 PLN.

6. Courses and Workshops:
   - Entrepreneurship - in order to strengthen soft skills and resourcefulness students, 156 students, 240h (30h/person)
   - Pro-ecological – to improve the ecological awareness and responsibility. 159 students, 24h (8h/person).
   - Technical: 136 students received this form of support, 652h of trainings, Budget: 266,148.65 PLN:
     - 3D Graphics,
     - Cisco Security,
     - Cisco Switching and Networking,
     - IBM Cognos – Framework Manager,
     - IBM Cognos – Report Studio,
7. Open Lectures conducted by practitioners (i.e., industry) to encourage students to practical use in order to supplement their knowledge and expertise through collaboration with external representatives of scientific/research background. The lectures covered the topics about JAVA and .NET programming, 20h of lectures, 72 students, budget: 24,000 PLN.

The total number of people receiving support: 219.

Mentoring program a recipe for efficient education at the Macrocourse on Automatic Control and Robotics, Electronics and Telecommunication, and Computer Science offered by the Silesian University of Technology (Project No. POKL.04.01.02-00-209/11, Human Capital Operational Programme co-financed by the European Union from the financial resources of the European Social Fund, 2011 – 2015),
Project Leader: Marek Pawełczyk, Ph.D., D.Sc., Prof.

The main objective of the project is to promote 60 graduates in 2015, who at the same time have good preparation in automation, robotics, computer science, electronics and telecommunications, speak fluent technical English, and are highly qualified, experienced in project realization and went through specialized training.

A major problem, is the lack of graduates, who combine the knowledge of automation, robotics, computer science, electronics and telecommunications at the level necessary for self-integration of complex systems and cooperation with personnel specializing in different areas. The reason for this is the fact that such training is carried out on a few departments of Polish universities.

Students of Macrofaculty will be the subject of this support, which will prepare them for effective learning, maintain the motivation to learn and strengthen practical aspects of acquired knowledge.

Implementation of the project will result in energizing the enterprises in the squad ready to take big challenges in the development and implementation of IT, who with ease make contact with foreign partners and other IT professionals. For the graduates, including women, this project provides lucrative jobs. The project should also raise the motivation for harder didactic work by the staff of the Faculty. It will be also a reason to motivate the pupils of many secondary schools for learning science subjects.


Employers’ Forum of the Faculty of Automatic Control, Electronics and Computer Science event, is a continuation of Computer Science Employers’ Forum event, which was initiated by Stanisław Kozieński, Director of the Institute of Informatics. From the edition taking place in 2013 the Forum has been extended to the entire AEI Faculty making it an event
common to all institutes and then the Dean of the Faculty Prof. Assoc. Eng. Adam Czornik become the patron.

Since 2013 edition, the Forum is divided into two parts. In the first part the companies have the opportunity to present to the students of the Faculty their offer for internships, practice, and implementation of theses. It is a peculiar form of job fairs combined with simultaneous short multimedia presentation taking place at the same time in the halls of the Department. The second part of the Forum is of closed nature. Its purpose is to discuss in the form of a seminar, the forms and possibilities of cooperation between the Faculty and the companies. Besides were discussed constituent parts of the educational process, including program of study, training, internships and practices, cooperation within theses, as well as mentioning the needs of companies to students and graduates of the Faculty. Moreover the possibilities of cooperation in field of scientific research, especially co-finances from public funds, are discussed and proposed.

The aim of the Forum is to exchange knowledge, expectations and needed experiences of Faculty graduates in the field of education graduates of the Faculty. The Forum have a significant impact on strengthening relations among all participants of the meeting, therefore, it become a cyclical event that builds a framework for future cooperation.

Ph.D. studies

Ph.D. studies at the Faculty of Automatic Control, Electronics and Computer Science are offered in four areas:
- Automatic Control,
- Computer Science,
- Electronics,
- Biocybernetics and Medical Engineering.

The program of the 3rd level Ph.D. studies in the discipline of Computer Science includes a total of 210 hours for full-time and 270 hours for part-time regime. It corresponds to 60 ECTS credits for both full-time as well as part-time studies.

The scope of a four-year doctoral studies comprises three main thematic lines: hardware problems, algorithms and software development, and issues related to the Internet and multimedia techniques. The program consists mainly of monographic lectures, which themes are related to the most important direction of development of modern computer science. The topics of monographic lectures reflect the research carried out by the employees of the Institute of Informatics.

The mandatory lectures cover in their thematics a wide range of subject starting with the basics in modern computing and finishing by identification of the most important direction of future research. Presentation of topics is organised in such a way that possible development of results might be the starting point for new research projects. Lectures are conducted mainly by the employees of the Institute of Informatics, SUT, however lecturers for some courses are professors invited from other universities or institutions.

The facultative courses aim in development of teaching and professional skills of Ph.D. student. The introduction to didactic work is given by lectures concerning teaching
methodologies and new technologies applied in the education of students. All Ph.D. students have their individual profile of lectures connected with building the bases of their future research work. Those topics are chosen in consultation with Ph.D. scientific supervisor and the departmental coordinator of Ph.D. studies. Lectures can be chosen from the pool of all Ph.D. level lectures offered at the Faculty and according to the needs and possibilities new courses can be started.

Following facultative courses are offered in the programme of Ph.D. studies:

- Bioinformatics,
- Computer Methods in Genomics,
- Computer Methods in Medical Statistics,
- Innovative IT Projects,
- Modeling of Biomolecules,
- Moodle as an Example of a Content Management System,
- Recursive Functions.

Apprenticeships take the form of 10 hours at part-time and 30 hours at full-time studies of didactic classes preparation. However Ph.D. students employed as academic teachers are exempted.

Apart from lectures the programme of Ph.D. studies includes Ph.D. seminars. The seminar group for a Ph.D. student is chosen in consultation with Ph.D. scientific supervisor and the departmental coordinator of Ph.D. studies. During the seminar, every Ph.D. student at least once within the semester should present directions of research and interests and the advances in scientific work. Ph.D. students are also encouraged to organise journal club meetings devoted to presentation of most recently published scientific results, related to topics of their Ph.D. theses.

Seminars and lectures are obligatorily held in English if at least one participant is a foreign language speaker. However, seminars and lectures can be held in English also basing on the agreement between the students and a lecturer, in consultation with the departmental coordinator of Ph.D. studies. For Ph.D. part-time students the programme includes English language classes.

In the second year of Ph.D. studies students should choose a Ph.D. thesis supervisor from full professors and conduct research in accordance to the recommendations.

**Ph.D. studies in Data Mining**

Ph.D. students have the opportunity to take part in the special 8-semesters studies in "Data Mining". Studies are meant for all candidates who have already received M.Sc. degree in Computer Science and want to expand their knowledge in this particular field. The curriculum consists of courses taught entirely in English, based on the best European practices in organising Ph.D. studies.

The curriculum of the doctoral studies comprises:

- Data Exploration and Extraction,
- Data Mining, Fusion, Compression,
- Database Management Systems,
- Databases and Data Warehouses,
- Image Compression and Lossless Compression,
- Industrial, Medical and Textual Data Analysis,
- Query Optimisation,
- Parallel Processing.

The programme includes lectures (total of 110 hours per semester) given by professors of the Institute of Informatics as well as visiting professors. Laboratory and project exercises are supervised by post-docs (total of 110 hours per semester). Ph.D. students take part in practical trainings in leading scientific and research institutions in Poland and abroad. A part of doctoral students’ activity is participating in scientific conferences. The studies are completed with presentation of the doctoral thesis which leads to receiving the doctoral degree in computer science.

'Scientists of the Future': the Scholarship Program

Dean of the Faculty of Automatic Control, Electronics and Computer Science announced the Scholarship Program "Scientists of the Future" at the Faculty of Automatic Control, Electronics and Computer Science, SUT.

The Scholarship is granted for a period of 12 months of the academic year for Ph.D. students of the Faculty, who meet the following requests: have the doctorate initiated, are the authors or co-authors of publications printed in leading journals, participated in scientific conferences, and submitted the opinion of the Ph.D. supervisor.

Postgraduate studies

Postgraduate studies are conducted as weekend studies, mainly on Saturdays. They are organised in two semesters of classes and offered in five specialisation areas:
- Computer Networks and Systems, Databases,
- Internet and Mobile Technologies in Information System Design and Realisation,
- Methods of Exploration of Enterprises’ Databases,
- Production Management,
- Teleinformatics in Aviation.

Computer Networks and Systems, Databases

Postgraduates have the opportunity to take part in the special two-semester studies meant for all technicians who want to expand their knowledge on computer networking, databases, programming in the Internet and mobile technologies. The studies include eight courses, most of them in the form of a lecture and laboratory exercises (total of 255 hours). Curriculum of the postgraduate studies consists of:
- Computer Networks,
- Computer System Security,
- Computer Systems Interfaces,
Methods of Exploration of Enterprises’ Databases

The objective of postgraduate studies is to educate data analysts who can effectively and rationally use the knowledge accumulated in data so as to assist their business activity. These studies allow the students:

- to get acquainted with data exploration models and techniques (data mining), i.e. explorations of hidden, valuable information so as to be able to apply it in various domains: industry, management, commerce, marketing, banking, finance, medicine, biology, sociology, psychology;
- to get acquainted with the environment of different software modules (e.g., STATISTICA DATA MINER, WEKA), which enable one to use these technologies in practice;
- to conduct a real data exploration on large data sets;
- to show how to solve real business problems by means of widely available exploration technologies.

The studies are dedicated to university graduates with different profiles who want to supplement their education within the range of modern methods of conducting exploration analysis, and particularly to managers of analytic departments and other employees dealing with preparation of analyses and reports in banks, production companies, consulting and insurance agencies, telecommunications, commercial enterprises or public administration.

Internet and Mobile Technologies in Information System Design and Realisation

Studies are addressed to computer scientists and alumnus of universities who use software tools. During the courses students are acquainted with basics of designing websites and tools for building the Internet systems. They also learn features of mobile devices and techniques of their programming.

Curriculum of studies consists of ten subjects. Architecture and Design of Internet Information Systems addresses basic concepts and terminology of programming languages, basics of databases and information system designing. Fundamentals of Creating the Website familiarises with standard and technologies used for websites programming. Among the key subjects of the studies there should be enumerated lectures presenting three basic platforms for the Internet systems creation: .NET, Java, and Open Source technologies. During Database Management Systems lecture students are also acquainted with popular
database systems like Oracle, MS SQL Server, PostgreSQL. Amid other lectures students find three subjects concerning mobile technologies and presenting operating systems, mobile databases, mobile programming languages and various aspects of Internet and mobile system security.

Teleinformatics in Aviation

The studies offered by the Faculty of Automatic Control, Electronics and Computer Science, SUT, at the Personnel Training Center of Civil Aviation of Central and Eastern Europe is a novelty on the Polish education market.

The Center has been created in response to the growing demand for aviation industry employees—it is estimated that over the next 5 years the employment will increase by about 23 thousand, with additional posts concerning the use of airports and airspace. There will be required not only professionals in navigation, but also familiar with airport management and the organisation of work in the airline industry. Airports will need people responsible for maintenance of runways, technical state of aircraft flight control, security and passenger service, etc.

Aviation Personnel Training Center for Central and Eastern Europe (the first in Poland) is the training place of such specialists. It is a joint initiative of the Ministry of Transport, Civil Aviation Office (CAO), Silesian University of Technology and Aviation Association. Silesian University of Technology provides experienced and highly qualified staff, educational and training infrastructure, and coordinates organisational activities of the Center. CAO ensures authorisation of educational programmes within the scope of air rules and supervision to guarantee compliance of study, training and courses with the international standards for civil aviation. GTL—a management company for the International Airport in Katowice-Pyrzowice—ensures access to aviation infrastructure.

The first enrollment for the postgraduate studies took place in October 2008. The list of subjects taught:

- Airport Management Systems,
- Communication Systems in Civil Aviation,
- Diploma Seminar,
- Information and Communication Technology, and Radio Communication in Aviation,
- Information Systems for Meteorology,
- Integration of Information and Communication Systems Airline,
- Management of Air Navigation Services,
- Management of Complex IT Projects,
- Navigation Systems,
- Passenger Service Systems,
- Security of Information and Communication Systems,
- Strategy Development of Civil Aviation,
- Surveillance Systems in Civil Aviation,
- Transport Systems and Segregation of Luggage.
Production Management

Due to the rapid development of science and technology and increasing competition in the labor market, continuous expansion of skills of the modern engineering staff is required for effective practice. The aim of the study is to deepen and update the knowledge on the automation and industrial information technology. The program of study concerns the latest technologies in control systems and production management, and includes the following topics:

- design of automatic control structures of industrial processes carried out in a continuously or in a batch mode,
- programming and utilisation of industrial controllers (PLC) on the example of products of selected companies,
- industrial networks, their property, security components and the design of distributed control systems,
- computer networks and their application to build the Internet systems and services using Internet technology,
- industrial database,
- design and programming of computer control, monitoring, and visualization systems of industrial processes (SCADA),
- creation of operator interface using operator panels,
- integrated ERP systems, supporting control and production management.

The program of the course consists of 240 hours of classes, including 105 hours of lectures and 135 hours of laboratory exercises.
Scientific activities

Research areas

1. Algorithmics (Z.J. Czech, S. Deorowicz)
   - Adaptive algorithms (R. Starosolski)
   - Generic algorithms
   - Minimal perfect hashing (Z.J. Czech)
   - Optimisation algorithms
     - Multicriteria optimisation algorithms in transportation and other problems (J. Widuch)
     - Parallel simulated annealing for the vehicle routing problem with time windows (Z.J. Czech)
   - String and sequence algorithms (S. Deorowicz)
     - Bit-parallel algorithms
     - Longest common subsequence and related problems
     - Longest increasing subsequence problem
     - Sequence alignment (A. Debudaj-Grabysz)
     - Suffix trees and suffix arrays algorithms (A. Danek)
       * Bit-parallel algorithms (A. Danek)
       * Longest common subsequence and related problems (A. Danek)

   - Ant colony programming (Z.J. Czech)
   - Artificial neural networks (K.A. Cyran, D. Myszor, U. Stańczyk)
     - Probabilistic (K.A. Cyran)
   - Classifiers—feature extraction for pattern recognition (K.A. Cyran, P. Fabian, A. Gruca, P. Pruszkowski, U. Stańczyk)
   - Computational intelligence
     - Expert systems (A. Gruca, A. Polański, M. Sikora, U. Stańczyk)
     - Fuzzy sets and methods (P. Czekalski, M. Sikora, K. Simiński)
       * Computational aspects of fuzzy reasoning systems
       * Fuzzy reasoning (K. Simiński)
       * Fuzzy reasoning based on fuzzy truth value
       * Genetic algorithms, evolutionary computing and programming (K.A. Cyran, D. Myszor)
         * Rough sets (K.A. Cyran, A. Gruca, M. Michalak, M. Sikora, U. Stańczyk)
           - Classical rough set approach
• Dominance-based rough set approach
• Quasi dominance-based rough set approach (K.A. Cyran)
• Rough biclustering (M. Michalak)
• Selection of relative value reducts (U. Stańczyk)
• Theoretical foundation of rule quality measures (M. Sikora)

− Hybrid methods
  * Fuzzy-neural networks—improvement of efficiency of the learning methods (M. Sikora)
  * Multi-sensor data fusion systems (G. Baron)
  * Neuro-fuzzy systems (K. Simiński)
  * Rough-neuro classifiers (U. Stańczyk)

− Machine learning (A. Gruca, M. Michalak, M. Sikora)
  * Oblique rule induction (M. Michalak, K. Nurzyńska)
  * Rule induction (A. Gruca, Ł. Wróbel)

− Optimisation
  * Heuristic training methods for fuzzy models (K. Simiński)
  * Rule and rule set quality measures (M. Sikora)
  * Selection of rough set relative value reducts (U. Stańczyk)
  * Simulated annealing (K.A. Cyran)
  * The exIWO metaheuristic (expanded Invasive Weed Optimisation) (H. Josiński, D. Kostrzewa)

− Probabilistic methods for uncertain reasoning—analysis of computational efficiency and optimisation possibility of Bayesian learning algorithms (A. Momot)

− Support vector machines (M. Kawulok, M. Michalak, J. Nalepa)

− The study of under- and over-sampling methods’ utility in analysis of highly imbalanced data on osteoporosis (M. Bach, A. Werner)
− The impact of the development of the IT and telecommunication technologies on financial markets (M. Bach, A. Werner)

• Evolutionary algorithms (J. Nalepa)
  − Genetic algorithms (M. Kawulok, J. Nalepa)
  − Memetic algorithms (M. Kawulok, J. Nalepa)

• Training set selection (M. Kawulok, J. Nalepa)

3. Assistive technologies
• Brain-Computer Interfaces (BCI) (K. Dobosz)
• Mobile applications for visually impaired people (K. Dobosz)
• Software tools for impaired people (P. Fabian)
• Support for the rehabilitation of cognitive impairment (K. Dobosz)
• Ultrasonic environment recognition to aid visually-impaired persons (G. Drabik)
4. Biosciences

  - Analysis of DNA sequencing methods (M. Garbulowski)
  - DNA microarray technology (A. Gruca)
  - RNA sequencing technology (A. Gruca)
  - Role, venue and classification of bioinformatics databases (A. Gruca)
  - Similarity searching in protein structure (B. Małyśiak–Mrozek, D. Mrozek)

- Theory of evolution (K.A. Cyran)
  - Complexity threshold in RNA-world
  - Genetic drift
  - Origins of life (D. Myszor)
  - Population genetics (D. Myszor)
    * Coalescence theory (A. Polański)
    * Mitochondrial Eve dating
    * Natural selection


- Computer architecture (D. Caban, P. Stera, A. Ziębiński)
- Computer-based measurement systems and their programming (D. Caban, W. Mielczarek)
- Computer peripherals (W. Mielczarek, M. Sawicki)
- Computer system communication (D. Caban, A. Chydziński, W. Mielczarek, M. Sawicki)

- Control
  - Control based on visual information (K. Wojciechowski)
- Data acquisition and control systems (D. Caban, W. Mielczarek, S. Wideł)
- Design and coding an integrated Facebook web application (M. Bach, A. Werner)
- Electromagnetic compatibility (M. Maćkowski, K. Skoroniak)
  - Electromagnetic discharge
  - Electromagnetic pulse/transients
  - Grounding and shielding
  - Radiated and conducted emissions
  - Radiated and conducted susceptibility/immunity

- Industrial networks
  - Component-based automation (R. Cupek)
  - Embedded systems for industry (D. Caban, R. Cupek, P. Gaj, Ł. Herb, A. Ziębiński)
  - Enterprise management systems (J. Frączek)
  - Fieldbus systems and industrial Ethernet solutions (R. Cupek, P. Gaj, A. Kwiecien, J. Stój)
  - SCADA, MES, ERP—design and implementation methodologies (R. Cupek, J. Frączek, P. Gaj, A. Kwiecien, J. Stój)
Software standardisation (A. Kwiecień, J. Stój)
Wireless networks for industry (P. Gaj, M. Maćkowski)

- Industrial computer systems
  - Virtualization in networked control systems (P. Gaj, J. Stój)
  - Cyber-physical systems in industry (P. Gaj)
  - Industrial controllers (P. Gaj, Ł. Herb, A. Kwiecień, J. Stój)
- Internet (A. Chydziński, T. Czachórska)
  - Distributed system for monitoring of the medical prescriptions (D.R. Augustyn)
  - Future Internet (A. Chydziński)
- Network applications performance in virtual machines environment (A. Chydziński, J. Flak, M. Skrzewski)
- Network traffic modelling - AQM modification (D.R. Augustyn, A. Chydziński, A. Domański)
- Networked application efficiency measurement (A. Domański, M. Skrzewski)
- Performance evaluation of computer networks (A. Chydziński, T. Czachórska, M. Nycz)
- Publish-subscribe networks (R. Wójcicki)
- Remote access (P. Stera)
- Response time measurements and analysis in network systems (A. Chydziński, J. Flak, S. Wideł)
- SAN system networks in multiprocessor system architecture (S. Kozielski)
- VoIP traffic (A. Biernacki, S. Wideł)
- Wireless computer networking (O. Antemijczuk, A. Brachman-Piotrowska, J. Padera, M. Skrzewski, K. Tokarz, B. Zieliński)
  - Analysis and synthesis of medium access protocols
  - Design and configuration of personal, local and wide area wireless networks
  - Data link layer protocols
  - Efficiency estimators
  - Factors having influence on the performance of wireless network
  - Implementation of wireless protocols in microprocessor systems
  - Mobile and embedded Linux based operating systems (F. Klębczyk)
  - Optimisation of Java application for mobile devices (K. Dobosz)
  - Remote control of robots (P. Czekalski)
  - Remote statistical calculation services (D.R. Augustyn)
  - Topology of wireless networks
  - Video data acquisition application over the wireless networks

6. Computer vision and graphics (P. Pruszowski, P. Skurowski, M. Staniszewski, K. Stąpór)
- 3D graphics (E. Lach)
  - Geometric modelling (A. Szczęsna)
- Real-time rendering and 3D graphics engines architecture
- Surface meshes (A. Szczeńsa)
  * Multiresolution representation of objects,
  * Second generation wavelets used for multiresolution decomposition and reconstruction of irregular data
- Animation and games (E. Lach, K. Wojciechowski)
  - Motion analysis and synthesis (A. Szczeńsa)
  - Motion capture
  - Serious games (A. Szczeńsa)
  - Skeletal animation
- General processing on GPU (D.R. Augustyn, S. Deorowicz, B. Małysiak–Mrozek, D. Mrozek)
- Moiré formation (P. Skurowski)
- Multimedia data flow organisation and storage (O. Antemijczuk, J. Paduch)
- Multispectral images analysis (M. Michalak)
- Visualisation
  - Software visualisation (P. Szmali)
  - Visualisation in industrial systems (R. Cupek)

7. Cryptography and information security (J. Lach, M. Skrzewski, A. Ziębiński)
- Computer networks security (M. Skrzewski, P. Stera)
- Hardware security (A. Ziębiński)
- Intrusions and threats detection (M. Skrzewski)
- Steganography (J. Lach)

8. Data processing and storage
- Cloud computing (D.R. Augustyn, M. Bach, P. Bajerski, R. Brzeski, A. Duszenko, B. Małysiak–Mrozek, D. Mrozek, A. Werner)
  - Cloud computing/cloud-oriented information systems (D.R. Augustyn)
  - Databases in cloud computing
  - Processing in cloud computing
- Compression
  - Compression of medical images (R. Starosolski)
  - General lossless data compression (S. Deorowicz, J. Flak, R. Starosolski)
  - Image compression (lossless and lossy) (R. Starosolski)
  - Image compression standards (JPEG-LS, JPEG2000, JPEG XR, DICOM) (R. Starosolski)
  - JPEG compression/decompression for different processor platforms (O. Antemijczuk, J. Paduch)
  - Specialised lossless data compression (A. Danek, S. Deorowicz, R. Starosolski)
- Data fusion—multi-sensor systems (G. Baron)
- Data mining (A. Gruca, K. Simiński, U. Stańczyk)
  - Analysis of human motion (H. Josiński, P. Pruszowski, A. Świtoński, A. Szczeńsa)
– Analysis of incomplete data (K. Simiński)
– Biclustering (M. Michalak)
– Clustering (A. Gruca)
– Data mining of survival data (Ł. Wróbel)
– Feature selection and feature extraction (A. Gruca, H. Josiński, A. Świsłoński)
– Hierarchical biclustering (M. Michalak)
– Industrial and medical data analysis (A. Gruca, M. Michalak, M. Sikora, Ł. Wróbel)
– Textual analysis (U. Stańczyk)

• Data warehouses (J. Frączek, M. Gorawski)
  – Extraction processes and data stream renew processes
  – Grid data warehouse systems
    * Selecting indexing structures (A. Chrószcz, M. Thiele)
    * Software agents and grid processing
  – Spatial data exploration
  – Spatio-temporal data warehouse systems

• Databases
  – Database design (P. Bajerski)
  – Database schema synchronisation (K. Harężlak)
  – Definition of granularity level for some graphical objects metadata storage (A. Duszeńko)
  – Fuzzy logic in databases (B. Malysiak–Mrozek, D. Mrozek)
  – Hybrid column/row-oriented DBMS (M. Bach, A. Werner)
  – Internet archiving (F. Klębczyk)
  – Long-term preservation of digital data (D. Kusnik)
  – Minimising the cost of accessing data, stored in distributed relational database (A. Werner)
  – Mobile databases (K. Harężlak)
  – Multimedia databases (A. Duszeńko)
    * Graphical objects recognition
    * Searching in colour image databases
  – NoSQL databases (D.R. Augustyn, R. Brzeski, E. Pluciennik)
    * Standardization of NoSQL database languages (M. Bach, A. Werner)
    * Object-NoSQL mapping (E. Pluciennik)
    * Preserving integrity in NoSQL databases (D.R. Augustyn, M. Bach, P. Bajerski, R. Brzeski, A. Duszeńko, A. Werner)
  – Object databases (E. Pluciennik)
  – Query optimisation techniques and processing
    * Distributed query optimisation (H. Josiński, D. Kostrzewa)
* Query selectivity estimation methods (D.R. Augustyn)
* Query optimization (D.R. Augustyn)
* Querying image semantic metadata with hybrid data model (A. Duszeńko)
* Recursive queries partitioning (A. Duszeńko, A. Werner, H. Zghidi)

- Security of database systems (J. Frączek)
- Semantic data search (M. Bach)
- Social network analysis
- Spatial databases (P. Bajerski)
- Temporal information inscribing and relational database schema versioning by the use of XML documents (A. Werner)
- XML databases

9. Digital circuits
   - Computer-aided design
     - ASIC/VLSI structures
     - Digital circuits (B. Pochopień)
     - VLSI structures of a very high speed
     - VLSI/ULSI monolithic structures
   - Educational programmes (H. Małysiak, B. Pochopień)
   - Logic circuits fundamentals and arithmetic (K.A. Cyran, H. Małysiak, B. Pochopień, U. Stańczyk)
     - Application of BDD for multilevel synthesis (A. Opara)
     - Properties of arithmetic operations
     - Properties of Boolean functions
     - Synthesis, analysis and transformations of Boolean functions
   - Microprocessor and embedded systems (O. Antemijczuk, G. Baron, G. Drabik, J. Paduch, K. Tokarz, B. Zieliński)
     - Architecture and organisation of modern general-purpose processors
     - Design, implementation and development of systems
     - Embedded systems for wireless transmission
     - Modules for audio and video data acquisition and processing
   - Programmable logic devices
     - Field programmable analog array mixed-signal informatic systems design
     - Hardware description language (D. Caban, A. Ziębiński)
     - Microprocessor and embedded systems for FPGA (D. Caban, A. Ziębiński)
     - Reprogrammable and dynamically reconfigurable FPGA elements (A. Ziębiński)
     - Synthesis of logic circuits with programmable logic devices (A. Opara)

10. Knowledge representation and engineering
    - Clustering XML documents (M. Kozielski)

11. Modelling and simulations
    - Branching processes and coalescence distributions (K.A. Cyran)
• Digital modelling (J. Respondek)
• Discrete event systems modelling with OMNet++ environment (M. Skowronek)
• Discrete-event simulation (A. Chydziński, R. Wójcicki)
• Discrete mathematics in computer simulation (J. Respondek)
• Dynamic continuous system modelling in Matlab and .NET (D.R. Augustyn)
• New technologies in computer networks modelling (T. Czachórski, M. Nycz)
• Numerical methods (J. Respondek)
• Queueing systems and active queue management (A. Chydziński)
• Solution of parameter optimisation tasks using Matlab-Simulink environment (M. Skowronek)
• Systems and networks modelling using SimEvents package (M. Skowronek)
• Traffic modelling (A. Chydziński, M. Nycz)
• Weather simulation and rendering models

12. Nanoscience and nanosystems of informatics (J. Flak)
• Biological and quantum systems
• Nanotechnologies

13. Natural language processing (M. Bach, K. Simiński, P. Szmal)
• Automatic identification of key abstractions for OOA/OOD
• Automatic recognition of emotional expression
• Automatic syntax and semantic analysis
• Automatic translation of database queries formulated in natural language to SQL language (M. Bach)
• Computer model for natural Polish language
• Linguistic analysis server
• Linguistic engineering
• Modelling of meaning of prepositional and adverbial groups of Polish for the automatic word processing (M. Bach)
• SGGE grammar and SG-parser for English
• Spelling correction methods (S. Deorowicz)
• Stylometry (U. Stańczyk)
• Translation of texts into the sign language

14. Parallel and distributed computing
• Tools and practices simplifying efficient parallel programming
• Parallel algorithms for solving complex transportation problems (J. Nalepa)
• Parallel simulated annealing for the vehicle routing problem with time windows (Z.J. Czech)

15. Signal processing
• Algorithms of property extraction from ultrasonic signals (G. Drabik)
• Analysis and processing of medical signals (A. Momot)
• Bar codes (D. Kusnik)
• Denoising algorithms (D. Kusnik)
• Digital geometry processing (E. Lach, A. Polański, A. Szczęsna)
• Discrete wavelet transform (R. Starosolski)
• Eye movement processing (P. Kasprowski, K. Haręzlak)
– Eye tracker calibration
– Processing of eye movement events (fixation, saccades, tremors, etc.)
– Eye movement based biometric identification
– Enhancing human computer interaction with eye movement modality
– Eye movement analyses
• Image processing and recognition (K. Nurzyńska, K. Stąpor, K. Wojciechowski)
  – Automatic segmentation and classification of medical images
  – Emotion recognition (K. Nurzyńska)
  – Gesture recognition (M. Kawulok)
  – Human skin segmentation in digital images (M. Kawulok)
  – Image colourisation (M. Kawulok)
  – Image retrieval
  – Lifting scheme as a 2nd generation wavelet construction tool (A. Szczęsna)
  – Multispectral imaging (A. Świtoński)
  – Reversible color space transforms (R. Starosolski)
  – Wavelets
• Multimedia data (O. Antemijczuk, J. Paduch)
  – Acquisition application over the wired and wireless networks
  – Data flow organisation and storage
  – Performance analysis of data acquisition and storage
• Nonlinear time series analysis (H. Josiński)
• Speech and audio processing and storage
  – Music genre classification (M. Michalak)
  – Speech processing and recognition (P. Fabian)
  – Ultrasonic recognition of environment to aid visually-impaired persons (G. Drabik)

16. Software engineering (K. Harężlak)
• Customizing CASE tools for development process (D.R. Augustyn)
• Development and organisation of open source projects (F. Klębczyk)
• IT project management (J. Frączek)
  – Project management in the Scrum methodology (M. Bach, A. Werner)
  – Project team organization (J. Frączek)
  – Risk management (J. Frączek)
  – Work and cost models (J. Frączek)
• Methods and tools for automation of software testing (D.R. Augustyn)
• Multilayer software architecture (D.R. Augustyn)
• Multilayer software based on micro architecture (D.R. Augustyn)
• Software visualisation (P. Szmal)
• Source code processing tools (P. Szmal)
• Translation theory (M. Kolano, P. Szmal)
• User interface design (K. Dobosz)
• Using frameworks for effective programming (K. Dobosz)
17. Statistical and probabilistic reasoning (K. Stańor, A. Polański)
  • Bayesian inference (A. Momot)
  • Branching processes (K.A. Cyran)
  • Markovian models (A. Chydziński)
  • Principal component analysis (A. Polański)
  • Support vector machines (M. Kawulok, J. Nalepa)

International research projects

Artificial Intelligence, Branching Processes and Coalescent - Searching the Information from a Genetic Cornucopia
(European Commission FP7, ARSInformatiCa, Grant Agreement No. 298995, Project Coordinator (SUT): A. Polański, 2012–2014)

The objective of the ArSInformatiCa International Outgoing Fellowship was to reinforce the international dimension of a research career of European computer scientist Prof. K.A. Cyran, by training him in complementary skills in a world-class research centre, the George R. Brown School of Engineering at William M. Rice University in Houston, USA. The research has been carried out in two fields of information sciences: artificial intelligence (in particular machine learning) and distributed computer simulations applied to retrieval meaningful information from the genetic data. Developed by the investigator rule-based method known as quasi-dominant rough set approach, has been tested in a search for signatures of natural selection at molecular level in genes involved in human familial cancers. Computer simulations of branching processes have been applied to Neandertal Genome Project data to estimate the admixture of Neandertal DNA, subject for the genetic drift, in a gene pool of Paleolithic, anatomically modern humans. Finally, unsupervised and supervised machine learning methods have been applied to Cancer Genome Project data in a search for recessive cancer genes (RCG) from regions of large homozygous deletions.

Automated Assessment of Joint Synovitis Activity from Medical Ultrasound and Power Doppler Examinations using Image Processing and Machine Learning Methods, acronym: MEDUSA

The main research goal of the MEDUSA project is a computer aid diagnostic system that will allow for automated assessment of synovitis severity. Medical ultrasound imaging is an important tool in diagnosing and monitoring of synovitis, an inflammation of the synovial membrane that surrounds a joint. Ultrasound images are examined by medical experts to assess the presence and progression of synovitis. Automating the image analysis should reduce the costs and increase the availability of the ultrasound diagnosis of synovitis and diminish or eliminate subjective discrepancies. The MEDUSA project, a collaboration between five institutions, is being conducted in Poland and Norway towards automated assessment of synovitis activity, or synovitis estimator. Our research is
focused on applying an ultrasound confidence map for bones region detection for Rheumatoid Arthritis assessment. The confidence map is directly related with the likelihood of ultrasound transmission. The values of the confidence map can be interpreted as relative signal strengths at different image locations and we expect to observe the stronger reduction of signal strength, when the signal passes through the bone. The bone feature descriptor based on confidence maps allows for highly accurate localization of the bones surface.

We have constructed the synovitis estimator that uses a novel approach that includes digital image processing techniques and multiple layers of classifiers trained using methods of machine learning. To begin with, examples of ultrasound images of finger joints that show varying degrees of synovitis are provided by physicians and annotated by trained personnel who inscribed anatomical features such as joint, bones and skin, and circumscribed the area of synovitis. To help with the process of collecting USG images and manually annotating the structures of interest, as well as verifying the annotations by a specialist, we have created a tool called Annotation Editor.

The annotated images are used to train and to test the classification and recognition methods. The synovitis estimator consists of two main parts. The first part, called registration, finds the joint and the bones in an ultrasound image. They need to be detected in an image, in order to establish a frame of reference for measuring geometric parameters of an evaluated area which represent a synovitis.

The registration method first utilizes local feature detectors, tuned to seek in an image the joint, bones and the skin. Each of these detectors is a classifier, trained on the annotated images to find a particular feature type. Since these local feature detectors make mistakes, instead of relying on a single detector, the entire set of detector responses is matched with a structural model consisting of parts representing the local features and geometric relations among the parts, with an objective of minimizing the discrepancy of feature identities and the geometries between the model and the set of detector responses. Such a collective structural match is more likely to correctly identify the joint and bones, than individual detectors. The models used for such structural recognition are constructed using unsupervised learning. The second part of synovitis estimator is a trainable classifier which seeks a synovitis region and estimates the level of synovitis activity, based on image features and geometric measurements of the region relative to the frame of reference.

**Automotive Production Engineering Unified Perspective based on Data Mining Methods and Virtual Factory Model, acronym: AutoUniMo**


AutoUniMo is an Industry-Academia Partnerships and Pathways project carried out under FP7 Marie Curie Actions. AutoUniMo joins two academia (Silesian University of Technology, Technische Hochschule Ingolstadt) and two industrial partners (Continental, AIUT) that conduct research in the area of automotive engineering and applied informatics. The main goal of the project is to share academic knowledge and industrial expertise to fulfil knowledge gaps in automotive production support area. AutoUniMo’s academic
partners help industrial partners to apply new engineering and informatics approaches and to verify their usefulness in automotive industry. All project partners are convinced that proper identification of patterns and data structures available in production systems will make possible the more efficient ways for converting raw materials into final products and will support more competitive production.

SUT leads the research on the 'Artificial Intelligence in Advanced Driver Assistance Systems'. The main goal of WP3 is a fusion between artificial intelligence and data mining applied in Advanced Driver Assistance Systems (ADAS). WP3 has been started from the case studies on the existing solutions available for ADAS. The research work results are presented in report titled 'Strategies for Artificial Intelligence in Advanced Driver Assistance Systems'. The preparation of research environment for the application of artificial intelligence for ADAS support has been started. The first version of mobile platform based on RaspberryPI board has been prepared and tested. The communication between radars, lidars, cameras and control system is ensured by CAN network. The research on the application of artificial intelligence for mobile platform control includes the work on neural network implemented in FPGA.

AutoUniMo project gives strong support to the research carriers of ten researchers (ERs and ESRs) directly involved in the secondments mechanism. Moreover, tens of partners’ staff members including industrial research staff, Ph.D. and master students are involved in activities carried out under AutoUniMo project. Partners strongly believe that new experiences and new skills obtained by research teams’ members are crucial for their future career development. AutoUniMo will also give direct support to project partners. SUT will benefit from new research environment for artificial intelligence in advanced driver assistance systems support that will be used both in future researches and education activity as well.

Cloud Computing in the Service of 3D Protein Structure Similarity Searching, acronym: Cloud4Psi

(Microsoft Azure for Research Award grant, Project Manager: D. Mrozek, 2014–2015)

Protein 3D structure similarity searching refers to the process in which a given protein structure is compared to another protein structure or a set of protein structures collected in a database. The aim of the process is to find common fragments of compared protein structures, fragments that match to each other. The presence of matching fragments, and occurrence of protein structure similarities, may indicate common ancestry of proteins, and then organisms, their evolutionary relationships, functional similarities of investigated molecules, existence of common functional regions, and others. The role of the process is especially important in situations, where sequence similarity searches fail or deliver too few clues and then, protein 3D structure similarity searching becomes the primary technique allowing to draw reasonable conclusions, e.g. regarding the function of the unknown protein. There are also several processes, e.g., validation of predicted protein models, where protein structure similarity searching plays a supportive role.
Although, protein structure similarity searching belongs to a group of the primary tasks performed in the domain of structural bioinformatics, it is still very difficult and time-consuming process. The three key factors deciding on this are as follows:

- Protein 3D structures are complex - proteins are built up with hundreds of amino acids, and therefore, thousands of atoms, and sometimes have several chains in their quaternary structures, which makes the comparison process difficult;
- The similarity searching process is computationally complex - the problem belongs to the NP-hard problems, although, some of the methods report to complete it in a linear time and space; most of the widely accepted algorithms, like VAST, DALI, LOCK2, FATCAT, CE, FAST, have a high computational complexity; and the process itself is usually carried out in a pairwise manner, comparing a given query structure, provided by a user, to successive structures from a database, one-by-one;
- The number of 3D structures in macromolecular data repositories, such as the Protein Data Bank (PDB), grows exponentially; as of Feb 11, 2014 there were 97,789 structures in the PDB.

These factors motivate scientific efforts to develop new methods for 3D structure similarity searching and building scalable platforms that allow completing the task much faster. Cloud computing provides such a kind of scalable, high-performance computational platform.

The objectives of this project are therefore to:

- Collect protein macromolecular data in the storage space of the Microsoft Azure cloud,
- Design a dedicated architecture and algorithms for scheduling scientific workflows related to protein structure similarity searching on the Cloud.
- Develop a cloud-based, high-performance and highly scalable system for protein 3D structure similarity searching and protein function identification.
- Verify scalability of the system, both horizontal and vertical, by distribution of computations on the Microsoft Azure cloud platform.

**Helicopter Deploy GNSS in EUROPE - Next, acronym: HEDGE NEXT**
(European Commission FP7, Cooperation, Transport including Aeronautics, Galileo Grant Agreement No. 287225, Coordinator: Pildo Labs., Barcelona, Spain, Project Leader at SUT: K.A. Cyran, 2012–2014)

The HEDGE NEXT project had the following two overall objectives:

- to complete the life-cycle for the implementation of APV procedures in the rotorcraft sector at multinational panorama involving main important Emergency Services Operators,
- to perform R&D towards the full exploitation of EGNOS services into the rotorcraft sector in coordination with main rotorcraft manufacturers strategies and developments.

A Team complemented by different European ANSPs and Rotorcraft operators, has built up a Consortium to:
• operationally implement Rotorcraft EGNOS (European Geostationary Navigation Overlay Service) APV (Approach with Vertical Guidance) in selected sites from Spain, Poland and Switzerland, by involving national leaders rotorcraft operators on Emergency services, being INAER a Design Organization Approval (DOA);
• create low-level RNAV routes that intercept previous SOAP (SBAS Offshore Approach Procedure) procedure criteria implemented in the North Sea;
• move forward on the development, test and validation of curved approaches for rotorcraft helicopters using GPS and SBAS as sensor: PinS RNP-AR concept;
• develop a "e-VFR" (enhanced-VFR) navigation module in order to improve the safety of the navigation in marginal VFR conditions, initially based on EGNOS but in the future enhanced with Galileo services.

HEDGE NEXT was framed as follow up of activities initiated under previous HEDGE activity. This new project phase aimed at completing the operational implementation of EGNOS operations into the rotorcraft domain, by supporting the certification of vehicles and validation of EGNOS enhanced operations from different operators spread over Europe. HEDGE NEXT in addition included an important part on R&D, towards the full exploitation of EGNOS services into the rotorcraft sector. Those initiatives were either identified and recommended to pursue during the first phase of the activity, or upcoming from parallel activities under Clean Sky framework, and as such endorsed by Eurocopter and Augusta Westland R&D strategy.
The EGALITE project was designed for intersectorial transfer of knowledge and staff training between Silesian University of Technology (as coordinator of the project), and two efficient SMEs: Pildo Labs from Spain and LG Nexera from Austria. The project has achieved this goal in the field of multi-sensors mobility applications for emergency prevention and handling using European EGNOS/Galileo global navigation satellite system (GNSS). Through collaborative research programme, the partners have developed prototypes of original and innovative terrestrial and aviation GNSS applications. Starting with multisensor studies and exploiting professional integrating technologies, the EGALITE partnership have implemented and verified in the field tests:

- new functionalities to e-Call service intended to bring through mobile devices with integrated accelerometers rapid assistance to motorists involved in a collision or traffic jams anywhere in EU,
- system aimed to prevent emergency for helicopters flying close to ground in foggy conditions by using satellite navigation systems integrated with electronic flight instrument system (EFIS) developed by SUT researchers in collaboration with Pildo Labs.

The research addressed also in artificial intelligence and machine learning methods in order to recognise the type of the emergency situation from sensor raw data supplemented by mathematical models. The project has studied the employment of a hardware black box installed in vehicles that is able to wirelessly send information about impact (measured by accelerometers), as well as GNSS coordinates to local emergency agencies. The use of mass-market mobile phones devices with integrated GNSS receiver in combination with accelerometer has been also considered in the implementation of the enhanced e-Call service concept. For that purpose, investigating of the precision limits in positioning techniques for single frequency low cost GNSS receivers has been studied. Noteworthy, the application of GNSS in aviation industry has been studied in SUT’s Virtual Flying Laboratory equipped with professional flight simulators of airplanes and helicopters with mounted GARMIN 430 GPS receivers.
Development and goal-oriented projects supported by Ministry

Creation of a new specialisation: Data Mining for postgraduate studies in computer science discipline
(Project supported within Human Capital Operational Programme—Priority 4.1.1 Strengthening and development of didactic potential of universities, Project leader: S. Kozielski, coordinator responsible for organisation: R. Cupek, 2009–2014)

The basic task in the project was to create at the Faculty of Automatic Control, Electronics, and Computer Science, SUT, the new specialisation increasing the attractiveness of education offer at the 3rd level studies. Other goals of this project involve improving qualification of the scientific-didactic staff and modernisation of the curriculum. Visits and professional trainings on teaching techniques for the staff of the Institute are arranged as well. The project aims at ensuring contacts of the staff with scientists from other institutions by organising some invited lectures and adapting the programme for doctoral studies to industry needs. Works are also focused on preparation of new lectures and books. Besides, the mainframe workstation was deployed and facilitated to the Ph.D. students. Heterogeneous structure of the workstation gives the opportunity to conduct multi-directional research.
Compression and data mining algorithms for genomic data and their implications for comparative genomics
(Grant No. 2011/01/B/ST6/06868, Project leader: A. Polański, 2011–2014)

The project aims include elaborating new algorithms and refining/developing existing algorithms for compression and searching through genomic data and applying the developed algorithms to several research tasks in molecular biology and comparative genomics. The research plan of the project includes four steps.
- Elaborating and developing algorithms for compression of genomic sequences.
- Elaborating new algorithms for searching through genomic sequences, focused on targeting specific features of individual variation at the genomic level, such as: copy number variation (CNV), single nucleotide polymorphisms (SNP), variable number tandem repeats (VNTR).
- Application of the above described tools to several data mining researches related to the 1000 Genomes Project.
- Construction of the www server for supporting dissemination of the obtained methods and making available collected and compressed data to researchers.

The project is conducted on the basis of the cooperation between the team of bioinformaticians and computer science engineers from the Institute of Informatics, Faculty of Automatic Control, Electronics and Computer Sciences, Silesian University of Technology, Gliwice and the team of bioinformaticians and molecular biologists from Faculty of Biology, Adam Mickiewicz University, Poznań. Engineers develop computational models and algorithms and biologists supervise research tasks related to comparative genomics, will help in tuning the developed methods, formulate suitable optimization indexes and will verify the obtained results. The important part of the repository is the web based interface that allows researchers to browse and retrieve stored data. With the huge amount of data coming from the 1000 Genomes Project and other large-scale sequencing projects it is essential to manage these enormous amounts of data in a coherent, clear, and concise way. By using the intuitive interface users can easily query the database for the genomic regions of interest as well as access and download the whole genome sequence alignment data files.

Grants awarded by the Ministry of Science and Higher Education

M. Kawulok: Hand detection and hand pose estimation for creating human-computer vision-based interaction
(Iuventus Plus Grant No. IP2011 023071, 2012–2014)

Existing gesture recognition systems are inefficient and require the use of a number of simplifying assumptions. Low efficiency of algorithmic solutions in the field of image analysis limits the deployment of vision-based interfaces, resulting in their low prevalence. However, it may be observed that the systems based on the additional sensors (e.g., a sensor glove which provides information about the location of hands and fingers, or a depth
sensor) are characterized by a much higher efficiency than systems operating solely on the basis of 2D computer vision. This leads to the conclusion that the primary limitation of the vision-based solutions lies in poor detection of relevant parts of the human body, especially the hands and arms. This motivates the research direction undertaken within this project.

The aim of the project is to develop new algorithmic solutions designed to detect hands in digital images, and then track them in video sequences. The difficulty of this task is primarily due to the high number of degrees of freedom of a human hand, which is the reason for a large variation of its image. Also, human skin color is characterized by a large variance and low specificity.

For the sake of the project, a database of human gestures was created, available at http://sun.aei.polsl.pl/~mkawulok/gestures. It includes still images of the gestures along with ground-truth skin presence masks and data files with hand feature points locations. The project encompasses several main computer vision tasks, namely: skin region detection, hand feature points location, hand shape matching, and feature points tracking. So far, a number of novel ideas have been proposed and published during the research carried out within the project, which altogether contributes to the state-of-the-art regarding gesture recognition.

M. Kawulok: Evolutionary methods for support vector machines training set optimization

Support vector machines (SVMs) are a supervised classifier, which was applied to solve a number of problems that require advanced pattern recognition, primarily in the field of computer vision and bioinformatics. Training the SVMs consists in finding a hyperplane that separates the data belonging to two classes after their projection into a higher-dimensional space, in which the data are linearly separable. Due to the fact that the projection is realized indirectly using kernel functions, the hyperplane is not given by an equation, but instead it is determined by some vectors from the training set, termed support vectors.

A significant disadvantage of SVMs lies in their high time \(O(n^3)\) and memory \(O(n^2)\) complexity of the training, where \(n\) is the number of vectors in the training set. Not only does it make SVMs practically inapplicable, when the training set is large, but it also results in a greater number of support vectors, which in turn increases the classification time. This drawback can be addressed by reducing the original training set, and selecting only those vectors which are most likely to be picked as support vectors during the training stage.

The problem of reducing the training sets is known in the research community, however it has received relatively little attention. Existing approaches consist in random sampling or in the analysis of the data geometry, either in the input space or in the kernel spaces. The aim of this project is to investigate the possibilities of exploiting evolutionary methods for this purpose, which has not been explored so far. Results of the initial works indicate that the SVMs training sets can be successfully selected using a genetic algorithm, and
this research direction is followed in this project. In particular, attention is given to memetic approaches which combine the genetic methods with data structure analysis. Also, the research plan includes making the genetic algorithm adapted to the presented training set, which improves the convergence of the optimization process.

Grants awarded by the National Centre for Research and Development


Major tasks of the project:

- Proposing a loosely-coupled component multilayer architecture of a hospital information system (HIS) designed for networked medical units.
- Proposing information technologies for medical systems based on a flexible definable business processes approach.
- Proposing communication technologies for distributed software components of a networked HIS.
- Preparing scalable components of HIS for deploying and processing in a Data Center or a public cloud.

Grants awarded by the National Science Centre

S. Deorowicz: Algorithms for text data processing (Grant No. PBU/19/RAU2/2012/505, Decision No. UMO-2011/03/B/ST6/01588, 2012–2015)

The project concentrates on the algorithms in which the data being processed are texts, e.g. words, strings of characters or integers. In practical applications the sizes of these data can be very large. For example, the human DNA sequence consists of 3 billion pairs of nucleotides containing 30 thousand of genes grouped into 23 chromosomes. Books edited by various publishing tools (editors, spellcheckers, formatters etc.) can be of size of several millions of characters. The dictionaries and lexicons commonly used in natural language processing may contain from 100,000 words (e.g. English dictionary) to 700,000 words (e.g. French dictionary with inflected forms).

In order to process effectively the text data of large sizes, the fast and scalable algorithms are needed. The main goal of this project proposal is the development of the theory and practice of this kind of algorithms.

The research of this project concern the selected problems in the area of text data processing. Among them are the problems of:
• sequence comparison,
• multiple sequence alignment,
• induction of the minimum size automata consistent with the sets of examples and counter-examples,
• decomposition of finite languages.

The detailed tasks which are planned to be accomplished in the project are as follows:
• Elaboration of a set of tools (general procedures) unifying the bitwise parallelism approach for sequence comparison problems.
• Design of the serial and parallel algorithms for the multiple sequence alignment problem.
• Formulation of the problem of finding the smallest nondeterministic finite automaton as a linear or nonlinear integer programming task.
• Formulation of the problem of finding the smallest push-down automaton as a linear or nonlinear programming task, or by making use of some other exact method like divide-and-conquer, branch-and-bound, dynamic programming.
• Establishing the limitations of the devised algorithms for inducing minimum size automata in terms of the input data size and the computation time.
• Elaboration of the examples which show that the devised algorithms for inducing the automata can serve as a useful tool in enumerative combinatorics and combinatorial game theory.
• Design of the efficient and scalable parallel algorithms to solve the complex tasks formulated during the investigation of the project’s problems.

S. Deorowicz: Memory efficient algorithms for processing and analysis of genome sequencing data
(Grant No. PBU/11 /RAU2/2013/505, Decision No. UMO-2012/05/B/ST6/03148, 2013–2016)

Intensive progress in bioinformatics in recent years, especially in development of cheaper and faster sequencing technologies, results in huge growth of data volume. The answer for such challenges are usually data compression methods, which not only reduces the requirements of external memory, but often also speeds up the analysis of data directly in compressed form, processing more data in a fixed (and limited) amount of memory of the used working station. A similar approach is a use of external memory as a much cheaper, but also much slower, extension of RAM. We plan to design specialized techniques of memory efficient representation of bioinformatics data, often using external memory as an extension of operating memory. Our works are focused on:
• compression of data from genome sequencing,
• counting of k-mers occurrences in genome sequencing data,
• correction of errors in reads, handling also insertion and deletion errors,
• mapping of sequencing data onto a reference genome, also with support for insertions and deletions.

Our research hypothesis is: the considered problems can be solved in a tolerable time at a relatively cheap working station (single 6-core CPU, 2-4 HDD, 32 GB RAM) for real data
of Homo sapiens size. Sequencing data for a single individual often consumes hundreds of gigabytes, so most known algorithms require computers (or even clusters) with at least 128 GB of RAM. More memory efficient algorithms (if they exist) are usually slow. The aim is to find the fundamental constraints relating computational power, external memory and RAM usage for basic bioinformatics problems, mentioned above. This theoretical aim has very important practical implications.

A. Gudyś (Principal Investigator), S. Deorowicz (Supervisor): Algorithms for the multiple sequence alignment problem and its variants
(Pre-doctoral grant in PRELUDIUM funding scheme, Decision No. UMO-2012/05/N/ST6/03158, 2013–2015)

The aim of the project is to develop new algorithms for the multiple sequence alignment problem (MSA). There are three research directions to be followed in the project:

- improving quality of the final alignment,
- introducing additional biological knowledge to the alignment procedure,
- reducing computation time (particularly by parallelizing algorithms on CPU or GPU).

As a result of the project, new algorithms better than existing ones in terms of results quality, execution time and feasibility of incorporating a priori knowledge will be developed. Efficiency of presented methods will be evaluated on a variety of datasets (synthetic, benchmarking and real-life ones). Algorithms will be published online in a form which allows them to be easily used by the community in biological analyses.

A. Polański, M. Garbulowski (Executors): An atlas of brain regulatory regions and regulatory networks - a novel systems biology approach to pathogenesis of selected neurological disorder
(Symfonia3 scientific project, National Science Centre, Faculty of Mathematics Informatics and Mechanics University of Warsaw, Nencki Institute of Experimental Biology of the Polish Academy of Sciences, Institute of Computer Science of the Polish Academy of Sciences, Institute of Informatics of the Silesian University of Technology, Poland, 2015–2020)

We would like to identify brain regulatory regions and regulatory networks in glial brain tumors (gliomas) and intersect them with ENCODE regulatory DNA maps to make an atlas of brain regulatory regions and networks. Due to their diffusive nature, surgically removed gliomas contain tumor tissue and approximately 40% of normal nervous tissue and immune cell infiltrates, which provides a heterogeneous pool of cells. Our innovative strategy capitalizes on the recent advances in the ENCODE project, the completion of the high-resolution maps of the regulatory regions, as well as on new developments in computational data analysis and systems biology. Based on the assumption that DNA variants associated with specific human diseases or clinical traits concentrate in the regulatory DNA sites revealed by our studies, we will pursue whether genetic alterations and candidate variants identified by recent GWAS studies in common neuropsychiatric disorders occur within brain specific, regulatory regions.
The results will elucidate the today unknown role of transcriptional and epigenetic dysfunctions in brain tumors and major neuropsychiatric disorders and likely identify novel predictions that may allow further research on better diagnostics. We may reveal novel targets for the therapy of lethal tumors. The development of new computational approaches and tools will stimulate new research in computing and statistics as well as influence the way other diseases are studied. The results will be published in high impact international journals and be presented at leading domestic and international conferences.

Rector’s grants

M. Kawulok: Habilitation Grant

The aim of this research grant consists in developing new algorithms for human skin detection and segmentation in color images. Applications of skin detection are of a wide range and significance, including gesture recognition and human-computer interaction, objectionable content filtering, content-based image retrieval, image coding using regions of interest, and many more. In general, the existing techniques for skin detection are based on the premise that the skin color can be effectively modeled in various color spaces, which in turn allows for segmenting the skin regions in a given color image. Effectiveness of pixel-wise color-based skin color models is limited due to high variance of skin color and its low specificity, and their discriminating power can be increased by employing additional sources of information. This research direction is exploited within this grant, and particular attention is given to: 1) involving textural features, 2) spatial analysis of pixels preliminarily classified as skin, and 3) skin model adaptation to a particular scene or individual. Algorithms which benefit from these data sources offer much higher accuracy, and they substantially reduce the detection error.

A. Kwiecień: Mentoring program - a recipe for efficient education at the Macrocourse on Automatic Control and Robotics, Electronics and Telecommunication, and Computer Science offered by the Silesian University of Technology
(POKL.04.01.02-00-209/11, 2011–2015)

R. Starosolski: Habilitation Grant
(No. 02/020/RGH15/0060, 2015)

A common approach to RGB color image compression is to independently compress the image components obtained using a color space transform from the RGB to a less correlated color space. An unwanted side effect of color space transform performed using lifting steps is that removing correlation contaminates the transformed components with noise from other components and therefore may increase the amount of noise that must be encoded during compression of an image. To alleviate this problem, the replacement of lifting steps with reversible denoising and lifting steps (RDLS), which are basically lifting
steps integrated with denoising filters, was proposed. The approach was found effective for the RDgDb color space transform and for the discrete wavelet transform (DWT). For the latter, the noise filtering is most effective when applied to some lifting steps only. On the other hand, some images are better compressed when the color space transform or DWT stage of the image compression algorithm is skipped. The main aim of the research supported by the 02/020/RGH15/0060 grant is to improve effects of lossless compression algorithms by: finding better denoising filters and better image-adaptive denoising filter selection methods for RDLS, partial skipping of transforms, and applying RDLS to other color space transforms and to 3D DWT.

Co-operation in grants

S. Deorowicz (head of the laboratory), A. Gudyś, A. Danek: High performance computing laboratory within GeCONiI (POIG.02.03.01-24-099/13 grant: 'GeCONiI–Upper Silesian Center for Computational Science and Engineering')

The study of nucleotide and amino acid sequences contributes to a better understanding of the living organisms and their evolution. The gained knowledge influences the practical approach in such areas as medicine, pharmacology, breeding or crop production. However, the vast amount of genomic and proteomic data, caused by the recent rapid progress in high-throughput sequencing techniques, presents new challenges in the field of storing, processing, and analysing large scale text data (as text is typically used to represent information about genomes and proteomes).

Our team is focused on providing biologists and bioinformaticians with effective, fast, and succinct algorithms for manipulation of biological data. Our efforts are aimed at most burning issues in the computational biology, including genomic data compression and indexing, sequence comparisons, or phylogeny.

In pursuit of best performance, our algorithms are designed to take advantage of latest achievements in computer technology. They are especially suited for multicore and multiprocessor architectures. Thus, available computational power can be fully utilised, no matter if software is run on a low shelf netbook or a million dollar cluster. Most demanding tasks can be executed on massively parallel devices like graphics processors. Their raw computational power expressed in floating point operations per second is tens times larger than that of central processors. At the same time our algorithms are memory efficient. This allows user to turn his desktop PC into high performance computing centre and analyse terabytes of biological data with impressive rate.

Developed techniques are among the most effective solutions to related problems and create new opportunities for high-performance analysis of genomic data. For example, QuickProbs, a tool for multiple sequence alignment, handles protein families with several thousand of sequences in several minutes at superior accuracy, the Genome Differential Compressor allows a thousand of human genomes to be stored at a single compact disk, while thanks to the Multiple Genome Index a PC equipped with a mere 8GB of RAM
is sufficient to search for exact and approximate pattern in such collection in less than a millisecond.

S. Deorowicz, A. Danek (Executors): Algorithm engineering for full-text indexes
(Project No. 2013/09/B/ST6/03117, Leader: Szymon Piotr Grabowski, Institute of Applied Computer Science, Faculty of Electrical, Electronic, Computer and Control Engineering, Lodz University of Technology, Łódź, Poland)

The primary objective of the project is to develop new variants of the suffix array SA (or search algorithms for it) with lower space requirements and/or high pattern search speed compared to the standard version. Some of the efforts are focused on compressed indexes as well. The research topics comprise, among others:

- designing a non-standard data layout in the SA (cache-friendliness, faster search),
- exploring non-standard (i.e. different than binary) search strategies in the SA,
- designing new memory-frugal SA variants,
- practical implementations of some compressed indexes (e.g., from the FM family),
- using a novel suffix array based algorithm for searching in large genome collections.

The project’s goals are associated with the huge (and rapidly growing with each year) amount of data stored in digital form. From the point of IT systems it is a major challenge to provide fast access to stored resources, by reducing the times of pattern search and document extraction. Among the diverse of date types used in practice, text is still ranked high, and this umbrella term comprises, among others, non-structured natural language documents, bioinformatics data (DNA, RNA, protein sequences), log files (from the Web servers, database systems etc.), program source codes, scripts, Web pages, and XML databases and repositories. Such a broad notion of ‘text’ implies the need to search arbitrary sequences of characters, without assuming that the text is segmented into words/tokens. Using a (full-text) index is a natural approach to searching in textual databases.

A. Kwiecień (Project Manager), D. Caban, J. Flak, M. Skrzewski, P. Stera (Executors): Development of the systems of orientation and direction signaling of the crew retreat on the escape road in longwall sidewalks
(Grant No. PBS-21/RG-3/2013, National Centre for Research and Development, P/22492/07/2014, Improving safety in mines, Main contractor: Silesian University of Technology, Faculty of Mining and Geology (leader), 2013–2015)

The purpose of this work was to develop a method of signaling the evacuation direction of the crew from underground walkways in coal mines. After analysis of available solutions, concepts has been selected of escape route signaling with broadband acoustic signals (directional sounders) using nodes of wireless sensor networks, equipped with acoustic and visual signaling. Software that controls the operation of a sensor network nodes has been developed and some proposed algorithm of signaling escape routes in the laboratory.
environment were tested. Using prepared models of sensor network nodes the available range of radio communication and effectiveness of controlling the direction of evacuation in conditions of limited visibility were tested in coal mine environment. The work resulted in development of an algorithm of acoustic signaling, which is effective in condition of deterioration of audibility due to breathing rescue apparatus usage and preparation of guidelines for the proper deployment of signaling elements in the underground sidewalks.

K. Nurzyńska (Leader): Visualization of cavity evolution in underground coal gasification process
(Grant No. LIDER/09/30/L-2/10/NCBiR/2011, Central Mining Institute, Katowice, Poland, 2011–2014)

In the process of underground coal gasification an important role plays monitoring of the whole phenomena during this process, in order to determine the optimal operating conditions and to obtain a gas of the required characteristics. Monitoring of the coal gasification processes and defining the parameters affecting the progress of physicochemical processes provide the basis for monitoring and controlling of the entire process.

Due to the surface nature of most of chemical reactions occurring in the process of coal gasification the particular importance role in gasification process plays the size and shape of the cavity growth (void). This area is limited by space formed in the place of coal consumed in the process. Additionally, an area separating the char layer as a result of pyrolysis reaction from seam coal and the surrounding rocks can be highlighted. Knowledge of these surfaces, for example, their shape, location in space, and size, is one of the most important parameters allowing to control the gasification process and to describe the process using models.

Scientific objective is to prepare methods for monitoring and visualization of the development of the emerging area of cavity growth in the process of underground coal gasification, which is a digital (discrete) representation of the real area of the physical model. An additional objective of this project is to provide a tool for controlling and optimizing the reactor operation in conjunction with the developed mathematical model to predict the underground coal gasification process.

The basis for preparing the proposed visualization method are the measurement data of the parametric surfaces described by the ground penetrating radar method, in amounts necessary to obtain correct calculations. In addition, properties of these parametric surface (void, char, rock) will be explored basing on the results of the proposed method. Result of the work will describe the method and software (algorithm) to support the application of the method. The software will allow introduction of the measurement data recorded by the ground penetrating radar. These data will be processed according to the algorithm of the proposed methodology. The result of the algorithm is output data describing the surface (or set of them) determined basing on the ground penetrating radar data. The software will be developed in the form of library, with the possibility of use as an element in a variety of software packages or copyright solutions.
A. Świtoński (Leader), H. Josiński (Executor): Diagnosis of selected gait abnormalities based on multi-modal acquisition of motion
(Project No. 2011/01/B/ST6/06988, Branch Faculty of Information Technology of the Polish-Japanese Institute of Information Technology, Bytom, Poland, 2011–2014)

The aim of the project is to develop methodologies for using multimodal motion capture experimental setup including gait measurements, force plate measurements and electromyographic assays, combined with appropriate computational algorithms for supporting clinical diagnosis of two gait disturbances: gait disturbances related to the degenerative disease of hip joint (coxarthrosis) and post stroke gait abnormalities.

A. Świtoński (Leader), H. Josiński, A. Szczęsna, K. Wojciechowski (Executors): Virtual Physiotherapist
(Project No. 269419, Research and Development Center of the Polish-Japanese Academy of Information Technology, Bytom, Poland, 2015–2016)

The main goal of the project is to construct the system named Virtual Physiotherapist (VPh) supporting rehabilitation in home environment or in a medical facility according to a specified training plan, which utilizes online voice feedback in case of improperly conducted training. The key feature of the system is related to the fact that training does not require direct supervision of the human physiotherapist. Motion data of a patient’s training is stored in VPh memory and it is available offline to be analyzed and assessed by a medical expert who supervises the rehabilitation process. VPh consists of the acquisition and visualization modules and software which supplies specified functionality of the system. Both the acquisition system and software are configurable in respect to the type of training.

A. Świtoński, H. Josiński, A. Michaczuk, K. Weresczyński (Executors): Intelligent video analysis system for behavior and event recognition in surveillance networks
(Project UOD-DEM-1-183/009, Research and Development Center of the Polish-Japanese Academy of Information Technology, Bytom, Poland, 2014–2016)

The project’s objectives relate to the following topics:

- elaboration of the modern technology for the purpose of motion analysis,
- real-time multi-view human motion detection and tracking,
- automatic recognition of untypical or dangerous behavior,
- recognition of intent within individuals and crowds,
- retrieval of persons and distinctive behaviors from a video database based on motion features and studied behavior patterns.

107
K. Wojciechowski (Leader), E. Lach, A. Polański, A. Szczęsna, A. Świtoński (Executors): Costume for acquisition of human movement based on IMU sensors with collection, visualization and data analysis software
(Project No. 178438 path A, Branch Faculty of Information Technology of the Polish-Japanese Institute of Information Technology, Bytom, Faculty of Automatic Control, Electronics and Computer Science of The Silesian University of Technology, Gliwice and The Textile Research Institute, Łódź, Poland, 2012–2014)

The aim of the project is to create ergonomic, economical, easy to adapt to different applications costume for acquisition of human movement based on IMU sensors. Modular software will allow data collection, visualization, analysis and creation of various plug-ins with new functionalities.

K. Wojciechowski (Leader), A. Szczęsna (Executor): New technologies for highresolution acquisition and animation of facial expressions
(Project ID: INNOTECHK2/IN2/50/182645/NBCBR/12, Branch Faculty of Information Technology of the Polish-Japanese Institute of Information Technology, Bytom, Polish Academy of Sciences, Gliwice, The Farm 51, Gliwice, 2013–2015)

The aim of the project is to develop and test three alternative technologies for acquisition of high-resolution facial expressions, which will be judged in terms of the possibility of commercialization by a member of the Consortium - The Farm 51. Tested algorithms:

• VICON markers technology,
• mixed technology based on the use of VICON markers and the multi-camera system,
• multi-camera system.

Algorithms for multiresolution mesh representation will be also developed for computer games.

General statutory research projects

A. Chydiński (DCNS): Internet management and virtualisation, multimedia services quality, data analysis in bioinformatic and technical systems, 2014–2015

The research covered links virtualisation in a virtual machines environment and a network packet traffic scheduling algorithms. The works on the development of methods and tools for intelligent objects networks were done, which cover all possible types of Internet of things, including wireless sensor networks. The works focused on analytic and simulation models, using parallel and distributed calculations. One of the most important aspects was a problem of network modelling, which are difficult to simulate due to their size and a big number of generated events.

A research on packets transmission delays changes fluctuation and other parameters of network transmission that influence on a multimedia transfer quality were also carried out. A PlanetLab laboratory was used, which offers experiments in a real networks
environments. Also a technical aspects of this tool was evaluated, especially during a
teaching activities.

In the area of data exploration works on a development of methods of decision rules
application for searching small groups of connected genes were done. In order to obtain
connected genes, during building a rule, an experiment results (coming from an expression
profiles measuring) and domain information (gene functional annotations) were taken into
consideration.

In the area of multimedia systems a further research on HTTP protocol video packets
scheduling algorithms were carried out, to smooth the traffic of packets and a minimization
of their loss and delays.

Results of research were presented in papers and conferences.

Z.J. Czech, S. Deorowicz, J. Widuch, A. Debudaj-Grabysz, R. Starosolski,

In the project the following problems have been solved:

• Parallel induction of nondeterministic finite automata.
• Fast and accurate alignment of protein sequences for large data sets.
• Parallel algorithms for the analysis of finite automata.
• Application of reversible denoising and lifting steps to DWT.
• Solving the multicriteria maximum clique problem using simulated annealing algo-
  rithm.
• Parallel algorithms for induction of nondeterministic finite automata.
• Algorithms to alignment a protein sequences for large data sets.
• Comparative analysis of two parallel algorithms for decomposition of finite lan-
  guages.
• Reversible transformations of color image components for lossless image compres-
  sion.
• A multistart hybrid algorithm to solve the sequential ordering problem.

Most of these research have been carried out within works on professorship achievements
and habilitation and doctoral theses of their authors.

Keywords.
Induction of nondeterministic finite automata, alignment of protein sequences for large
data sets, parallel algorithms for analysis of finite automata, reversible denoising and lifting
steps in DWT, multicriteria maximum clique problem solved by simulated annealing.

P. Czekalski (DMAT): Digital logic circuit design - development of the
synthesis and analysis methods

The research addresses development of the software implementation and corresponding
algorithm complexity analysis of the Theory of Logic Circuits design methods. It regards
both combinational and sequential circuits. The resulting research is available as a so
called ZMITACSIM system - a WEB based solution providing a set of ToLC related soft-
ware methods for both research and education. The 2014/2015 work regards asynchronous
system design using Huffman’s method.

109
There were following research topics in 2014 and 2015:

- **Touchless text input interface based on gaze tracking.** Among many ways of communication between man and machine almost all require some kind of physical contact with the device and performing movements. For people affected by extreme forms of disabilities, e.g. total paralysis, these methods are not available. Often only eyeballs are moving. The result of the work was an interface allowing disabled people to communicate only by movements of eyeballs, analyzed on the basis of images provided by a miniature camera. The camera is focused on the eye and placed close to it. The user is presented a table with characters or other symbols and chooses these symbols only by looking at them. The precision of gaze location is enough to distinguish about 40 different symbols.

- **A brain-computer interface for mobile devices.** The human brain produces weak electrical signals, which may be measured and later used to control a machine. In this part of the research, a wearable device measuring brain signals and muscular action potentials was used as an input device. Raw brain signals appeared too noisy for a useful application, but the action potential could be adapted as an input for a man-machine interface.

- **Feature dimensionality reduction.** In many cases non-standard man-machine interfaces require some kind of recognition or classification. This part of the research was focused on a method of reducing the amount of information in machine learning. The method may be used in cases where the feature vector has several hundreds of components and may reduce the number of components, possibly keeping the classification quality.

The research covered the following topics:

- Selectivity estimation for database queries optimization.
- Processing in cloud computing, architecture of cloud-oriented information systems, databases in cloud computing, preserving object-relational interfaces and object-NoSQL interfaces.
- Research in bioinformatics databases.
- Advanced methods for signal analysing and processing.
- Modern technologies in number theory.
- Agent systems in similarity searching in text sets.
- Methods for automated land subdivision.
- Modern technologies in practical use.
- Software engineering.
• Eye movement analysis for biometric identification.
• General processing on GPU.

A. Kwiecień (DID): Gaining on communication network efficiency with redundant multi-network interface, 2014

Redundancy is the main method for achieving high reliability level in industrial computer systems. It is often applied to network interfaces to maintain the operability of the communication subsystem even when faults occur. In most cases, the redundant communication buses realize exactly the same functionality as the single, non-redundant bus. That makes the system more reliable but the additional throughput of the redundant buses is never used even if the system condition would allow it. The idea to take advantage of that throughput had made the authors to work on multi-network interface node which could maintain high reliability of the communication subsystem on one hand, and on the other, make it possible to exploit the additional communication resources and increase some parameters of the network.

A. Kwiecień (DID): Safety of transmission data in industrial multiprotocol’s nodes systems, 2015

There are two most important factors that determine the usability of a given system: temporal characteristics and reliability. The first is obtained by the usage of real-time components and communication protocols that are deterministic in the time domain. The second feature is usually achieved by the use of redundancy of the most critical elements of the system. When the communication bus redundancy is concerned, additional buses are introduced to the system. Their role is to duplicate the operation of the basic non-redundant communication bus. In other words, using redundant devices and network connections, there is an additional throughput introduced to the communication subsystem. It is used however only to multiply the exact set of communication tasks, that would be defined in the same system without redundancy.

In a system with for example double communication bus redundancy, on both buses the same communication process is executed. It is easy then to maintain the requested data exchange in spite of a fault of one of the busses. In fault-free conditions however, the additional throughput delivered by the redundant bus could be used for implementation of some extra functionality or an improvement of the communication system efficiency. This observation made to develop a multi-network interface node MuNetIN capable of maintaining high level of communication bus reliability together with improved communication network efficiency.

A. Kwiecień, M. Maćkowski, K. Skoroniak (DID): The research on electromagnetic compatibility of computer systems, 2014–2015

Modern electronic devices are more and more prone to the electromagnetic disturbances that come mostly from radio emitters or power supply converters. What is more, the grow-
ing number of electronic equipment used in the industry, results in increasing importance of the mutual influence of such devices.

During the research, the authors proposed the idea of multiprotocol node in the distributed real time systems in order to increase the communication reliability. Moreover, also the method applying such nodes for increasing the speed of data transmission in distributed control system was conducted. The proposed method implied hardware and software solution, and is based on a new node communication protocol. Such protocol may serve various protocols allowing, at the same time data transmission via various buses. Thanks to the developed method not only the bandwidth increased, but also the security of data transmission.

The authors marked also the potential possibilities of using equipment for EMC (Electromagnetic Compatibility) measurements in the process of testing and simulating the real threats (disturbances) that may appear in the real object. Such tests allow to verify the correctness of proposed device platform, and also check the effectiveness of developed algorithm of query scheduler. The final results point out the correct work of developed query distributor system and the opportunities of automatic adjustment of the network topology in case of electromagnetic disturbances.


Computer interfaces (USB, IEEE 1394, Thunderbolt) must follow computer technology. As computers process still greater and greater amount of data, computer interfaces must transport still greater and greater data units. So, in consecutive versions of any port specification the bit rate and efficiency are expanded. The bit rate expansion often requires a new transmission medium and a new transmission methods.

In this project some experiments on communication in computer systems based on USB 3.0, IEEE 1394b (FireWire 800) and Thunderbolt were performed in order to analyse setup process for communication, bus management and communication protocols (for example: SBP-2, IIDC). The communication efficiency with selected peripherals like CD drive, pendrive, camera, equipped with USB 3.0 and Thunderbolt were tested.


There is an increasing number of practical solutions employing graphics and computer vision techniques. In addition this trend shows strong growth as a result of the advancement in the development of mobile devices, computer games, virtual and augmented reality, video surveillance systems, medicine. For this reason, development of new algorithms, their improvement and implementation in the form of tools supporting analysis, synthesis and visualization of various types of data, is desirable.
The conducted research involves development of appropriate algorithms related to the topic of acquisition, storage, analysis and synthesis of multimedia data. Processed data are used in games, virtual and augmented reality.

In the project the problem of dynamic difficulty adjustment in computer games is also addressed. A simple and fast method for computer opponent adjustment is proposed. An empirical investigation of the method when playing FPS game is conducted.


Neuro-fuzzy systems have proved to be a powerful tool for data approximation and data generalisation. They can handle imprecise data due to fuzzy approach. They can also modify their parameters to better fit the presented data. The research focuses both on theoretical analysis and practical applications of neuro-fuzzy systems with logical interpretation of fuzzy rules. The research focuses on improvement of precision, interval type-2 and type-2 fuzzy systems, inversion of fuzzy systems, and analysis of incomplete data (rough-neuro-fuzzy systems). The research also aims at combining neuro-fuzzy systems with support vector machines. In this cooperation the neuro-fuzzy systems are responsible for evaluation of kernel functions.

M. Skrzewski (DID): Reasearch on monitoring methods of network threats, 2014

Monitoring the emergence of new threats are based on gathering information from systems-traps (honeypots systems). Most of the honeypot systems are placed in the networks on random, unused IP addresses (one can talk on random addresses), and detected threats are assumed to be representative pictures of the current state of network threats. This approach is not entirely correct. Analysis of scanning intensity of the class C of IP network address space shows the uneven distribution of scans at different parts of the IP address space, with more than 50% prevalence of scans in the initial range (30-45%) address space. Conducted research on multiple systems traps, spaced evenly in the class C address space showed different threats distribution mechanisms and qualitatively and quantitatively different types of threats recorded by various honeypots. The actual picture of threats is therefore more complex and single trap provides only narrowly specialized information about the malware activity.

M. Skrzewski (DID): Methods of threats detection on the mobile platforms with Android system, 2015

Research of the threat propagation methods and available ways of information leakage protection in an mobile systems environment requires methods for traffic monitoring and threat detection appropriate for network environment with smaller possibilities to control the flow of information. The environment of mobile systems uses several channels of radio communication (Bluetooth, LTE, 3G, WiFi) which are difficult for monitoring. In corporate network it is possible to monitor the communications of mobile devices on the cables between access points and network servers. It is also possible to monitor the
network activity of machines running Android x86 (versions for PC systems). There were studied the operations of virtual machines with the Android 4.4, 5.0, and 5.1 (x86) systems on the network to get the knowledge of the ways of network communication and to fit malware detection methods to the environment of mobile systems.


Virtualization of computer systems has become important solution for implementation of application servers systems (cloud computing) and user systems (desktop virtualization). It implies questions about developing the performance of many virtual systems simultaneously running on a single hardware platform. The research are concerned on assessment the influence of virtualization on the performance of client-server applications while interacting with other applications running on the hardware platform, e.g. WWW servers, industrial applications. The research concerns also development of methods for testing performance of applications taking into account the influence of virtualization environment.

U. Stańczyk, G. Baron (DMAT): Deployment of systems using computational intelligence

The research works concerned the usage of some statistical and machine learning approaches to the problem of stylometric analysis for texts, with recognition of authorship treated as classification tasks, with special attention given to the problems of feature evaluation, selection and reduction. The characteristic features related the frequencies of usage of selected punctuation marks and function words, which resulted in continuous numbers. Within the research works there were employed Bayesian classifiers for discretised data, for selected discretisation methods, and artificial neural networks and Dominance-Based Rough Set Approach procedures for real-valued features. With dedicated algorithms and procedures several rankings of considered characteristic features were obtained, employed next for estimation of their relevance as well as in the process of selection of decision rules for rule classifiers, resulting in dimensionality reduction.


Works in the field of software visualization were aimed at systematization of a comprehensive description of the issues of dynamic software visualization – the result is intended to be published as a monograph. A group of reworked monograph chapters focuses on the visualization as perceived by the participant of the projection; another group includes the results of a literature review on modern techniques of program instrumentation.

In the range of computer analysis and translation of inflective languages, works were continued on the development of automatic methods of linguistic analysis and the development of tools to facilitate the work of the language engineer. In order to significantly
improve the quality of translations produced by the Thetos system we decided to take into account the meaning of sentences, syntactic groups (SGs) and individual words they are composed of, what we previously ignored. In this connection, we started to work on a multi-level SG-model of semantics and tried to apply cognitive architectures in construction of the Polsem semantic analyzer as well as to take advantage of the communication grammars.

B. Zieliński (DMAT): Deployment of wireless segments of computer networks

During this year’s research we made an attempt to implement AX.25 protocol and basic functionality of TNC controller in ARM9-kernel microprocessor environment. The TNC functionality has been reduced to the level that allowed us to conduct efficiency tests and compare the results with those obtained before for commercially available TNC controllers.

Individual statutory research projects

3. A. Brachman-Piotrowska: Modelling and analysis of the new generation of sensor networks, 2014
5. T. Czachórski (tutor), M. Nycz: Models and control algorithms for different system and information structures, 2015
8. A. Gruca: Methods of analysis and identification of relations in complex biological, social and technical data systems – Adding new functional annotations into premises of logical rules generated in order to describe functionally groups of genes, 2014
12. G. Kwiatkowski, P. Sadowski: Selected aspects of semantic analysis related to fusional languages, 2014
13. A. Kwiecień, M. Sawicki: The scheduling of data transactions in real time providing the quality of service in communication interfaces, 2015
17. M. Paszkuta: Research on classification of objects using video track, 2014
24. K. Tokarz (tutor), G. Powała, M. Maćkowski: Analysis of the possibilities of using the phenomena occurring in wireless networks to navigate objects inside buildings with specific regard to the Doppler effect, 2015
Statutory activities of the Institute

D.Sc. degrees (habilitations) conferred on staff members of the Institute

1. M. Kawulok: Analysis of the local features similarity in digital images, applied to human skin detection and image colorization (Analiza podobieństwa cech lokalnych w obrazach cyfrowych w zastosowaniu do wykrywania ludzkiej skóry oraz koloryzacji obrazów) confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2015.
2. M. Sikora: Selected methods of decision rule evaluation and pruning (Wybrane metody oceny i przycinania reguł decyzyjnych) presented to and confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.

D.Sc. degrees (habilitations) conferred on non-staff members of the Institute

1. J. Domańska: Improvement of the efficiency of mechanical-active management of buffers in the presence of self-similar traffic (Poprawa efektywności mechaniczno aktywnego zarządzania buforów w obecności ruchu samopodobnego) presented to and confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.
2. P. Gawron: Environment influence on computer science quantum process (Wpływ oddziaływania środowiska na informatyczne procesy kwantowe) presented to and confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.
3. W. Kempa: Queueing models with limited access to server (Modele kolejkowe z ograniczonym dostępem do serwera) presented to and confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.
4. L. Luchowski: Mobile stereovision and second degree surfaces presented to and confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.
5. J. Miszczak: Modelling of quantum informatics systems with the use of quantum programming languages and symbolic computation (Modelowanie kwantowych systemów informatyki z wykorzystaniem kwantowych języków programowania i obliczeń symbolicznych) presented to and confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.
6. **Z. Puchała**: The geometrical methods in quantum computing (Metody geometryczne w kwantowej teorii informacji) confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2014.

7. **A. Tomaka**: Multimodal image analysis for non-invasive orthodontal diagnosis use (Analiza obrazów wielomodalnych dla potrzeb nieinwazyjnej diagnostyki ortodontycznej) confirmed by the members of the Board for the Faculty of Automatic Control, Electronics and Computer Science, SUT, 2015.

Ph.D. degrees conferred on staff members of the Institute

1. **A. Danek**: Algorithms for analysis of genomic data in compressed domain (Algotrymy analizy danych genomowych w postaci skompresowanej).

2. **A. Gudyś**: Serial and parallel algorithms for multiple sequence alignment problem and some of its variants (Szeregowe i równoległe algorytmy dla problemu dopasowania wielu sekwencji oraz wybranych problemów pokrewnych)
   Thesis supervisor: Deorowicz S., Ph.D., D.Sc., Professor at SUT, April, 2014.

3. **K. Folkert**: The use of software agents and service-oriented architecture in designing data acquisition and processing systems.

4. **P. Foszner**: Bi-clustering - algorithms and applications (Bi-klasteryzacja - algorytmy i ich zastosowania).


6. **D. Kostrzewa**: Search space exploration based on the optimization of query execution plans using IWO algorithm (Przeszukiwanie przestrzeni rozwiązań w optymalizacji planów zapytań do baz danych z wykorzystaniem heurystycznego algorytmu IWO).

7. **M. Lachor**: Application of rough-set methods to binary biclustering (Wykorzystanie metod zbiorów przybliżonych w algorytmach biklasteryzacji binarnej).
   Thesis assistant supervisor: Michalak M., Ph.D.

8. **T. Nycz**: Diffusion approximation in the description of the dynamics and assessing the quality of Internet broadcasts (Aproksymacja dyfuzyjna w opisie dynamiki i ocenie jakości transmisji internetowych).

9. **A. Rosner**: Multi-instrumental automatic recognition of musical genres (Multiinstrumentalne automatyczne rozpoznawanie gatunków muzycznych).
10. **J. Rosner**: Methods of parallelizing selected computer vision algorithms for multicore graphics processors (Metody zrównoleglania wybranych algorytmów wizji komputerowej pod wielordzeniowe procesory graficzne).

11. **M. Simon**: Fault tolerant data acquisition through dynamic load scheduling (Niezawodna akwizycja danych poprzez dynamiczne szeregowanie obciążeń).
   Thesis supervisor: Kozielski S., Ph.D., D.Sc., Professor, April, 2014.

12. **A. Skowron**: Sequential covering regression rule induction and optimization of regression rule-based data models (Regulowe modele danych bazujące na indukcji i optymalizacji reguł regresyjnych za pomocą algorytmu sekwencyjnego generowania pokryć).

13. **M. Staniszewski**: Signal analysis of magnetic resonance spectroscopy by application of SVD decomposition (Analiza sygnałów magnetycznego rezonansu jądrowego z wykorzystaniem dekompozycji).
   Thesis assistant supervisor: Boguszewicz Ł., Ph.D.


**Ph.D. degrees conferred on non-staff members of the Institute**

1. **I. Codello**: Computer disordered speech recognition using wavelet transform and artificial neural network (Komputerowe rozpoznawanie niepłynności mowy z zastosowaniem transformaty falkowej i sztucznych sieci neuronowych).

2. **M. Dolecki**: Classification of the synchronization time of Tree Parity Machine network used for cryptographic key exchange (Klasyfikacja czasu synchronizacji sieci Tree Parity Machine używanych do uzgadniania kluczy kryptograficznych).

3. **B. Kwiecień**: Link failure detection algorithms for industrial redundant distributed systems in real-time continuous data transmission by two buses (Algorytmy detekcji awarii łączna redundanatnego w przemysłowych systemach rozproszonych czasu rzeczywistego z ciągłą transmisją danych dwiema magistralami).

4. **M. Kubica**: Decomposition and technology mapping using binary decision diagrams (Dekompozycja i odwzorowanie technologiczne z wykorzystaniem binarnych diagramów decyzyjnych).

5. **M. Młyński**: Dynamic resource allocation in computer system based on the machine virtualization (Dynamiczny przydział zasobów w systemach komputerowych...
6. **M. Piróg-Mazur**: Acquisition and modeling of expertise for intelligent manufacturing (Pozyskiwanie i modelowanie wiedzy dla inteligentnego systemu wytwarzania).


7. **S. Święrc**: Automated identification of breaking changes in continuous integration systems using under uncertainty reasoning.

The journal *Studia Informatica* publishes both fundamental and applied memoirs and notes in the field of computer science. The Editor’s and the International Editorial Board aim is to provide an active forum for disseminating the original results of theoretical research and applications practice of computer science understood as a discipline focused on the investigations of laws that rule processes of coding, storing, processing and transferring information or data. The published papers are from fields of computer science inclusive of, but not restricted to computer science, engineering, and life and physical science. The full text papers are downloadable from the web site [http://studiainformatica.polsl.pl](http://studiainformatica.polsl.pl).

The journal *Studia Informatica* is published quarterly with classification number PL ISSN 1642-0489 (former: 0208-7286) and it is indexed by INSPEC/IEE (London, UK).

The Editor in Chief of the *Studia Informatica* journal is Bartłomiej Zieliński. The International Editorial Board for this journal includes scientists from Italy, Germany, France, US, Russia, Ukraine, and Poland:

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Adam Wolisz, Professor, Technical University of Berlin, Berlin, Germany.

In years 2014—2015 eight issues of the journal were published, four in 2014 (Vol. 35, Issues 1, 2, 3, 4) and four in 2015 (Vol. 36, Issues 1, 2, 3, 4).

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Fax: (+48) 32 237 27 33
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Scientific conferences organised by the Institute

Man-Machine Interaction

4th International Conference on Man-Machine Interactions 2015, Kocierz, October 6-9, 2015, with the Conference Chair: Prof. S. Kozielski. Total number of papers: 54.

Conference proceedings published as:

Beyond Databases, Architectures and Systems

10th International Conference Beyond Databases, Architectures and Structures, Ustroń, May 27 – 30, 2014, with the Chairman of the Programme Committee: Prof. S. Kozielski.

Total number of conferees: 90 (including 19 from the Institute of Informatics) and total number of papers: 81.

Conference proceedings published as:
11th International Conference Beyond Databases, Architectures and Structures, Ustroń, May 26 - 29, 2015, with the Chairman of the Programme Committee: Prof. S. Kozielski.

Total number of conferees: 90 (including 15 from the Institute of Informatics) and total number of papers: 69.

Conference proceedings published as:

Computer Networks

21th Conference on Computer Networks 2014 (Sieci komputerowe), Brunów, June 23–27, 2014, with the Chairman of the Programme Committee: Prof. A. Kwiecień.

Total number of conferees: 65 and total number of papers: 41 (7 in Polish and 34 in English).

Conference proceedings published as:
22th Conference on Computer Networks 2015 (Sieci komputerowe), Brunów, June 16–19, 2015, with the Chairman of the Programme Committee: Prof. A. Kwiecien.

Total number of conferees: 70 and total number of papers: 49 (7 in Polish and 42 in English).

Conference proceedings published as:

- P. Gaj, A. Kwiecien, and P. Stera (Eds.) *Studia Informatica*, Volume 36, number 2 (120), Silesian University of Technology Press (Wydawnictwo Politechniki Śląskiej), Gliwice, 2015.
Cooperation with foreign institutions

Participation in international projects

1. Automotive Production Engineering Unified Perspective based on Data Mining Methods and Virtual Factory Model (R. Cupek) realized within FP7-PEOPLE. Co-operating institutions:
   - AIUT, Poland
   - Conti Temic Microelectronic GMBH, Germany
   - Hochschule fur Angewandte Wissenschaften Fhingolstadt - Fachhochschule Ingolstadt, Germany

2. EGNOS/Galileo in Aviation and Terrestrial Multi-sensors Mobility Applications for Emergencies Prevention and Handling, acronym: EGALITE (K.A. Cyran) realised within 7th Framework Programme. Co-operating institutions:
   - LG Nexera Business Solutions AG, Kolonitzgasse 10, 1030 Wien, Austria, www.lgsoft.at, (Beneficiary No. 2);
   - Pildo Labs, Parc Tecnologic de Barcelona Nord, Marie Curie 8 -14, 08042 Barcelona, Spain, www.pildo.com (Beneficiary No. 1);
   - The Silesian University of Technology, Akademicka 2A, 44-100 Gliwice, Poland, www.polsl.pl (Coordinator).

3. Helicopter Deploy GNSS in EUROPE - Next, acronym: HEDGE NEXT (K.A. Cyran) realised within 7th Framework Programme. Co-operating institutions:
   - CGx AERO in SYS, rue Victor Hugo, 2, Castres, 81100, France (Beneficiary No. 6);
   - Entidad Pública Empresarial Aeropuertos Españoles y Navegación Aérea, C/ Arturo Soria, 28043 Madrid, Spain (Beneficiary No. 10);
   - Helileo SA, Rue Bernard Palissy, 553, Saint Paul Les Dax 40990, France (Beneficiary No. 5);
   - Helios Technology Limited, Aerospace blv, Hercules Way, 29, Farnborough, GU14 6UU, UK (Beneficiary No. 1);
   - Inaer Helicopteros S.A.U., Partida LaAlmaina, 92, Muchamiel 03110, Spain (Beneficiary No. 2);
   - Pildo Consulting S. L., Marie Curie, 8, 08042 Barcelona, Spain (Coordinator);
   - Polish Air Navigation Services Agency, ul. Wieżowa, 12, 02-147, Warsaw, Poland (Beneficiary No. 9);
   - Samodzielny Publiczny Zakład Opieki Zdrowotnej Lotnicze Pogotowie Ratunkowe, ul. Księżyco- wa, 5, 01-934 Warszawa, Poland (Beneficiary No. 4);
   - Silesian University of Technology, Akademicka 2A, 44-100 Gliwice Poland (Beneficiary No. 7);
- Skyguide, Swiss civil and military air navigation services Limited, Route de Pre-Bois, 15-17, Geneva, CH-1215, Switzerland (Beneficiary No. 8),
- Swiss Air-Rescue (rega), Rega-Center, Postfach 1414, Zurich Airport, CH-8058, Switzerland (Beneficiary No. 3).

**International faculty and student exchange**

1. Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany - internships available for students of Computer Science faculty
2. Erasmus - students exchange and internships available for students of Computer Science
3. Erasmus Mundus - funding for a joint study conducted by consortia of universities. Joint study under the Erasmus Mundus program includes the second and third degree courses (postgraduate courses - leading to a master's degree, PhD degree - leading to a doctoral degree).
4. Erasmus Mundus External Cooperation Window (ECW) - Silesian University of Technology is the only university in Poland, which is involved in the project EMUNDUS20, carried out under the Erasmus Mundus External Cooperation Window (now the "Partnerships"). The project consortium consists of 11 universities from Central American countries: El Salvador, Guatemala, Honduras, Nicaragua, Mexico, and from the European Union partners are 8 universities from France, Belgium, Spain, Italy, Finland and Poland. The project is coordinated by the Spanish Basque Country University (Universidad del País Vasco) from San Sebastian. University cooperation takes place mainly on the mutual exchange of students and academic staff.
5. Summer School is a European project aimed at students from around the world. Students have the opportunity to spend their holiday at a foreign university, which organises academic lectures, excursions to explore the city and exploring the local culture and customs. Through this program Polish youth have the opportunity to learn teaching standards at the international level while widening their life experience and knowledge of foreign languages.

**Visits of Polish researchers abroad**

- O. Antemijczuk:
  - 6 months in Pildo Labs, Barcelona Spain,
  - 10 months in LG Nexera, Vienna, Austria within 2014-2015, EGALITE.
- G. Baron:
  - 11 months within a period: July 2014 - November 2015, EGALITE, LG NEXERA, Vienna, Austria.
- R. Cupek:
  - participation in Automotive Production Engineering Unified Perspective based on Data Mining Methods and Virtual Factory Model, acronym: AutoUniMo,

- K.A. Cyran:
  - 10 months within a period: October 2014-October 2015, EGALITE, LG NEXERA, Vienna, Austria,
  - August, November 2015, EGALITE, Pildo Labs, Barcelona, Spain.
- M. Garbulowski:
  - participation in FSS project, number: FSS/2013/IIC/W/0015/U/0022, Cooperation in subject: RareVariantVis: new tool for identification of causative variants in rare monogenic disorders using whole genome sequencing data, Country: Norway, Institution: University of Bergen, Department of Informatics, Computational Biology Unit, 01.05.2015 – 15.08.2015.
- K. Haręzłak:
  - Invited lecture: Eye movement: recording, processing and analyzing, School of Computing, Clemson University, September 2015.
  - Seminar talk: Eyes as the window to the soul - Eye movement analysis, School of Computing, Clemson University, September 2015.
- D. Mrozek:
  - Visiting professor at Department of Computer Engineering, Izmir Institute of Technology (IYTE), Izmir, Turkey, September 2014.
- J. Paduch:
  - July 2015-September 2015, EGALITE, LG NEXERA, Vienna, Austria.
- M. Paszkuta:
  - October 2014-September 2015, EGALITE, LG NEXERA, Vienna, Austria.
- D. Sokołowska:
  - 6,5 months in Pildo Labs, Barcelona Spain,
  - 9,5 months in LG Nexera, Vienna, Austria within 2014-2015, EGALITE.
- B. Szady:
  - September 2013-August 2015, EGALITE, Pildo Labs, Barcelona, Spain.
- A. Ziębiński:
  - participation in 'Automotive Production Engineering Unified Perspective based on Data Mining Methods and Virtual Factory Model', acronym: AutoUniMo, 7th Framework programme, UE/28/RAu2/2013/509. Secondment to Continental AG Ingolstadt, Deutschland, PhD Hueseyin Erdogan, (05.05.2014 – 06.05.2014)
participation in 'Application for funds for the costs of preparing the project proposal to the European Union research program entitled 'Enhancement of Fabrication Reactivity by applying Agile Manufacturing”, acronym: eFRAM, GGM/3/RAl2/2014/500. Secondment to Gruppo SIGLA Srl, Genova (Italy), PhD Eng Cristiana Degano (27.01.2015 – 29.01.2015)

Co-operation in research

- Battelle Center for Mathematical Medicine. The Research Institute at Nationwide Children’s Hospital. Ohio State University, Columbus, Ohio, USA (A. Gruca): Co-operation in design and application of machine learning, optimization and visualization of biomedical data.
- Centre nacional d’anàlisi genòmica, Spain (S. Deorowicz, L. Roguski) - co-operation in the field of algorithms of genome data compression.
- Continental AG, CONTI Temic Microelectronics GmbH, Ingolstadt, Germany (dr Hueseyin Erdogan) (R. Cupek, A. Ziębiński): Artificial intelligence in advanced driver assistance systems.
- Tel Aviv University (David Amar and prof. Ron Shamir), Swedish University of Agricultural Sciences (dr Erik Alexandersson, dr Itziar Frades, dr Estelle Proux-Wera and prof. Erik Andreasson), Technical University of Munich (Tatyana Goldberg), The James Hutton Institute (dr Sanjeev K Sharma and dr Pete E Hedley), The Weizmann Institute of Science (dr Oren Tzfadia) (A. Danek): Co-operation in evaluation and integration of functional annotation pipelines for newly sequenced organisms.
- Institute Curie, Paris (dr. Janet Hall), University of Sussex England (prof. Penny Jeggo); Erasmus University, Netherlands (dr. Dik van Gent and dr. Jeroen Pothof) (A. Polański): Co-operation in the field of risk assessment the disclosure of cancer at a constant exposure to low radiation dose
- Université Paris Nord, France (T. Czachórski): Co-operation in the field of diffusion approximation methods applied to assess the effectiveness of scheduling packets in IP routers
University Uppsala, Linnaeus Centre for Bioinformatics (LCB) Sweden (Prof. Jan Komorowski) (A. Polański): Co-operation in the development of algorithms for search and verification of gene signatures for the analysis of gene expression data

Long-term cooperation agreements

1. Aalborg University, Denmark (www.aau.dk)
2. Bern University of Applied Sciences, Switzerland (www.bfh.ch)
3. Bournemouth University, United Kingdom (www.bournemouth.ac.uk)
4. Budapest University of Technology and Economics, Hungary (www.bme.hu)
5. Copenhagen University College of Engineering (IHK), Denmark (www.ihk.dk)
6. Cork Institute of Technology, Ireland (www.cit.ie)
7. Cranfield University, United Kingdom (www.cranfield.ac.uk)
8. ESIGETEL, Ecole Supérieure d’Ingénieurs en Informatique et Génie des Télécommunications, France (www.esigetel.fr)
9. Fachhochschule Ingolstadt, Germany (www.fh-ingolstadt.de)
10. Friedrich Alexander Universität Erlangen-Nürnberg, Germany (www.uni-erlangen.de)
11. Høgskolen i g Jovik, Norway, (www.hig.no)
12. ICAM Groupe (Institut Catholique d’Arts et Métiers), France (www.icam.fr)
13. Institute Polytechnique de Grenoble, France (www.grenoble-inp.fr)
14. Izmir Institute of Technology, Turkey (www.iyte.edu.tr)
15. Karel de Grote Hogeschool, Belgium (www.kdg.be)
17. Pamukkale University, Turkey (www.pau.edu.tr)
18. Politecnico di Milano, Italy (www.polimi.it)
19. Politecnico di Torino, Italy (www.polito.it)
20. Ruhr Universität Bochum, Germany (www.ruhr-uni-bochum.de)
21. Sogn og Fjordane University College, Norway (www.hisf.no)
22. (SUPSI) Scuola Universitaria Professionale della Svizzeria Italiana, Switzerland, (www.supsi.ch)
23. Tampere University of Technology, Finland (www.tut.fi)
24. Technical University of Denmark, Lyngby, Denmark (www.dtu.dk)
25. Technische Universität Clausthal, Germany (www.tu-clausthal.de)
26. Technische Universität Dresden, Germany (www.tu-dresden.de)
27. Universidad Carlos III de Madrid, Spain (www.uc3m.es)
28. Universidad de Oviedo, Spain (www.uniovi.es)
29. Universidad de Valladolid, Spain (www.uva.es)
30. Universidade da Beira Interior Covilhã, Portugal (www.ubi.pt)
31. Universidade do Algarve Faro, Portugal (www.ualg.pt)
32. Universidade do Minho, Portugal (www.uminho.pt)
33. Università degli Studi di Brescia, Italy (www.unibs.it)
34. Università degli Studi di l’Aquila, Italy (www.univaq.it)
35. Universitat Jaume I, Spain, (www.uji.es)
36. Université Joseph Fourier, France (www.ujf-grenoble.fr)
37. Universität des Saarlandes, Germany (www.uni-saarland.de)
38. Universität Koblenz-Landau, Germany (www.uni-koblenz-landau.de)
39. Universität Stuttgart, Germany (www.uni-stuttgart.de)
40. University of Applied Sciences Upper Austria, Austria (www.fh-ooe.at/en)
41. University of Burgos, Spain (www.ubu.es)
42. University of Craiova, Romania (www.ucv.ro)
43. University of Iceland, Reykjavík, Iceland (www.hi.is)
44. University of Oulu, Finland (www.oulu.fi)
45. University of Southern Denmark—SDU, Denmark (www.sdu.dk)
46. University of Ulster, United Kingdom (www.ulster.ac.uk)
47. VIA University College, Denmark (www.viauc.dk)
48. Západočeská Univerzita v Plzni, Czech Republic (www.zcu.cz)
Cooperation with Polish or Poland-based institutions

The Faculty of Automatic Control, Electronics and Computer Science (AEI) intensively cooperates with the Employers operated in the area of ICT, Automatic and Electronics. The Faculty cooperates with over 135 companies located in Silesian District and with over 30 from other area. With over 30 companies the cooperation is very strong and covers the cooperation on many fields, some of those companies has international range, like: ABB, ADB, Bombardier, Comarch, Danieli Automation, Delphi, General Motors, Hybris SAP, IBM, Kroll Ontrack, Magneti Marelli, Mentor Graphics, Motorola Solutions, Nokia, Orange, Rockwell Automation, Sabre, Samsung, Siemens, SII, Wincor-Nixdorf. The Faculty see also the potential of smaller, medium-size companies, as a pioneer of new, niche technologies, which doesn’t need to be used in mass production/services in near future, like: Autea, Anshar Studios, Artifex Mundi, Bluesoft, Child & Xsolve, Fluytronic, Fundacja Media 3.0, i3D, IT Silesia, Pro Business Solutions, Prointegra, Propoint, Sholrelabs. Other companies focuses on creating dedicated systems: 3S, 3Soft, AIUT, EUVIC (former LGBS), Future Processing, Grupa Kapitalowa WASKO, JCommerce, Kamsoft, Sygnity. Then, there are also the one related to our local field of industry – coal mining, among them are: COIG - Centralny Ośrodek Informatyki Górnictwa Spółka Akcyjna, Instytut Techniki Górniczej KOMAG, Metso Automation Poland, Instytutu Technik Innowacyjnych EMAG, Przedsiębiorstwo Kompletacji i Montażu Systemów Automatyki „CARBOAUTOMATYKA”, SOMAR.

Apart from that, several research cooperation conducted by the staff members of the Institute of Informatics are worth mentioning:

**AIUT, Sp. z o.o. R. Cupek**

Research cooperation focuses on issue: Energy Efficient Production Systems for Automotive Industry. Methodology and supporting software tools for energy efficient production systems for automotive industry includes: energy efficiency in industrial production systems, energy and media consumption monitoring, energy and media consumption optimisation, virtual factory models and component based technologies applied for energy efficient production systems.

**Asseco Poland S.A.**

Asseco Poland S.A is a system integrator and a provider of IT services for corporate and institutional customers. The company is also interested in promotion of new technologies and exchange of ideas and solutions between its workers and the faculty staff of the Institute.
Association for children with developmental disabilities BRUNO (Stowarzyszenie na Rzecz Dzieci z Dysfunkcjami Rozwojowymi BRUNO), Rzeszów
P. Kasprowski
The cooperation is focused on the preparation of experiments aiming to improve possibilities to correctly diagnose and treat children with complex intellectual disabilities.

Central Mining Institute, Katowice K. Nurzyńska
Cooperation with the Central Mining Institute GIG in Katowice focuses on the realisation of research project concerning the problem of underground coal gasification process visualization. This work aims in development of a software which will support three-dimensional visualization of the mathematical model describing the process as well as enables augmentation of the artificial data with radar profiles recorded during experiments.

Departament of Ophthalmology, Medical University of Silesia, Katowice
P. Kasprowski
The cooperation is focused on the preparation of experiments aiming to improve possibilities to correctly diagnose and treat children with vision deficits.

EMAG A. Gudyś
Cooperation with The Institute of Innovative Technologies EMAG in Katowice is focused on the field of application of computational intelligence methods to predict hazards in coal mines.

EMAG M. Sikora
CMMS systems analysis in the following areas: functionality, capabilities of data stream processing and integration with automatic classification systems. Proposal of CMMS system operating in the big data area.

Faculty of Pedagogy and Psychology, University of Silesia, Katowice
P. Kasprowski
The cooperation is focused on the preparation of scientific experiments that use eye tracking based methods to reveal various human brain’s properties.

IBM K. Wereszczyński
The cooperation with IBM has been continued on the ground of Partners in Education programme. The AS400/iSeries systems passed to the Institute are continuously used in teaching and research activities. In design of databases and server applications there have been included: IBM WebSphere Software Architect environment, software for defining data structure WebSphere Data Architect and developer software WebSphere Studio. IBM provides required service, software updates and technical support. Representatives of IBM participate in preparation of M.Sc. theses as consultants, and students are offered training and intership in Polish division of IBM in Warsaw and Katowice. Power6 and Power7 based systems with AIX operating systems are also available in new cluster configuration created for Ph.D. studies research.

IBM Academic Competence Center in Information Management was created as the official structure for future cooperation between Silesian University of Technology, IBM
and IBM Partners. This center is focused on scientific cooperation, consultations and solutions verification.

**Institute of Theoretical and Applied Informatics of the Polish Academy of Sciences D. Krasnokucki**

Cooperation with IITiS was connected with project of AIUT company and IITiS. Daniel Krasnokucki was responsible for design and development of Enterprise Service Bus. ESB is a middleware layer, that helps the company connect many applications into one big, well organized system. Cooperation lasted almost year and contained theoretical background - introduction for the company and research as well as practical part - comparing couple available solutions and design of new individual solution.

**Maria Skłodowska-Curie Memorial Cancer Center and Institute of Oncology Gliwice Branch, T. Jastrząb,**

The cooperation involves the design and implementation of a user-friendly system supporting proteomic spectra analysis. The system is made available online and as a standalone application.

**Maria Skłodowska-Curie Memorial Cancer Center and Institute of Oncology Gliwice Branch, M. Staniszewski, P. Skurowski**

Cooperation included:

- analysis and modeling of NMR signal,
- application of preprocessing techniques in NMR spectroscopy,
- analysis and interpretation of NMR trials.

**National Institute of Telecommunications**

**Warsaw University of Technology**

**Wroclaw University of Technology**

**Gdansk University of Technology**

**Poznan Supercomputing and Networking Center**

Cooperation within PL-LAB2020 project (A. Chydziński).

**Proloc Company**

Proloc is the leader among the Polish system integrators. The scope of its activities ranges from system designing to practical application of computer systems in industry. The main industry branches are heat and power generating plants, machines, pump stations, drives etc. The main field of cooperation with the Institute refers to tools and methods of collecting data, networking, telemetric, monitoring, programming of embedded and mobile systems and custom applications.

**Research and Development Center. Polish-Japanese Academy of Information Technology**

In cooperation with the Centre for Research and Development PJAIT are carried out research projects for analysis of the human movement, facial animation and inertial motion capture system. Due to the joint research it is possible to access the modern laboratory of Motion Capture created at PJAIT.
SIMPLE Dąbrowa Górnicza sp z o.o. and Microsoft, J. Szedel, M. Kolano
A large number of complex implementations of IT systems take place in business, in areas such as finance, materials management, production, customer relationships etc. Therefore, the Institute of Informatics established contacts with suppliers of medium and large ERP systems and decided to extend the range of courses, introducing classes covering practical implementation of enterprise management systems. During the course students are familiarized with the theoretical foundations of ERP and CRM system implementation. The associated labs are conducted using commercial systems such as Microsoft Dynamics AX, Microsoft Dynamics CRM and SIMPLE.ERP.

WASKO S.A., T. Jastrząb, K. Wereszczyński
The cooperation is focused on the design, implementation and partial integration of the proteomic spectra analyzer with the Onko.SYS system realized in Maria Skłodowska-Curie Memorial Cancer Center and Institute of Oncology, Gliwice Branch. The cooperation is supported by a scientific research project held at the Silesian University of Technology.
Laboratory and research equipment and software

DCGVS: Laboratory for Interactive Computer Graphics (LabDE)

Laboratory for Interactive Computer Graphics is equipped with 20 computer stations, 5 virtual reality glasses (Oculus DK2), Reference Monitor NEC SpectraView REFERENCE 242, colorimetric spectrophotometer X-Rite i1Photo Pro 2, electroencephalography set EEG Emotiv EPOC and 4 depth cameras Asus XPro.

We have also the test sites with software that support the creation of computer games, including Unity engine, UDK engine, Blender and Visual Studio. In laboratory research projects and courses are carried out concerning game programming, virtual reality and motion capture.

DCNS: Laboratory PL-LAB2020

Within the Institute of Informatics, a node of the wide-area networking laboratory named PL-LAB2020 has been built. The node is equipped with specialized devices for carrying out research in several directions, including Software Defined Networking (SDN), Network Function Virtualization (NFV) and Internet of Things (IoT). The node is connected via dedicated 10Gb/s fiber links with other nodes, located in Warsaw, Cracow, Poznań, Gdańsk and Wrocław. Wide spectrum of technology domains and connectivity to five different locations, with different hardware, allows executing complex scientific experiments and organizing modern and interesting laboratories for students.

In our node there are six SDN/OpenFlow switches from two different vendors (Pica and QuantaMesh). Each of them contains over forty 10Gb/s ports and is connected to a server acting as an SDN/OpenFlow controller. The SDN infrastructure consists also of a server with Data Plane Development Kit, which allows low-level manipulation on forwarding mechanisms. There are also two additional HP servers with 10Gb/s networking cards and dedicated virtualization software.

Very important devices in the node are two hardware traffic generators and analyzers (from Spirent), which can validate the performance and analyze security of the studied solutions. The first generator is equipped with twelve 10Gb/s optical ports, the second – with four 1Gb/s electric ports. The generators support a very rich set of networking protocols (over 80 protocols), technologies, multimedia codes and security-connected solutions.
Regarding IoT, our node contains multiple IoT devices and sensors – single-chip computers working under Linux operating system and RISC OS, prototyping kits for Raspberry PI with additional modules and LCD screens, kits for Arduino based on 8-bit microcontroller ATMEAL AVR, multiple sensors (for example: a carbon dioxide sensor, a motion sensor and other), communication modules (WiFi, XBee, Bluetooth) and RFID/NFC sets. IoT devices are available from PL-LAB2020 network using IoT Gateway, built with a server with dedicated software.

The node is connected to the PL-LAB2020 topology through two high-end MPLS switches – Juniper ACX series, each containing 96 ports (1Gb/s or 10Gb/s) and configured to be accessible by other PL-LAB2020 nodes via VPLS and DWDM technologies.

**DCNS: OPNET**

Computer Systems and Networks Performance Evaluation laboratory participates in Academic OPNET Research and Educational Project. OPNET provides a comprehensive development environment supporting the modelling of communication networks and distributed systems. Both behaviour and performance of modelled systems can be analysed by performing discrete event simulations. The OPNET environment incorporates tools for all phases of a study, including model design, simulation, data collection, and data analysis. Systems simulated in OPNET consists of objects, each with configurable sets of attributes. Objects belong to classes, which provide them with their characteristics in terms of behaviour and capability. Definition of new classes are supported to address as wide scope of systems as possible. Classes can also be derived from other classes, or “specialised” to provide more specific support for particular applications. OPNET models are hierarchical, naturally paralleling the structure of actual communication networks. Wherever possible, models are entered via graphical editors. These editors provide an intuitive mapping from the modelled system to the model specification. Also it is possible to specify models via a programmatic interface. This is useful for automatic generation of models or to allow the simulations to be tightly integrated with other tools. OPNET provides a flexible, high-level programming language with extensive support for communications and distributed systems. This environment allows for realistic modelling of all communications protocols, algorithms, and transmission technologies. Model specifications are compiled automatically into executable, efficient, discrete-event simulations implemented in C programming language. The environment provides built-in performance statistics that can be collected automatically during simulations. Modellers can also augment this set with new application-specific statistics that are computed by user-defined processes. Simulation runs can be configured to automatically generate animations of the modelled system at various levels of detail and can include animation of statistics as they change over time. OPNET is used for laboratory exercises and coursework assignments in the teaching of Systems and Networks Performance Evaluation. The topics include simulations of:

- LAN, MAN, WAN,
- TCP/IP congestion control,
- Active queues management.

137
DCNS: Wireless sensor network

For the purposes of the research project there has been designed and developed a wireless sensor network (WSN) for gathering data from devices and retransmitting them to a central unit of the network. The central unit is responsible for collecting data and retransmitting it to a central system, where data is processed and visualised. Typical applications of WSN are building management systems, alarm systems, habitat monitoring, and vehicular tracking. In the implemented system there was employed automated meter reading (AMR) for water, heat and gas. The only power supply of all or most of WSN nodes by meters is a battery. WSN has to be ready for containing hundreds of nodes gathering measurements and transmitting them to other nodes via a wireless medium.

Development of communication module hardware and electric interfaces, selection of energy efficient microcontroller and radio transceiver were the first objectives realised within the project. Radio transceiver uses the license-free 869.4–869.65 MHz frequency band. These frequencies allow transmitting with RF power up to 500 mW. The next task was to develop some energy efficient medium access (MAC) protocol, which uses a sleep mode for conserving energy of battery—transceiver is switching off when no packet can be sent by other node. A node can cooperate with another 2-way node and retransmit packets from 1 way node. Very important thing is correct implementation of transmission and reception procedures, selection of encoding and forward error correction (FEC) mechanisms. Mechanisms have to be effective and not complicated, because low power computing and cheap components reduce the cost of manufacturing. Executing an energy efficient routing protocol is also very important in multi-hop networks. Most data flows from meters to the central unit (upstream) in AMR applications, only configuration or data requests are sent from the central unit to end devices (downstream). Routing protocol reduces upstream data and counteracts sending redundant packets. Diagnostics of network operation were defined and deployed. Transmission security mechanisms are necessary in wireless networks hence algorithms of encryption and authentication were proposed and developed.

DID: Computer Aided Design of the Electronic Circuits laboratory

The main aim of the laboratory is to present the methodology and the chosen CAD and EDA software tools in design of electronic systems in the following technologies: PCB (Printed Circuits Board), FPGA (Field Programmable Gate Arrays) and FPAA (Field Programmable Analog Arrays). The laboratory is equipped with modern software and hardware tools from Xilinx and Motorola. The students are presented with main ideas
and tools of FPGA and FPAA systems used in computer structure with PowerPC and Microblaze processors, BlockRAM, computer system interfaces and peripheral devices. The laboratory is used for research on the hardware implementation of complex computational algorithms with use of the HDL. The research concerns mainly the hardware implementation of cryptographic algorithms and the construction of the co-processor for the industrial PLC controller.

DID: Computer System Interfaces and Peripheral Devices laboratory

The Laboratory of Computer Systems Interfaces is well-equipped with state-of-art instruments that provide students with hands-on experience with concepts introduced in the lectures. Students use instruments such as oscilloscopes for visualizing periodic signals, function generators for producing voltage signals, logic analyzers for investigating the performance of digital circuits, high end protocol analysers (like Ellisys USB Explorer). The specialized software is used, like Agilent VEE and NI LabVIEW.

DID: Diskless Remote Boot and Terminal Services laboratory

Laboratory for Windows and open source solutions to manage the deployment of the operating system across many clients, provides a diskless or systemless environment for client machines. It uses distributed hardware resources and makes it possible for clients to fully access a local hardware, supports RPL/IPX and PXE/etherboot to provide services to client machines so that it is not necessary to install an operating system on the client hard drives individually. The client machines can boot via RPL/IPX or PXE/etherboot remotely from a network. This could be useful in, for example, switching all laboratory computers from Windows applications to GNU/Linux cluster cloud processing. This approach provides great flexibility in the deployment application for heterogeneous network environment.
DID: Electromagnetic Compatibility laboratory

The new regulations enforce in Poland after the EU accession the manufacturers of electronic and IT equipment to supply the declaration of conformity of the equipment to the criteria specified in the Directive of Electromagnetic Compatibility. Manufacturer is obliged to conduct appropriate research that confirms the conformity of a product with the requirements. In order to cope with the market requirements in this case, Faculty of Automatic Control, Electronics and Computer Science took, in 2004 the initiative to establish the Laboratory of Electromagnetic Compatibility.

In 2007, the Institute of Informatics received 1.2 million PLN grant from Ministry of Science and Higher Education to finance the development of the laboratory. The main purpose of the project was to expand and modernize the laboratory base at the Institute of Informatics, which has contributed to the improvement of market measurement services in the field of electromagnetic compatibility. Laboratory provides research service to companies (mainly small and medium), from the region of Silesia, as well as other Polish regions.

Laboratory conducted the following electromagnetic tests:
- conducted emission measurement in the frequency range: 150 kHz to 30 MHz,
- radiated emission measurement in the frequency range: 30 MHz to 3 GHz in GTEM,
- harmonic current emissions test,
- voltage changes, voltage fluctuations and flicker tests,
- electrostatic discharge immunity test,
- electromagnetic field immunity test in GTEM in the frequency range: 80 MHz - 4 GHz,
- electrical fast transient/burst immunity test,
- surge immunity test,
- conducted disturbances, induced by radio-frequency fields immunity test,
- voltage dips, short interruptions and voltage variations immunity test.

DID: Industrial Computer Systems laboratory

The Industrial Computer Systems ICS Laboratory is equipped with modern hardware especially suited for industrial applications. It allows to learn Programmable Logic Con-
controllers programming techniques for compact solutions (e.g. Moeller X100), modular solutions (e.g. GE Fanuc VersaMax), advanced devices used in big systems (e.g. GE Fanuc PACSystems RX7i, Siemens S7-300) and industrial and embedded PC (e.g. Beckhoff CP and CX). It provides also necessary equipment for studying of distributed control systems (e.g. ABB Frilance), many industrial network solutions (PROFINET I/O, Ethercat, CAN, Genius, DeviceNet, Profibus, EGD, Modbus) and component based industrial automation systems (e.g. PROFINET CBA). In many cases the studies on communication networks goes as deep as to the physical layer (e.g. Genius network communication process registration and analysis with the use of National Instruments DAQ USB module) or data link layer (e.g. Profibus network operation analysis with Softing network analyzer).

Every device in the laboratory is connected to at least one industrial network. It enables research on connectivity and distribution issues within industrial computer systems. Moreover, some of the devices support more than one networking standard allowing to present the methods of integration of different systems. Further advantage of connecting every device to a network is the possibility of studying high reliability systems with implementation of different types of redundancy. For example, with specialised extension equipment modules for PAC Systems RX7i controllers (the Redundancy Memory Exchange RMX modules), the research on systems with hot standby redundancy with bumpless switchover is possible.

Apart from great variety of PLCs, the laboratory is also equipped with execution devices (e.g. elevator model, motor system, production line models, 3 dimensional robot model) and other devices commonly used in industrial computer systems like frequency inverters for motor control (e.g. Danfoss VLT 2800, Beckhoff Servo Drives). The laboratory enables also the access to visualisation devices, SCADA and industrial database software (e.g. ArchestrA Wonderware, Indusoft Web Studio) as well as GE Fanuc QuickPanel, Unitronics panels, with embedded control ability, and control devices with web interface (GE Fanuc PACSystems PLCs, Saia Burgess PLCs, embedded solutions based on Rabbit microprocessor).

Apart from the hardware, the ICS laboratory provides many applications concerning issues of design, programming and commissioning of computer systems in industry. Software packs consist of programming and configuration environments for every device, software environments for creating acquisition, archiving and data presentation and other software commonly used in industrial computer systems (like OPC clients/servers).
DID: Internet Security Monitoring laboratory

The laboratory is used for Internet/network threats monitoring and studying new and available means of system and user threats protection. The main resource is a separated, directly connected to the Internet, research network of C class, equipped with dedicated security systems (e.g. ASA 5510) and ordinary computer hardware, configured as IDS systems, device under test (DUT) systems: physical and virtual (e.g. Virtual PC, xen) systems, honeypot networks, and monitoring or analysing systems. Research activities are focused on algorithms of threat detection in system and network operation, based on non-signature processing methodology, theoretically promising 0-hours threats detection. The students are presented with main ideas and tools of systems and information protection, users authorisation, network operation monitoring and threats detection. Subjects of system vulnerability detection, system hardening, network access configuration and penetration testing are also practically tested on virtual systems.

System protection side is represented by selected biometric (e.g. Fingerprint Reader: Identix BioTouch USB 200 and Veridicom 5th Sense Personal Authentication Peripheral with Development Kit) and multifactor security devices (e.g. Smart Card Environment from ZeitControl Cardsystem GmbH), dedicated hardware and software security systems with the core of cryptographic algorithms.

DID: SAP technology based on IBM DB2 database

Within the framework of agreement between Silesian University of Technology and SAP Poland software IDES SAP ERP 6.0 SR3 and SAP Solution Manager 7.0 EHP1 was installed on IBM DB2 version 9.7 and OS AIX 6.1. SAP Poland, IBM Poland, and Silesian University of Technology launched subject ‘Introduction to SAP technology’. This subject provides a broad insight into the many tasks of SAP system administrators and creates a solid foundation for the training of SAP system and IBM DB2 database administrators. The equipment of the laboratory is used on the course Introduction to SAP technology.
DID: Wire/Wireless Local Area Network laboratory

The laboratory is devoted to studying and presenting problems encountered on the crossroads of wire and wireless network connection technology with modern logical design and configuration (VLAN, VPN). The laboratory is equipped with selected networking hardware (cables CAT 5, 6, 6E, managed level 2 and 3 switches, wire and wireless routers, access points and network cards 802.11a/g/n) and specialised measurement and network monitoring tools (cabling analysers, wire/wireless protocol analysers, rf field analysers). It allows students to learn multiple aspects of physical network design, namely structured wire network design and cabling certification, logical VLAN based network configuration, VLAN interconnections design, wireless network planning and channel allocation design, channel coverage measurement and monitoring, and networks integration management. On software side students can learn different ways of system network protocol configuration, communication software setup and testing. Network configuration tasks are concluded with the setup and configuration of network services: DHCP, DNS and remote access servers. Results of configuration settings are then tested with the throughput measurements in different network configurations.

DMAT: Blackfin evaluation board

In construction of digital circuits and devices it is often needed to study audio and video signals and to this end there can be used Analogue Device’s Blackfin evaluation board. The whole unit provides HPUSB-ICE emulator, colour day/night camera, speakers and power supply sources for devices. The Blackfin processors family is intended to be used in embedded systems so the processors are equipped with different types of interfaces such as TWI, CAN bus, SPI, as well as serial and parallel ports. These interfaces are available on the evaluation board. Programming environment includes audio and video codecs, and also VisualDSP development software which allows to programme the processor in C++, or assembly language using a lot of ready to use library DSP functions. The connection between PC and evaluation board is done via high speed emulator which lets to download executables directly to the memory of the processor and controls the debugging process.
DMAT: Infrared camera

FLIR A-320 infrared camera is an example of an affordable and accurate solution for machine vision and automation systems that require non-contact imaging and temperature measurements. The detector used is Focal Plane Array with high resolution (16 bit, $320 \times 240$ dots), highly sensitive ($<50\text{mK}$) and with response of 9 images per second. Measurement temperature range is from $-20^\circ\text{C}$ to $+120^\circ\text{C}$. The camera can be connected using Ethernet protocol or composite video standard (PAL). With the use of MPEG-4 streamed video this very affordable camera also allows to view live images at up to 30Hz with an image resolution of $640 \times 480$. It is equipped with five I/O ports, opto-isolated, which can be programmed for controlling camera functions and generating alarms (e.g. high temperature on polygon) without PC computer.

DMAT: LEGO Mindstorm NXT robots

The idea to use LEGO building blocks for studying the aspects of construction of robots, programming and remote control originated first at the Massachusetts Institute of Technology, US, but with each new kit being released it spread worldwide and they are now popularly used in research and teaching facilities and institutions.

LEGO Mindstorms NXT kit was released in 2006. It is far more advanced than previous series and contains not only standard LEGO elements such as building blocks, wheels, axles, etc., but also has additional elements that allow for communication with the environment – sensors and engines. The sensors include improved touch and light sensors, and a new sound and ultrasonic sensor technology allowing the robot to measure distance. A rotation sensor, previously
separate, is now directly incorporated into the NXT motors. There is also a Bluetooth compatible hookup that can send and receive messages from a cellphone and other Bluetooth compatible devices.

LEGO Mindstorms NXT enables construction of robots and a wide range of programming methods with the use of universal robotics platform. Programming can be performed by means of NXT-G visual language within LabVIEW environment (autonomous systems), in C# through Microsoft Robotics Studio (remote systems), or running programs can be executed on dedicated Virtual Java Machine. Communication aspects for both inter-robotics and robots-to-mainframe models can be studied as well as internal construction of NXT Intelligent Brick and popular sensors, which can lead to design and implementation of other interfaces.

DMAT: POLARX3 Receiver

In May 2009 the Institute of Informatics joined the European research EDCN project led by EUROCONTROL, aimed to test stability of the EGNOS system. After installing Septentrio PolaRx-3 GNSS receiver, an antenna at the rooftop of the Faculty building and installing PEGASUS software on available servers, the base station began collecting measurement data from the constellation of GPS satellites and receiving SBAS correction messages from 3 EGNOS geostationary satellites. This data is processed by the software PEGASUS and transmitted continuously to EUROCONTROL servers, where it is subject to statistical analysis. Analysis results can be viewed at http://edcn.pildo.com website.
Most of the implementations of information systems take place in business. These systems play different roles supporting, among many others, accounting, manufacturing, logistics, marketing and human resource processes. Although such systems exist in the market for many years, only recently some of them became open to customization made in the way of direct programming. Such customization made with advanced configuration, via open APIs or - in the most advanced systems - through built-in specialized programming languages utilizing object-oriented model of the system.

In order to familiarize students with capabilities of customization of such a system that could be done by programming, DS decided to sign an agreement with Microsoft Corporation (Microsoft Dynamics Academic Alliance) and Simple System SA. Thanks to this starting from 2011 students are familiarized with modern ERP solution (Microsoft Dynamics AX and Simple System) and CRM systems (Microsoft CRM). The recently launched BAS server, hosting mentioned solutions, supports students during the course of ‘Practical Implementation of Information Systems’.

DS: FP Lab - Laboratory for GPU-based parallel computing

The laboratory is intensively used both for research, as well as for teaching purposes. Its equipment was funded in 2013 by Future Processing – a software company, which tightly cooperates with Institute of Informatics. The laboratory contains 27 highly-specified workstations equipped with CUDA-enabled graphics processing units (GPUs), and two multimedia projectors. In addition, Future Processing provided licenses for Adaptive Vision Studio, a software suite for designing machine vision
algorithms. This has made it possible to introduce a new specialized teaching module focused on machine vision algorithms and their optimization using GPU-based programming. Apart from that, the laboratory is exploited for regular programming and software engineering courses.

**DS: General processing on Graphical Processing Units**

In the past 40 years, the performance of top central processing units (CPUs) has been growing roughly according to Moore’s law, i.e. their computational power was doubled every 18 months. Nowadays, there is no possibility to sustain this law for a single processor, so a widely-used solution is a parallelisation. Therefore, modern CPUs consist of several (4 or more) cores that work as separate processors.

A very interesting alternative to the computations made at CPUs become GPUs, since contemporary GPUs are developed to be usable in general processing, not only in graphical processing. The architectures of GPUs and CPUs are, however, quite different, e.g. the GPUs contain hundreds of cores, which however are not independent. The theoretical computational power of GPUs is about an order of magnitude larger than the computational power of CPUs. Moreover, this gap seems to be growing. These days, two main GPU vendors, NVidia and AMD, promote their own GPU technologies, i.e. CUDA and ATI Stream, respectively. Fortunately, recently a group of many companies (including NVidia and AMD) reached a compromise and decided to develop the OpenCL language. At present no public release of OpenCL compilers is ready.

The application of CUDA has shown different results in many areas. In some of them, e.g. solving an $N$-body problem in astrophysics, solving kinetic equations, Monte Carlo simulation of photon migration, the gain was huge, and in some, e.g. discrete event simulation of queuing networks very small. A catalogue of CUDA applications can be found at NVidia’s home page.

The equipment allows for performing experiments for graphic cards of both dominant vendors: NVidia and AMD.

**DS: Linguistic Analysis Server (LAS)**

(http://las.aei.polsl.pl/las2/)

The Linguistic Analysis Server (LAS) is a multipurpose system developed in the Institute of Informatics, performing various kinds of text analysis. It takes a source text in Polish as input and outputs linguistic information about the source text in XML format. Other programs can use LAS as a tool to perform some of processing. Among such programs there can be mentioned Thetos, which translates Polish texts into sign language (http:
The Linguistic Analysis Server consists of several linguistic modules that typically work grouped in chains. There are three basic linguistic processing chains: morphological, syntactic, and semantic analysis. The morphological analysis divides the source text into words, and determines the type and the morphological features of each word. The syntactic analysis builds a parse tree on the basis of Syntactic Groups Grammar for Polish (SGGP) and finds syntactic relations between groups. SGGP divides compound sentences into simple sentences. The semantic analysis determines the semantic roles of each syntactic group. Another processing chain is used by the Thetos system during translation. New linguistic modules and chains can be added to the LAS server at any time.

DS: Thetos (http://thetos.polsl.pl)

Thetos is a prototypical translator of Polish texts into the Polish Sign Language, or more precisely-into a PSL dialect. Its significant part was developed in the framework of two research projects financed by Polish Ministry of Science and Higher Education. In 2012-2013, the translator was successively developed.

The translator contains two modules: linguistic and multimedia. The former transforms the input, textual utterance, into a sequence of Polish words, which are ordered according to the Sign Language grammar rules and compose an equivalent SL utterance.
Utterance transformation is a multi-stage process. It is accomplished by a number of linguistic processors included in the Linguistic Analysis Server (LAS), a useful set of natural language engineering tools (see page 147). The multimedia module interprets consecutive words delivered by the linguistic module and in effect produces a smooth animated gesture sequence, which represents successive sign language signs. The signs are demonstrated by so-called avatar, a virtual character designed specially for that purpose. Initially the animation mechanism was based on FreeWill engine, but in 2007 it was replaced by a new one, based on FRS virtual reality engine. At the same time a new avatar generation was introduced.

The translator and its component mechanisms are popularised by means of Thetos application. It can be used as a Sign Language dictionary - the avatar demonstrates the signs corresponding to entries on the list of Polish words. The user can also use the translation functionality. For this purpose a text can be entered and then the output utterance can be observed - either for all or individually selected words from the textual translation. More information about the system and the Thetos project, including a demo version, can be found at project Web page.

**DS: Programming of Mobile Devices and Human-Computer Interaction**

Over the years people have been using many different approaches of interaction with machines. Standard and basic physical interfaces for computers are keyboard and mouse. Besides these interfaces, people also invented alternative solutions. One of them is touch screen technology mostly used in mobile devices. Nowadays this technology uses capacitive sensing of human body, particularly skin on user’s fingertip. All above technologies are based on physical interaction with devices and controllers.

There are also other ways of establishing connection between human and machine or computer system. What is interesting, interaction with computers can be achieved without touching anything. Human-Computer Interaction (HCI) researchers explore possibilities that allow computers to use as many sensors channels as possible. Most of the
concepts mentioned above, require some kind of action from human being. There are also people with strongly limited possibilities caused by illnesses, diseases and disabilities. Part of them is partially paralyzed or cognitively disabled. For such kind of people, present technology is unfortunately inaccessible. They must use new methods of interaction. At present in the Institute of Informatics various aspects of programming for mobile devices are provided. One of the most important direction of researches is development of mobile applications intended for people with special needs, mostly physically or cognitively impaired.

**DTI: Cluster**

Cluster configuration consists of 5 nodes, each node has 2 Itanium processor computer running SuSE Linux. Storage is based on SCSI disks and external disk matrix. Nodes are connected together with 2 types of network, based on Ethernet 1Gb/s and InfiniBand solution rated up to 10Gb/s.

The system is used for message based communication, parallel processing with PVM software and for research concerning database management. For this purpose DB2 database is configured as HADR and DPF cluster. These configurations are of typical high availability and high performance clusters build on database level. DPF configuration is used to implement surveillance analysis and indexing system.

Since the cost of accessing data stored in relational database (in particular DB2 database) should be minimised, the benefits of DB2 Connect Server installation in cluster can also be analysed.

DB2 Connect implements the Distributed Relational Database Architecture (DRDA) to reduce the cost and complexity of accessing data stored in different DRDA-compliant database servers. It concentrates and manages connections from multiple desktop clients and web applications to DB2 servers running on host or iSeries systems and enables local and remote client applications to create, update, control and manage DB2 databases and host systems using for example SQL Language. To improve DB2 Connect performance, the DB2 connection pooling and connection concentrator features are implemented in server.

New hybrid cluster was configured for Ph.D. students. This environment consists of Intel, and Power6 and Power7 nodes. It is based on IBM blades architecture and uses Blade Center integration. Whole nodes have symmetric access to common resources like communication interfaces and storage.

This configuration is dedicated for tests focused on the hardware and operating system architecture differences.
DTI: Database Servers and OLAP technology

The tasks of designing, querying and databases management are realized with the usage of various database management systems (DBMS). There are led some courses dedicated to such systems, in particular MS SQL Server, Oracle Server and IBM DB2.

The aim of the MS SQL Server course is to present the mechanisms of database management systems, especially making students familiar with the ways of configuration, administration and using the modern database servers. The course subject matter is discussion of administration, and usable aspects of the Microsoft SQL Server. They include issues like: database server installation, creating new databases with the data allocation analysis, using database security mechanisms, monitoring and tuning the server performance, explaining Transact-SQL language basis, and distributed databases. Additionally, SQL Server Analysis Services are used to present OLAP and data mining capabilities of the system. The laboratory exercise on SQL Server Analysis Services covers the following topics: defining data sources, dimensions and cubes, deployment of the prepared solution to the analysis server, cube processing, preparing reports and finding answers to given business questions.

The course on Oracle Database Management System covers the following topics: database architecture, security, backup and recovery, data import and export, data integrity, PL/SQL, SQL extensions, database tuning and SQL optimization, JDeveloper (Forms, Reports), Data Modeler, Oracle Data Guard and Oracle RAC. Silesian University of Technology is also an Oracle partner in the Oracle Academic Initiative program. The Advanced Computer Science program includes Oracle database and middleware software, development tools and curriculum courses.

IBM DB2 Universal Database Management Server represents leading products of database management systems. During laboratory exercises it is used to present elements of data recovery, query optimization, system performance tuning and basic administration. Database clustering is also implemented in this environment using high Availability Disaster Recovery feature. High performance solution is described using Distributed Partitioning Feature. DB2 system is used on multiple operating systems such as Windows, Linux, i5 OS and different hardware platforms like Intel, Itanium and Power. Database level programming is illustrated using User Defined Functions and User Defined Types. A new approach to In-Memory databases is presented with SolidDB database system. The ability to create entirely in memory data structures and cache approach for traditional disk
databases are the topics of dedicated laboratories. There are presented benefits and costs of In-Memory structures and the ways to increase performance in typical situations.

**DTI: Eye Movement Research Laboratory**

The laboratory aim is to provide opportunity for various aspects of eye movement analyses. The laboratory consists of:

- 4 infrared cameras
- 1 high speed camera
- 8 remote eye trackers Eye Tribe working with 60Hz frequency.
- 5 head mounted eye trackers Pupil Lab, able to work in natural environment (especially when connected to mobile devices). There are 2 PRO devices and 3 DEV devices with registration frequency 30Hz. Each eye tracker is equipped with two cameras: eye camera and scene camera.
- 1 head mounted eye tracker Jazz Novo working on the basis of DIROG (Direct Infra Red Oculography) method. It has 1000 Hz recording frequency.
- 1 homemade head mounted eye tracker with frequency 30Hz
The above mentioned equipment is used in many scientific experiments as well as during preparation of multiple B.Sc. and M.Sc. theses. Additionally, the laboratory uses different kinds of homemade software:

- Homemade software for communication with all the above mentioned devices.
- Image processing algorithms for finding eyes, eye center, glint that may be used with classic digital cameras and infrared cameras.
- Ready to use libraries for eye movement signal calibration using different algorithms - polynomial regression, SVR, ANN.
- Libraries for events (fixations and saccades) detection in eye movement signal.
- Application for enhancing human computer interface with gaze (gaze controlled interface).
- Different applications for eye movement visualization and analysis.

**DTI: IBM Rational Software**

IBM Rational software is a leader in supporting requirements engineering, UML modelling, database design and model transformations. During the course on Analysis and Design of Information Systems requirements capturing and management is carried out by Rational RequisitePro using document templates for product vision and use case specifications. Analysis and design phases are carried out using Rational Software Architect (RSA) - a sophisticated CASE workbench that leverages model-driven development with UML. RSA offers support for all UML diagrams, design patterns and transformation capabilities which are exercised during laboratory activities. Integration between RSA and RequisitePro is used to connect the requirements stored in RequisitePro repository.
to UML model elements in RSA. RSA allows to easily create layered architectures and relate cooperating elements from different layers. RSA transformations make it possible to easily generate and reverse engineer code (e.g. in Java). The tools offer sophisticated traceability and impact analysis.

Database design is carried out using IBM InfoSphere Data Architect (ISDA) - a specialised CASE tool for design of large and complicated database schemas targeted at DBMSs from different vendors. The platform makes it possible to transform an UML domain model created in RSA into logical data model in ISDA which can be in turn transformed into a DBMS specific physical data model from which SQL scripts can be generated. Also reverse engineering and model synchronization are supported.

**DTI: IFS Applications and MS Dynamics NAV**

Some of the research and didactic activities concern Enterprise Management Systems. The course on this subject covers the following topics: business processes, MRP/MRPII/-ERP/ERPII systems, basics of accounting, fundamental business reports, e-Business, B2B/B2C, electronic invoices, enterprise IT architectures (SOA, server integration and consolidation, virtualization, high availability, storage subsystems, networks), ERP deployment projects (ASAP, IFS AIM, Microsoft Dynamics Sure Step). The laboratory exercises include: IFS Applications 7.5 (administration, accounting) and Microsoft Dynamics NAV (financials, discrete production, programming).
Other achievements

Organised events

- **AutoUniMo** Workshop, Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, Institute of Informatics, Gliwice, Poland, 5th - 6th August 2015 (R. Cupek, A. Ziębiński)

- **AutoUniMo** Second Scientific Seminar: International Seminar on Data Mining and Artificial Intelligence Methods for Automotive Systems, Silesian University of Technology, Gliwice, Poland, November 26th, 2015 (R. Cupek, A. Ziębiński)

- **Employers’ Day** - free and open lectures and workshops presented by different companies. Since Autumn 2014 it became a cyclic event (at least once a week, 3-4 hours of classes). The aim of those meeting is to present to the students the newest technologies related to ICT and not only, which they can not find in the basic curriculum of studies, due to the limited time, and extend their knowledge and skills during additional classes. Those meetings are totally free and open to all participants - undergraduate, graduate, postgraduate student, Ph.D. candidates, employees, alumns.

  In the winter semester of academic year 2014/2015 47 hours of workshops were presented by 6 different companies (Comarch, Future Processing, JCommerce, Kroll Ontrack, Motorola Solutions, Sabre), and in the summer semester of 2014/2015 over 50 hours and 3 companies (Future Processing, Kroll Ontrack, LGBS) were presented.

  Apart of that additional events and workshops are widely promoted to students, e.g.: conferences, seminars, Joomla Day, IAESTE Case week, which are partially organized by AEI department.

- **Employers’ Forum** of Automatic Control, Electronics and Computer Science event (Forum Pracodawców Automatyki, Elektroniki i Informatyki) is a cyclic event, which gives the opportunity to summarize the one-year cooperation between Faculty and Employers and to exchange knowledge, expectations and experiences for students, employers as well as employees of the Faculty in the field of education graduates of the Faculty. More information can be found on page 75.

- **Eye movement signal - recording, processing and analyzing** - tutorial presented during 22nd International Conference on Pattern Recognition (ICPR 2014) (P. Kasprowski).


• The MEDUSA first scientific seminar, Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology, Gliwice, Poland, 10th February 2014 (R. Cupek)
• Co-organization of Net Masters Cup 2014 (together with NETIA, Allegro and 11 Polish Universities) (P. Kasprowski (coordinator), M. Sikora, J. Widuch).
• SKN MobileTech - Meetings of students’ scientific group (K. Dobosz).
• The Olympiad in Informatics (Olimpiada Informatyczna) - an annual programming competition for secondary school students. The second stage of the Olympiad was organised by Institute of Informatics.
• Wszechnica Informatyki - a monthly meeting for secondary school students and all those that are interested in Informatics, providing lectures on scientific themes for the general public. Includes quarterly visits in the laboratories managed by the Institute of Informatics and occasional invited talks.

Awards

• D.R. Augustyn:
  – Silver Medal for Long Service (2014)
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)
• A. Brachman-Piotrowska:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
• A. Chydziński:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)
• R. Cupek:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)
• Z.J. Czech:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)
• P. Czekalski:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)
• S. Deorowicz:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)
• A. Domański:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)
• J. Flak:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2015)
• P. Gaj:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014, 2015)

• M.戈rawski:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)

• A. Gruca:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
  – Participation in **TOP 500 Innovators**: Science - Management – Commercialization Program of the Polish Ministry of Science and Higher Education, Cambridge, England

• K. Harężlak:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)

• H. Josiński:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)

• P. Kasprowski:
  – Bronze Medal for Long Service (2014)
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)

• M. Kawulok:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)

• A. Kwiecień:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014, 2015)

• E. Lach:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2015)

• B. Małysiak–Mrozek:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)
• M. Michalak:
  – International Fuzzy Systems Association Award for Young Scientist at a conference “Advances in Artificial Intelligence and Applications” (together with M. Sikora and Ł. Wróbel)

• D. Mrozek:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)

• K. Nurzyńska:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2015)

• E. Pluciennik:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2015)

• B. Pochopień:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)

• A. Polański:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)

• J. Respondek:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)

• M. Sikora:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)
  – Individual award of the Rector of the Silesian University of Technology for achievements in science (2015)

• K. Simiński:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)

• U. Stańczyk:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014, 2015)

• R. Starosolski:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)

• K. Stąpor:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014, 2015)
• P. Stera:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014, 2015)
• J. Stój:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014, 2015)
• A. Szczęsna:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2015)
• A. Świtoński:
  – Individual award of the Rector of the Silesian University of Technology for achievements in science (2015)
• K. Tokarz:
  – Team award of the Rector of the Silesian University of Technology for organizational achievements (2014)
• A. Werner:
  – Silver Medal for Long Service (2014)
  – Team award of the first degree of the Rector of the Silesian University of Technology for achievements in science (2014)
• R. Winiarczyk:
  – Individual award of the Rector of the Silesian University of Technology for achievements in science (2015)
• K. Wojciechowski:
  – Individual award of the Rector of the Silesian University of Technology for achievements in science (2014)
• B. Zieliński:
  – Team award of the Rector of the Silesian University of Technology for achievements in science (2014)

Membership in scientific organisations

• P. Gaj:
  – IEEE Senior Member
• A. Gruca:
  – Member of the Board of the Polish Bioinformatics Society
• P. Kasprowski:
  – Association for Computing Machinery (ACM) Member
  – IEEE Member
  – Communication by Gaze Interaction (COGAIN) Member
• A. Kwiecień:
  – Member of Expert Group in European Program: ‘Informatics platform for welding knowledge and research potential along with the development of IT infrastructure of the Welding Institute’
  – Member of the Association of Polish Electrical Engineers
• D. Mrozek:
  – IEEE Member
• J. Stój:
  – IEEE Member
Reviewers and reviews

- D.R. Augustyn for:
  - Frontiers of Information Technology & Electronic Engineering (Journal of Zhejiang University-SCIENCE C)
  - Information Sciences (Informatics and Computer Science Intelligent Systems Applications)
  - International Journal of Applied Mathematics and Computer Science

- P. Czekalski for:

- P. Gaj for:
  - 13th IEEE International Conference on Industrial Technology (ICIT 2012 SS04)
  - Advances in Electrical and Electronic Engineering Journal (VSB-TU Ostrava 2015)
  - Annual Conference of the IEEE Industrial Electronics Society (IECON 2013, 2015)
  - Communications - Scientific Letters University of Zilina (2013)
  - EAI International Conference on E-mobility and Emerging Vehicular Technology (ECARS 2015)

- A. Gruca for:
  - 8th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems – KES 2014
  - Industrial Conference on Data Mining – ICDM 2014, 2015
  - International Conference on Man-Machine Interactions – ICMMI 2015
  - Medical Informatics & Technologies Conference MIT - 2014,2015
• H. Josiński for:
  – Asian Conference on Intelligent Information and Database Systems, ACIIDS 2015
  – Computer Animation and Virtual Worlds
  – Mathematics and Computers in Simulation
  – Sensors

• P. Kasprowski for:
  – IEEE Transactions on Cybernetics
  – IET Biometrics
  – Information Fusion (An International Journal on Multi-Sensor, Multi-Source Information Fusion)
  – International Journal of Biometrics
  – Journal of Behaviour & Information Technology
  – Measurement (Journal of the International Measurement Confederation)
  – Pattern Recognition Letters
  – Transactions on Information Forensics & Security

• M. Kawulok for:
  – 18th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems (KES 2014)
  – IEEE Transactions on Multimedia
  – IET Image Processing
  – International Conference on Man-Machine Interactions (ICMII 2013)
  – International Journal of Applied Mathematics and Computer Science
  – Journal of Electronic Imaging
  – Journal of Real-Time Image Processing
  – Multimedia Tools and Applications
  – Neurocomputing
  – Optical Engineering
  – Pattern Recognition

• M. Michalak for:
  – 16th International Conference on Intelligent Data Engineering and Automated Learning (IDEAL)
  – Applied Soft Computing
  – Mining Informatics Automation and Electrical Engineering
– Neural Networks
– Sensor
• D. Mrozek for:
  – African Journal of Biotechnology
  – Briefings in Bioinformatics
  – Neurocomputing
• J. Nalepa for:
  – Computers & Operations Research
  – IEEE Transactions on Evolutionary Computation
  – International Conference on Man-Machine Interactions (ICMMI 2015)
  – Soft Computing
  – The 8th International Conference on Neural Network and Artificial Intelligence (ICNNAI’2014)
• K. Nurzyńska for:
  – IET Computer Vision
  – International Conference on Interactive Mobile Communication, Technologies and Learning (IMCL 2014)
  – International Conference on Teaching, Assessment, and Learning for Engineering Conference (TALE 2014)
  – International Journal of Machine Learning and Cybernetics
  – Meteorological Applications
• K. Simiński for:
  – 19th International Conference on Methods and Models in Automation and Robotics, MMAR 2014
  – Applied Soft Computing
  – Expert Systems with Applications
  – Fuzzy Sets and Systems
  – IEEE Transactions on Fuzzy Systems
  – International Journal of Applied Mathematics and Computer Science
  – International Conference on Man-Machine Interactions (ICMMI 2015)
  – International Conference on Medical Informatics and Technologies (MIT 2015)
  – Journal of Approximate Reasoning
  – Pattern Analysis and Applications Journal
• R. Starosolski for:
  – Color Research and Application
  – Expert Systems With Applications
  – IEEE Signal Processing Letters
  – IEEE Transactions on Circuits and Systems for Video Technology
- IET Image Processing
- Journal of Electronic Imaging
- Journal of Imaging Science and Technology
- Journal of Medical Imaging

• J. Stój for:
- IEEE Transactions on Industrial Informatics

• A. Szczęsna for:
- 7th Pacific-Rim Symposium on Image and Video Technology, 2015
- International Conference of Numerical Analysis and Applied Mathematics, IC-NAAM 2015
- International Conference on Systems ICONS - 2014, 2015
- World Multi-Conference on Systemics, Cybernetics and Informatics, 2015

• K. Tokarz for:

• Almost all members of DTI staff for:
- International Conference Beyond Databases, Architectures and Structures (2014, 2015)
- Studia Informatica

Invited speeches

• P. Kasprowski for:
- Eye movement analyses. Open days of Silesian University of Technology, Gliwice, 2015.

Activity in Councils and Committees

• P. Czekalski:
- Member of the Program Committee: Asian Conference on Intelligent Information and Database Systems (ACIIDS 2014, 2015)

• P. Gaj:
- Associate Editor: IEEE Transactions on Industrial Informatics (2013-2015)
- Co-Editor: Communications in Computer and Information Science (CCIS series of Springer 2009-2016)
– Guest-Editor: Wireless Personal Communications Journal of Springer (SS WIRE 2015)
– Member of International Science Conference on Knowledge in Telecommunication Technologies and Optics (KTTO 2012 – 2015),
– Member of the IEEE International Workshop on Factory Communication Systems (WFCS 2013 – 2016),
– Member of the Organizing Committee: 'Computer Networks' (2007–2016)
– Member of the Program Committee: National Conference 'Real Time Systems’ ("Systemy Czasu Rzeczywistego") (2007–2014)
– Member of the Program Committee: International Conference on Advanced Wireless Information and Communication Technologies (AWICT 2015)
– Member of the Program Committee: International Forum on Research and Technologies for Society and Industry: Leveraging a better tomorrow (RTSI 2015)
– Member of the Program Committee: International Conference on E-mobility and Emerging Vehicular Technology (ECARS 2015)

• A. Gruca:
  – Chair of Organising Committee of International Conference on Man-Machine Interactions 2015
  – Conference Program Committee Member:
    * Industrial Conference on Data Mining (2014, 2015)

• P. Kasprowski:
  – Program Committee Member of Beyond Databases Architectures and Structures Conference (BDAS 2014, 2015)
  – Program Committee Member of 7th International KES Conference on Intelligent Decision Technologies (2015)
  – Program Committee Member of 2nd Workshop on Insight on Eye Biometrics (IEB 2015) In conjunction with The 11th International Conference on Signal Image Technology & Internet Based Systems (SITIS 2015)

• S. Kozielski:
  – Program Committee Member of Beyond Databases Architectures and Structures Conference (BDAS 2014, 2015)

• A. Kwiecień:
  – Member of the Program Committee: EMAG Journal: 'Mechanization and Automation in the Mining Industry'
  – Member of the Program Committee: 'Methods and Tools of Software Development’ Conference

• B. Małysiak–Mrozek:
  – Program Committee Member of Beyond Databases Architectures and Structures Conference (BDAS 2014, 2015)
• M. Michalak:
  – Associate Editor: Open Computer Science
• D. Mrozek:
  – Program Committee Member of Beyond Databases Architectures and Structures Conference (BDAS 2014, 2015)
• K. Nurzyńska:
  – Associate Editor: Open Computer Science
• K. Stąpor:
  – International Conference on Computer Recognition Systems (CORES)
• J. Stój:
  – Co-Editor: 'Studia Informatica' series
  – Member of the Organizing Committee: 'Computer Networks'
• A. Szczęsna:
  – Co-Chair of Workshop on Numerical and Symbolic Computation in Computer Vision and Data Management, International Conference of Numerical Analysis and Applied Mathematics, ICNAAM 2015
  – Programming committee member of Workshop 2D & 3D Geometric Properties from Incomplete Data, 7th Pacific-Rim Symposium on Image and Video Technology, 2015
  – Programming committee member of The International Conference on Systems ICONS - 2014, 2015
  – Programming committee member of World Multi-Conference on Systemics, Cybernetics and Informatics, 2015
• K. Tokarz:
  – Member of the Program Committee: Asian Conference on Intelligent Information and Database Systems (ACIIDS 2014, 2015)
• A. Ziębiński:
  – The MEDUSA First Scientific Seminar 10th February 2014 at Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology in Gliwice
  – The MEDUSA Second Scientific Seminar 26th September 2014 at Hogskulen i Sogn og Fjordane, Forde, Norway
  – International Seminar on Emerging Technologies in Automotive Area Technische Hochschule Ingolstadt, Bavaria, Germany, December 4, 2014
Michał Kawulok: Analysis of the local features similarity in digital images, applied to human skin detection and image colorization

The habilitation achievement was presented as a series of 12 articles, which introduce new methods for analysis of digital images based on the pixels similarity, extracted with the use of such local features as chrominance, luminance and texture. The similarity is analyzed both in the feature spaces, as well as taking into account the pixels neighborhood using the geodesic distance transform.

The proposed methods were applied to skin regions detection and segmentation in color images and for grayscale image colorization. Although the general goals of these two computer vision tasks are totally different, in both cases it is image segmentation, which plays the substantial role in the introduced algorithms. It is performed using similar techniques, such as the geodesic distance transform, modeling of color and luminance, and also simple textural features are exploited. Furthermore, the local feature models are adapted to a presented scene (i.e., an image or a video sequence).

The introduced algorithms are aimed at determining the cohesiveness of image regions, and they allow for obtaining better results than many state-of-the-art methods for image colorization and skin detection. The papers included into the submitted series discuss the problem of computing the local costs for the geodesic distance transform in different domains—chrominance, luminance, skin-presence probability, and also in the introduced space of discriminative textural features. Moreover, they embrace the problems concerning the similarity of local features, with particular attention paid to adapting the feature models to an analyzed scene.

Overall, the most important original contributions proposed in the habilitation achievement were as follows:

- New local costs metrics for the geodesic distance transform.
- Introduction of the discriminative textural features space, and its application to computing the local costs for the geodesic distance transform.
- The method of competitive propagation paths.
- Image segmentation based on scribble boosting.
- Application of the geodesic distance transform to skin detection and segmentation.
- Adaptation of the color models combined with the geodesic distance transform.

Wojciech Kempa: Queueing models with limited access to server

The monograph is devoted to the study of stochastic characteristics of single-server queueing systems with limited access to server. The limitation may be related to the finite buffer...
capacity, which implies the loss of packets arriving during the period of buffer overflow, as well as periods of temporary unavailability of the server (server vacations), or finally using more complex mechanisms affecting the slowing or reducing the service process (N-policy, setup times). In addition, a limited access to the server can also be connected with applying the AQM (Active Queue Management) algorithm, in which the packets may be rejected even when the buffer is not completely saturated.

In the monograph the most important characteristics of systems with limited access to the server are studied analytically, in particular queue-size distribution, virtual waiting time, departure process, duration of a single busy period or the number of packets served during this period. The results are obtained for both the transient and the stationary state of the system, using different techniques, including the embedded Markov chain approach, the method of supplementary variables, Kolmogorov-type equations, renewal theory or the method of potential.

Theoretical results are illustrated by numerical computations, in which the effect of parameters of real packet traffic (in the Internet or wireless sensor network) e.g. the intensity of arrivals and services, buffer size etc. on the distributions of key stochastic characteristics of the system is investigated.

**Jarosław Miszczak: Modelling of quantum informatics systems with the use of quantum programming languages and symbolic computation**

The main result of the work presented in the scientific achievement is the development of methods for modelling objects used to describe information processing in quantum computing systems. Such a description depends on the type of system under consideration. In the most general case, one can consider in this context two types of quantum systems: closed systems and open systems.

Closed systems provide the idealization of physical systems, which does not take into account the impact of the environment on the process of information processing. The description of such systems uses the pure state formalism (elements of a finite-dimensional complex vector space), and the information processing is described in the language of quantum gates, which, from the geometric point of view, represent unitary rotations.

In the case of open systems, the influence of the environment on a quantum system used to process the information cannot be neglected. The state of the system is represented by the density operator (positive definite operator with trace 1), while the transformations of the states are described by quantum operations, i.e. completely positive mappings preserving the trace. Many phenomena crucial for the analysis of quantum information processing, such as errors or interception of information, can be modelled as an interference from the environment. For this reason, the study of such systems is important for the technical realizations of quantum computing systems.

The research was focused on important issues that arise in the modelling of quantum information processing, both in closed and open systems. The results, presented in the publications listed in the achievement, concern the representation of quantum information
processing in closed systems, modelling of quantum operations in open composite systems and the application of quantum sources of randomness in simulations of quantum states and operations.

The results were obtained mainly through the implementation of three research projects in which I performed the role of a manager. Two of them - project IP2010 052270: Analysis and modelling of local properties of quantum states and operations, and IP2011 036371: Application of geometrical methods for the analysis of quantum states and operations - have received funding from the Ministry of Science and Higher Education under the Iuventus Plus program for years 2011–2014. The third project: N N516 475440: Application of quantum game theory in modelling of quantum information transmission received funding from the National Science Centre in 2011–2013. The work on the high-level description of quantum information processing has been also conducted in part during the research project N N519 442339: Distributed environment for numerical analysis of the quantum information theory conducted in 2010–2013 under the supervision of R. Winiarczyk Ph.D.

Zbigniew Puchała: The geometrical methods in quantum computing

For a detailed description of a given real number it is required, in generality, infinite number of bits, therefore, any finite representation of the continuous random variable is not ideal. The basic question in this situation is how well the random number from a given distribution can be restored. The answer to this question is associated with a defining the measurement of error which measures the distance between the random variable and its representation. This issue is widely discussed and described in the literature of classical information theory.

Similar problems appear in quantum information theory. Namely, while processing the quantum information in implementations of quantum computer systems, it is required to preserve the highest possible precision. However, given the inevitable interaction with the environment, as well as the imperfections of the system, errors occur. Therefore it is necessary for a quantitative characterization of similarity of the processed quantum state to the given final state. The above issue is one of the basic topics in quantum computing.

The main objective of the scientific work which are the academic achievements, is the analysis of the geometrical aspects appearing in the problem of the mismatch in quantum computing systems. As part of work there were considered geometrical properties of distance measurement in over the states and quantum operations as well as the use of geometrical methods to analyse the controllability of quantum computing systems as well as optimization of the quantum channels.

Marek Sikora: Selected methods of decision rule evaluation and pruning

The first part of the book is devoted to sequential covering rule induction algorithms and objective rule evaluation measures. Two algorithms that maximize values of rule
evaluation measures are presented. The properties of measures defined on the basis of the contingency table were analyzed and minimal sets of the properties desired for measures controlling the process of rule induction and evaluating descriptive quality of decision rules were specified. The analysis of equivalence and similarity of measures was carried out. The equivalence was analyzed both due to the rule ordering and the classification conflicts resolving. In the experimental part the efficiency of measures was verified, sets of the most efficient measures were identified. The adaptive method of measure selection in sequential covering rule induction algorithm was proposed. Moreover, theoretical properties of most effective measures were analyzed. In the first part measures that are not defined directly from the contingency table were also discussed. Furthermore, the possibility of complex evaluation of rules was discussed and the proposal of multi-criteria rule assessment on the basis of so-called utility function was presented.

The second part of the book focuses on algorithms of rule pruning. This part presents two algorithms of rule aggregation, the algorithm of rule redefinition based on information about the importance of the rule elementary conditions, and four algorithms of rule filtration. Through aggregation and redefinition complex elementary conditions may appear in rule premises which, in specific cases, better reflect dependencies in data. The effectiveness of all the algorithms proposed in the first and second parts was verified experimentally.

The last part of the work shows examples of new applications of the decision rule induction algorithms. The following three new areas of application are presented: forecasting of seismic hazards, analysis of bone marrow transplantation data and functional description of genes. The results of study presented in the first two parts of the book were used there. Two domain-oriented modifications of rule induction algorithms are proposed. The first one allows for the rule induction controlled by hypothesis defined by the user. The second adjusts the induction algorithm to the hierarchical structure of the analyzed data. The method of attribute reduction that takes into consideration the semantics of the attributes values is also the result of research on the functional description of genes.
Ph.D. theses descriptions

Agnieszka Danek: Algorithms for analysis of genomic data in compressed domain

The huge and rapidly growing amount of genomic data, resulting from the dramatic progress of high-throughput sequencing techniques, presents new challenges in the field of algorithms processing and analysing text data, as text is typically used to represent information about genomes. The first, quite obvious problem is the data storage and transfer. Their costs, with the dropping prices of sequencing, may soon surpass the cost of data production. In this context, design of efficient compression methods for genomic data is crucial. Another important issue is the analysis of such a large collection of information. Existing data mining solutions often cannot handle large-scale genomic data nor make use of their specific features. In particular, they are frequently useless because of excessive memory requirements or unacceptably long computation times. Hence, the development of specialised bioinformatics algorithms and tools has become an area of active research in the past years.

In the dissertation the attention is focused on compressing and indexing large collection of genomes, employing available biological knowledge contained in the files describing all variations occurring in all individuals in the set, with respect to some reference. The problem of finding approximate tandem repeats in genomic sequences employing text mining techniques is also considered.

Dissertation thesis: Applying specialised algorithms, designed for processing specific genomic data and possibly employing available biological knowledge, can:

- improve, in comparison to the existing methods, compression of a collection of genomes,
- enable efficient indexing of large collections of genomes, allowing for fast approximate pattern search within the compressed set,
- be an alternative or complement to known methods of approximate tandem repeats discovery.

To prove the aforementioned statements three algorithms were proposed: Thousands Genomes Compressor (TGC), Multiple Genome Index (MuGI) and Burrows-Wheeler approximate tandem repeat searcher (BWatrs). Two of them, TGC and MuGI, process large collections of genomes of the same species using available knowledge about polymorphisms occurring in the genomes. We demonstrated how the additional knowledge allows to represent the collection in a simple but clever way: as variant database plus byte vectors (VDBV). Such representation is more susceptible to compression than raw genomes, as all sequences are perfectly aligned and it is easier to exploit existing similarities. TGC, taking advantage of it and employing specialised Ziv-Lempel-style compression techniques, is able to compress a genome collection achieving compression ratios...
unavailable to modern genomic sequence compressors, as they ignore external knowledge and/or work on raw sequences, what is extremely resource consuming and complicates efficient search for existing genomes similarities. MuGI is based on a similar approach of representing a genome collection, which is adapted to create a succinct and efficient index of a customisable size. The size reduction is smaller than in TGC, but the data are more accessible. The index incorporates also additional structures containing information about all k-length sequences in the set. They allow for fast search for a given pattern of an arbitrary length. Both exact and approximate (with up to 5 mismatches) pattern occurrences can be found with MuGI. In contrast to existing algorithms, MuGI is able to build the index using a reasonable amount of memory resources, while the queries alone can be run on a standard PC. BWatrs searches for ATRs, defined on the basis of the model of substitution mutations. It applies the Burrows-Wheeler transform on the input text, to quickly find all near repetitions of some pattern, which are then treated as candidates for ATRs and further investigated. BWatrs is able to find many potentially biologically interesting ATRs, missed by other popular ATRs searching algorithms.

Jolanta Kawulok: Algorithms for approximate matching of patterns to genomic sequences

In the natural world, the information system that coordinates the processes of reproduction and vital functions regulation, is underpinned with the genome encoded using the deoxyribonucleic acid (DNA). The precise order of the nucleotides within a DNA molecule may be determined using DNA sequencing. In the recent decade, the DNA sequencing methods have been becoming cheaper and faster, hence the number of known sequences is increasing rapidly. Acquired DNA sequences are stored in a number of gene banks, such as the well-known GenBank, which contains billions of base pairs (i.e. nucleotides) from human DNA sequences. Therefore, the algorithms are needed which could help in fast searching of specific DNA patterns in the DNA databases. In many cases, the sequences are expected to be matched despite some small differences between them (termed insertions, deletions or mismatches), hence the searching algorithm should allow for approximate matching.

While the genome is the entire set of the genetic material acquired from a single organism, it is also possible to analyse the genomes of all the organisms living in a given environment at once. Such an acquired set of genomes is called the metagenome, and it may be subject to the same sequencing procedure as the genome derived from a single organism. During the metagenome sequencing, a collection of mixed reads is obtained, which is derived from the DNA sequences of all the microorganisms living in a single environmental sample. Characterization of the environment composition broadens the knowledge about the relationship between species composition and environmental conditions.

The goal of this Ph.D. work was to develop new methods for comparing strings of symbols representing the DNA sequence fragments with each other. In the framework of the Ph.D. work, two algorithms were developed and implemented: approximate string
matching for searching DNA sequences and classification of the reads generated from metagenomic samples.

In the first algorithm, a short sequence (pattern) is searched in both DNA strands with a given maximal number of errors. Each DNA reference sequence is preprocessed by compressing it using Burrows-Wheeler transform and wavelet tree. First, the pattern is divided into short words which overlap themselves, and then their positions in reference sequence are determined using FM-index. Connections between the words are searched under the assumption of an acceptable maximal error allowed. Experimental results indicate that the algorithm is highly effective and it outperforms a popular Basic Local Alignment Search Tool (BLAST) in case of searching for short sequences.

The second algorithm (called CoMeta) assigns a query read (a DNA fragment) into one of the groups previously prepared by the user. Typically, this is one of the taxonomic rank (e.g., phylum, genus), however prepared groups may contain sequences having various functions. In CoMeta, there were two main contributions proposed, namely the exact method for read classification using short subsequences (k-mers) and a fast program for indexing large set of k-mers. In contrast to the most popular methods based on BLAST, where the query is compared with each reference sequence, the classification was begun from the top of the taxonomy tree to reduce the number of comparisons. The presented experimental study confirms that CoMeta outperforms other programs used in this context.

Daniel Kostrzewa: Search space exploration based on the optimization of query execution plans using IWO algorithm

The Invasive Weed Optimization algorithm (IWO) is an optimization method, created by the researchers from the University of Tehran, inspired by dynamic growth of weeds colony. The expanded IWO algorithm (exIWO) is an optimization metaheuristic modelled on the original IWO version.

The author of the thesis has extended the original IWO algorithm introducing a set of both hybrid method of the search space exploration and a few of strategies of individuals’ selection. The goal was to evaluate the modified version of IWO algorithm by testing its usefulness in three optimization problems: numerical functions minimization, traveling salesman problem (TSP) and the join ordering problem. The optimized multidimensional functions: Griewank, Rastrigin, and Rosenbrock are frequently used as benchmarks which allow to compare the experimental results with outcomes reported in the literature. Both the results produced by the original version of the IWO algorithm and the Adaptive Particle Swarm Optimization (APSO) method served as the reference points. The exIWO also solved some test instances of the traveling salesman problem (TSP) taken from the TSPLIB collection which allows to compare the experimental results with outcomes reported in the literature. The results produced by other heuristic algorithms as well as the methods based on the self-organizing maps were taken into consideration.

The introduced strategies were also used to solving the most important optimization problem in the thesis - finding a satisfying solution to the join ordering problem, which
constitutes a crucial part of the database query optimization task. The method of strategy verification was based on the comparison of the execution time for the solution produced by the exIWO algorithm with the analogous value for the solution determined by the SQL Server 2008 optimizer. The results of the experiments showed that the exIWO algorithm can successfully compete with the SQL Server 2008 DBMS in optimization of join order in database queries.

Magdalena Lachor: Application of rough-set methods to binary biclustering

Doctoral thesis included the following research:

- a propositions of two algorithms for binary biclustering, which were based on foundations of rough set theory;
- a proposition of a method for comparison of sets of biclusters;
- an implementation of the most important algorithms for binary biclustering known in the literature;
- a comparison of algorithms for binary biclustering based on real and synthetic data sets;
- an analysis of quality indices of biclusters.

Jakub Rosner: Methods of parallelizing selected computer vision algorithms for multi-core graphics processors

In this thesis methods of parallelizing selected computer vision algorithms for multi-core graphics processors were presented. It presents two sequential algorithms, namely Kanade-Lucas-Tomasi detector/tracker and Scale Invariant Feature Transform used as a basis of this work. The thesis was presented and proved in conducted experiments. This thesis presents detailed structure of graphics processors, methods of parallelizing algorithms and explains where they can be used and why.

Adam Skowron: Sequential covering regression rule induction and optimization of regression rule-based data models

The main aim of this work is to analyse and evaluate two strategies - top-down and bottom-up - of the covering rule induction of regression algorithms, which use different methods to supervise the process of induction.

One of the additional goals of the work is also to evaluate the impact of a single rule optimization (optimization methods used during the induction process) and of the entire rule set (optimization methods used after the induction) on the final prediction accuracy and the transparency of the constructed model. Other objectives are: to examine the effect of modification of a fixed value of rule conclusion on both strategies, to examine the impact of the introduction of statistical adjustments to the number of positive and negative examples cover by the rule on the final prediction and usefulness of the rule and
to investigate and evaluate methods for resolving conflicts between the rules that cover the same examples.

The aim of empirical research (including two experiments carried out on real data) was to propose the most effective combination of covering rule induction algorithm to solve the regression problem, to propose the most accurate quality measure to control the induction process and to propose the most effective methods that can be used on different stages of the covering rule induction.

**Michał Staniszewski: Signal analysis of magnetic resonance spectroscopy by application of SVD decomposition**

Proton Magnetic Resonance Spectroscopy, 1H MRS, is a variant of analytic spectroscopy of Nuclear Magnetic Resonance 1H NMR, which can be used for receiving biochemical information in in vivo researches. Due to specifics of measurement in real body, 1H MRS in vivo technique requires precise support of computer software, which are applied in each step of analysis, during preprocessing and also while interpreting the results. The main purpose of Ph.D. thesis was to develop methods and scripts aiding preprocessing and analysis of magnetic resonance spectrum basing on Singular Value Decomposition (SVD) decomposition.

The main thesis are the following statements:

- methods which model signal with use of SVD can be used as an effective tool in analysis of MRS, moreover results of main components analysis can be improved by application of reiteration of decomposition method,
- addition of prior knowledge into modeling methods can influence on results of analysis,
- methods which are based on SVD can be applied in preprocessing techniques, in the step of removal of unwanted components and during analysis of metabolites concentration.

Modeling methods which use SVD decomposition are accurate in reproduction of whole signal, but obtained single components of FID do not have physical properties of metabolites. In order to solve that problem the author proposed modification of basic algorithm by double use of HSVD method. The given solution was compared to base method for main components of metabolites and proves to give better results. The modified method was also analyzed for real data and it was compared to commercial software, which confirms efficiency of presented tool in the analysis of NMR signal, in particular with respect to main components.

More complex and complicated signals coming from metabolites requires prior knowledge, which consists of signal parameters in chosen part of spectrum. Methods already implemented for HTLS algortim were applied for HSVD method. The author of the thesis introduced three different methods relying on prior knowledge and tested then on data obtained from NMR simulator. Results of HSVD_fdp algorithm were compared to complex NAA metabolite and it was proven that prior knowledge has influence on correct identification of metabolites which consists of many resonance signals and further analysis.
The Ph.D. thesis offers a careful analysis of preprocessing techniques and provides its examples. Moreover, while basing on the available articles the thesis underline how crucial is an application of proper correction. Additionally, the author proved that methods using SVD decomposition can be applied in the process of removal of unwanted components, as well as in filtration and phase correction.
Monographs, books, and textbooks


The book is a collection of exercises and solutions in the field of logic circuits, including issues of elementary digital circuits, synthesis and analysis of combinational and sequential digital circuits. It is an auxiliary material for lectures and exercises with the subject "Theory of Logic Circuits" Computer Science. It may also be useful to graduate and postgraduate students of other disciplines, such as: Automatic Control and Robotics, Electronics and Telecommunication, Mechatronics.


Recent developments in computer science enable algorithms previously perceived as too time-consuming to now be efficiently used for applications in bioinformatics and life sciences. This work focuses on proteins and their structures, protein structure similarity searching at main representation levels and various techniques that can be used to accelerate similarity searches. Divided into four parts, the first part provides a formal model of 3D protein structures for functional genomics, comparative bioinformatics and molecular modeling. The second part focuses on the use of multithreading for efficient approximate searching on protein secondary structures. The third and fourth parts concentrate on finding 3D protein structure similarities with the support of GPUs and cloud computing. Parts three and four both describe the acceleration of different methods. The text will be of interest to researchers and software developers working in the field of structural bioinformatics and biomedical databases.
This book:
• Highlights the potential of new computational technologies in protein bioinformatics.
• Presents a focus on protein structure, which remains poorly understood and is not effectively used in medicine.
• Describes methods for applying structural bioinformatics in medical diagnostics.
Complete list of publications


179


181


182


[133] T. Jastrząb. System for 1D proteomic spectra analysis as an example of distributed SaaS solution (System analizy widm proteomicznych 1D jako przykład rozproszonego rozwiązania typu SaaS). In I Seminarium Polskiego Towarzystwa Proteomicznego. 2014.


[350] K. Tokarz and P. Czekalski. SMAC-GPS and radar data integration to set the status of the objects in secure areas. In MAN-MACHINE INTERACTIONS 3.


[362] Ł. Wyciślik and Ł. Warchał. A performance comparison of several common computation tasks used in social network analysis performed on graph and relational databases. In MAN-MACHINE INTERACTIONS 3.


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