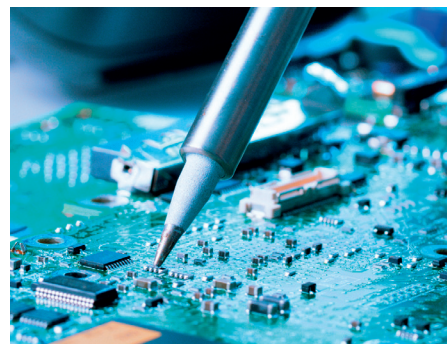
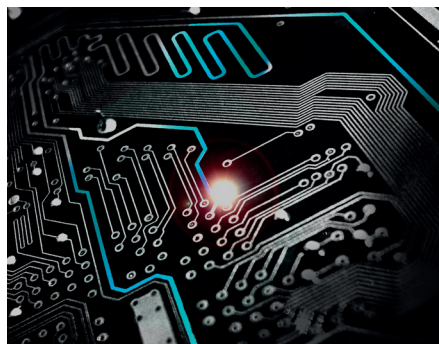
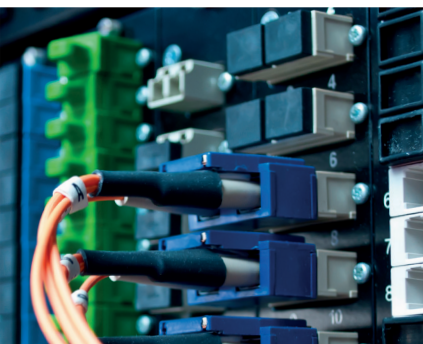




Wrocław University
of Science and Technology



FACULTY OF ELECTRONICS



www.weka.pwr.edu.pl



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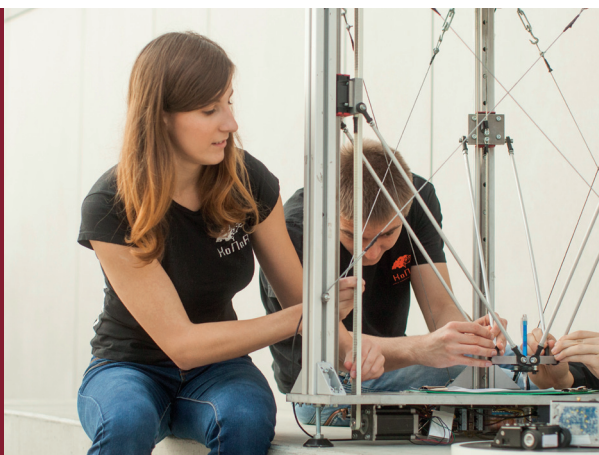
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General information

The Faculty of Electronics of the Wrocław University of Science and Technology is the largest faculty dealing with Information and Communication Technologies (ICT) including control engineering, robotics and electronics at the regional and national level in Poland. There are over 6 thousand students. Every year over one thousand graduates obtain their Bachelor or Master Studies diplomas. It is also one of the oldest faculties as its history dates back to 1945, although officially it was set up only in 1952, first it was the Communications Faculty and later its name was changed to the Faculty of Electronics. Although there is a wide spectrum of fields of study which have changed over these years, unlike other technical universities, the Wrocław University of Science and Technology did not change the faculty name and so it is still called the Faculty of Electronics.

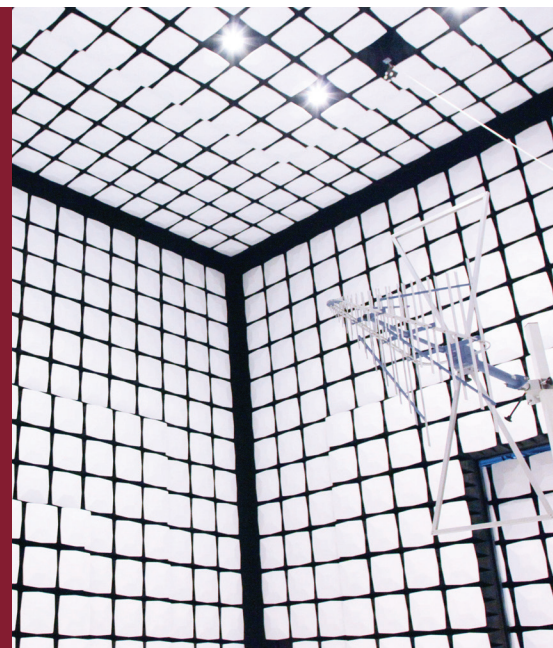
The faculty has excellent scientific and teaching staff, more than 60 years of experience in education and scientific research (including individual grants from the Ministry of Science and Higher Education and the European Framework Programme FP6, FP7), numerous international contacts, specialist laboratories with excellent equipment, a large library collection, spacious classrooms located in buildings C-1, C-3, C-4, C-5, C-15, at 11/17 Z. Janiszewskiego St. and E-1 at 53/55 B. Prusa St. In October 2014 the Faculty premises gained a new building – the Didactic-Technological Centre TECHNOPOLIS. In the Centre there are nearly 30 didactic laboratories with unique, state of the art equipment, lecture theatres and workplaces for PhD candidates and undergraduate students. The Centre is dedicated to educate WrUST students and PhD candidates at the highest, world level in areas related to the latest communication and information technologies as well as control engineering and robotics.

The academic staff includes 20 full professors, 28 Doctors of Science (most of them hold the position of an associate professor) and more than 150 doctors. This guarantees an opportunity to gain high professional and academic qualifications for our students. Results of our research are well known and published all over the world, and those of our students who conduct a part of their studies abroad are considered the best students at their host universities. The faculty runs a PhD studies programme and currently there are about 150 PhD students working on their dissertations. The Faculty of Electronics comprises:

- **Department of Electronic and Photonic Metrology (K-1),**
- **Department of Systems and Computer Networks (K-2),**
- **Department of Telecommunications and Teleinformatics (K-3),**
- **Department of Field Theory, Electronic Circuits and Optoelectronics (K-4),**
- **Department of Acoustics and Multimedia (K-5),**
- **Department of Signal Processing Systems (K-6),**
- **Department of Cybernetics and Robotics (K-7),**
- **Department of Control Systems and Mechatronics (K-8),**
- **Department of Computer Engineering (K-9).**

The faculty has the right to confer doctoral degrees as well as Doctor of Science degrees in the fields of control engineering and robotics, computer science, electronics and telecommunications.

Another strong point of the faculty are more than 20 student scientific interest groups involved in intense activity, and availability of studies in English.



Teaching

The studies at the Faculty of Electronics provide comprehensive knowledge in the fastest developing fields of science and technology, namely: computer science, telecommunications, teleinformatics, electronics, control engineering and robotics. Taking into account the unknown challenges of the new world, rapidly changing living conditions, new technologies, overlapping scientific disciplines, economic and social changes as well as the need for continuous education of the 21st-century society, we have shaped the scope of education in such a way that our graduates can meet the requirements of the modern world. We are trying to provide comprehensive professional education and an extensive basis for particular areas in electronics and computer science. We take special care of the development of creative thinking. We also improve self-education processes based on openness for knowledge. At the same time we teach managerial skills and proficient knowledge of languages.

Over 60 specialist laboratories with state of the art equipment of renowned manufacturers form a perfect basis for the education process. Good quality of education is guaranteed by external evaluations and certificates of the following institutions: the State Accreditation Committee (PKA – now the Polish Accreditation Committee) and the Accreditation Commission of Technical Universities (KAUT) for the following fields of study: Computer Science (the field distinguished by PKA), Control Engineering and Robotics (the field distinguished by PKA), Electronics and Telecommunications and Teleinformatics. They confirm the highest

quality of education offered by the faculty. In 2012 the EIT course was divided into two separate courses – Electronics and Telecommunications. Since that time students have been recruited separately for both courses- Electronics and Telecommunications. The fifth course is unique on a national scale – Teleinformatics.

This field of study accredited KAUT and accreditation of European education quality EUR-ACE Bachelor (for engineering studies) and EUR-ACE Master (for master studies). After completion this field of study, graduates are awarded the appropriate certificates.

After completing studies at the Faculty of Electronics, its graduates are prepared to start a professional career, set up their own business related to and using innovative technologies, and also to solve problems which are yet unknown.

The Faculty of Electronics uses the ECTS (European Credit Transfer System). Some programmes are taught only in English. Exchange of students within many international cooperation programmes and projects i.a. ERASMUS+ is developing intensively, which allows numerous students to pursue a part of their studies abroad or even obtain a diploma of a foreign university. Student foreign cooperation is conducted mainly within over 20 student scientific interest groups at the faculty, for example: SISK (Computer Systems and Networks Scientific Interest Group) every year organizes the Polish-British Workshop, during which Polish and British students present results of their research, KoNaR organizes the annual international Robotic Arena competition (inter-university competition of



robots-made and programmed mainly by students, MOS (Microsystems Oriented Society) develops e.g. the construction of the Powerful Indexed Window Display, which can be observed during Juwenalia (a student festival) or on You Tube. TK Games scientific union teaches students how to program, design, test, create sound and graphics for the PC and mobile games using today's technologies (Unity, Unreal Engine). The JEDI scientific circle was awarded with the cup of the Head of the National Security Council during the Robot Parade 'Droniada' for a quadrocopter (multirotor) which can receive and sent text messages. The EKSA scientific circle (Electronic Computer Control Engineering Systems) has three areas of activity: intelligent buildings, industrial control systems and quadrocopters. For many years the circle has organised the science and technology Conference of Intelligent Building Systems presenting innovative technologies of building automation systems. The Wireless Group actively supports research related to the use of the latest wireless systems. In one of the projects they beat the Polish record in the length of a WiFi connection (250 km). In terms of distance it is a second result in Europe and the third in the world. Another scientific circle worth particular attention is called Space Missions of European Students, it participates in spaceships construction programmes. In terms of international cooperation one should also mention summer schools organised at the Faculty, e.g. "Summer School 3E+", "Robotics Summer School", and

"Indian Summer School" as a result of cooperation with Indian partner, the Parul Group of Institutes"

At the Faculty of Electronics you can choose one of seven courses of study at the 1st and 2nd level of studies:

- **Control Engineering and Robotics,**
- **Electronics,**
- **Telecommunications,**
- **Computer Science,**
- **Teleinformatics,**
- **Electronic and Computer Engineering**
(only at the 1st level of studies in English).
- **Cybersecurity**
(only at the 1st level of studies)

After completing the fifth semester of Bachelor Studies or after the first semester of Master Studies, students make further, more precise selection within their field of study as then they choose a programme (specialisation). Full-time Bachelor Studies last – 3.5 years (7 semesters), and Full-time Master Studies last – 1,5 year (3 semesters). Extramural Bachelor Studies last 4 years (8 semesters), and Master Studies – 2 years (4 semesters).

Students have numerous opportunities to conduct research, publish and implement their results. The best students – every year several dozen of them – continue their education at the tertiary level (doctoral studies), as the Faculty of Electronics is one of few faculties in Poland which has the right to confer doctoral degrees in 4 disciplines: electronics, computer science, telecommunications, control engineering and robotics.



FIELDS OF STUDY AND PROGRAMMES



FIELD: CONTROL ENGINEERING AND ROBOTICS

LEVELS AND SYSTEMS OF STUDIES :

■ **Full-time Bachelor and Master Programmes** (7 semesters – Bachelor Studies, 3 semesters – Master Studies):

- Computerised Control Networks,
- Computer Management Systems in Manufacturing,
- Robotics,
- Computer Systems in Control Engineering,
- Information Technologies in Control Systems;

■ **Full time Master Programmes** (3 semesters):

- Embedded Robotics;

■ **Extramural Master Programmes** (4 semesters):

- Computer Systems in Control Engineering and Robotics,
- Systems of Control and Robotics.



FIELD: ELECTRONICS

LEVELS AND SYSTEMS OF STUDIES :

■ **Full-time Bachelor Programme** (7 semesters – Bachelor Studies)

- Acoustics Engineering;

■ **Full-time Bachelor and Master Programmes** (7 semesters – Bachelor Studies, 3 semesters – Master Studies):

- Electronic Equipment,
- Applied Computer Engineering;

■ **Full time Master Programmes** (3 semesters):

- Acoustics,
- Advanced Applied Electronics (studies in English);

■ **Extramural Master Programmes** (4 semesters):

- Acoustics,
- Electronic Equipment.



FIELD: TELECOMMUNICATIONS

LEVELS AND SYSTEMS OF STUDIES :

■ **Full-time Bachelor Programmes** (7 semesters – Bachelor Studies):

- Mobile Telecommunications,
- Teleinformation Networks,
- Multimedia in Telecommunications;

■ **Full time Master Programmes** (3 semesters):

- ICT Mobile Networks,
- Teleinformatics and Multimedia,
- Modern Telecommunications (studies in English);

■ **Extramural Bachelor Programmes** (8 semesters):

- Multimedia in Telecommunications,
- ICT Networks;

■ **Extramural Master Programmes** (4 semesters):

- ICT Mobile Networks,
- Teleinformatics and Multimedia.



FIELD: COMPUTER SCIENCE

LEVELS AND SYSTEMS OF STUDIES:

■ **Full-time Bachelor and Master Programmes** (7 semesters – Bachelor Studies, 3 semesters – Master Studies):

- Internet Engineering,
- Data Processing Systems Engineering,
- Applied Computer Engineering in Medicine,
- Computer Systems and Networks;

■ **Full time Master Programmes** (3 semesters):

- Internet Engineering (studies in English),
- Advanced Informatics and Control (studies in English);

■ **Full time Master Programmes** (4 semesters):

- Internet Engineering (studies in English);

■ **Extramural Master Programmes** (4 semesters):

- Computer Systems,
- Internet Systems Engineering.



FIELD: TELEINFORMATICS

LEVELS AND SYSTEMS OF STUDIES:

■ **Full-time Bachelor and Master Programmes** (7 semesters – Bachelor Studies, 3 semesters – Master Studies):

- Teleinformation Networks Design,
- Teleinformation Networks Maintenance.



FIELD: ELECTRONIC AND COMPUTER ENGINEERING

LEVELS AND SYSTEMS OF STUDIES:

■ **Full-time Bachelor studies** (7 semesters)



FIELD: CYBERSECURITY

LEVELS AND SYSTEMS OF STUDIES

■ **Full-time Bachelor studies** (7 semesters)

The first admission will take place in academic year 2017/18

The offered programmes are continuously evaluated and modified to adapt them to labour market needs.

Characteristics of Fields of Study



CONTROL ENGINEERING AND ROBOTICS

(THE FIELD HAS BEEN DISTINGUISHED BY POLISH ACCREDITATION COMMITTEE)

Students of Control Engineering and Robotics are specialists in design, implementation and operation of intelligent systems automatically controlling industrial facilities, technological processes, vehicles, equipment and robots, building security, etc.

The following programmes are offered in the Control Engineering and Robotics field:

- **Computerised Control Networks** (Bachelor and Master studies) – education encompasses issues related to technological processes control, design, activation and maintenance (exploitation) of automation systems. There is special emphasis on measurement data acquisition, industrial network communication, data transmission protocols and telemetry systems. The programme of specialisations comprises construction and programming microprocessor controlled automation equipment and also design of automation systems in intelligent buildings. Graduates of the 1st cycle of studies are prepared to design and programme Programmable Logic Controllers (PLC), other microprocessor equipment and the SCADA systems (process visualisation). Graduates of the 2nd cycle of studies have extended knowledge of advanced automation systems and in particular of the Distributed Control Systems (DCS) based on fast computer networks.
- **Robotics** (Bachelor and Master studies) is an interdisciplinary field using the achievements of electronics, cybernetics, mechanical engineering, computer technologies, artificial intelligence, and also cognivistics, psychology and sociology. Education in the Robotics specialisation encompasses design, control, construction and exploitation of equipment which is able to operate independently in a changing environment (autonomous, intelligent robots), also in a human environment (social robots). The curriculum encompasses models and control systems of manipulation and mobile robots as well as other intelligent automation objects, control algorithms and robot controllers, biocontrol, sensor and performance systems, image and signal processing systems, autonomous systems, embedded systems, programming languages, artificial intelligence methods and computational intelligence, robotisation and robot operation. Graduates of this specialisation can proficiently use contemporary electronic and information-communication technologies.
- **Computer Management Systems in Manufacturing** (Bachelor and Master studies) – the curriculum encompasses algorithms, software and hardware used in management and control of manufacturing processes in manufacturing units, using computer and robotic systems as well as optimisation and control in conventional and flexible manufacturing systems, including issues related to monitoring production quality using statistical methods and CCTV cameras image processing. Graduates are prepared to work as a manufacturing process engineer and to perform managerial duties connected with manufacturing systems (including optimisation and quality of manufacturing processes), to design computer systems supporting control and management of discrete and continuous manufacturing processes.
- **Computer Systems in Control Engineering** (Bachelor and Master studies) – the curriculum encompasses use of IT methods and techniques, including computer networks, in data acquisition and control of technological processes; design, programming and activation of software and hardware interfaces between equipment and its environment.
- **Information Technology in Control Systems** (Bachelor and Master studies) – the curriculum encompasses methods and techniques of applying modern IT in automation systems, including issues related to design of systems, neural networks and use of advanced image processing and recognition. Students can develop their skills in the lab of quality control using a wide range of cameras, covering all the spectrum from ultraviolet to infrared light.
- **Embedded Robotics** (Master studies in English) <http://kcir.pwr.edu.pl/embedded/> Modern electronic design more and more leads to the construction of embedded devices, which are complete microprocessor and computer systems integrated with the host devices. Such devices can be found in the construction of all advanced robotic systems; they also appear in modern automobiles, avionic and naval systems, telecommunication systems, medical life-support systems, automated cash and banking systems, as well as in household appliances and consumer electronics devices. Curriculum of Embedded Robotics includes control engineering methods, embedded systems design and analysis, robot motion and task planning methods, robot controllers, drive systems, artificial intelligence and machine learning, social robotics, and human-robot interfaces. The graduates of Embedded Robotics are prepared for creative engineering activities in the field of industrial and service robotics, embedded electronics, and also for research and scientific work including the 3rd level studies (PhD).

In the offer of extramural Master Studies there are two programmes: **Computer Systems in Control Engineering and Robotics** and **Systems of Control and Robotics**.

■ **Computer Systems in Control Engineering and Robotics** (Master studies) – the curriculum encompasses computer science, control systems and robotics, signal analysis as well as decision and computational algorithms. Graduates have knowledge of real time systems and computer applications in control systems and robotics. They are able to develop configurations and software necessary for information exchange in industrial computer networks and have knowledge of regulatory algorithms and other computational and decision algorithms.

■ **Systems of Control and Robotics** (Master studies) – the curriculum encompasses design and construction of control systems, control and software for robotic equipment decision support systems. Graduates gain knowledge necessary to analyse control systems, microprocessor control of industrial equipment as well as robot control and software. They are able to solve complex (interdisciplinary) problems related to control systems and robotics in a creative way.

Graduate profile

A graduate is prepared to solve complex problems related to widely understood control systems and robotics. They gain thorough knowledge necessary to analyse control systems, microprocessor control of industrial equipment as well as robot control and software. Studies prepare them for jobs of constructors, designers and related to research on systems application in industrial processes control, measurement data acquisition and processing, development of intelligent behaviour of equipment, manufacturing pro-

cess management, automation and robotisation. Universal preparation of graduates for future employment, encompassing control systems, robotics and computer science is a great advantage of our graduates in the job market.

> ELECTRONICS

Students of Electronics are specialists in design, implementation and operation of electronic equipment. The field of study provides an especially rich offer of programmes in widely understood electronics. At the first level of studies (Bachelor engineering studies) there are three programmes and at the second level of studies (Master studies) there are four programmes:

■ **Acoustics Engineering** (Bachelor studies) – the curriculum encompasses knowledge of electroacoustics, ultrasonic technology, digital processing techniques of acoustic signal, issues related to noise and vibration protection, speech signal communication (human-human or human-computer), basic audio engineering, design of equipment, electroacoustic systems and interior acoustics, measurements, analyses and acoustic signal processing, use of ultrasound apparatus applied in industry and medicine. Graduates are prepared to work as sound engineers for the radio, TV, cinema, phonographic and entertainment industry, drama theatres and opera houses, as designers of sound and amplification systems, as an engineer responsible for sales and service of audio systems, as an engineer in fields related to acoustic measurements and natural environment protection from noise and vibrations. The curriculum focuses on two main themes, the first one encompasses issues related to electroacoustic systems and ultrasound equipment, protection from noise and acoustics applications in telecommunications. The other theme is related to widely understood sound engineering, which encompasses also knowledge of psychoacoustics, music acoustics and interior acoustics. As



part of this programme students have an opportunity to extend their knowledge through participation in activities organized by the Audio Engineering Society student group and Radio LUZ – a student radio station.

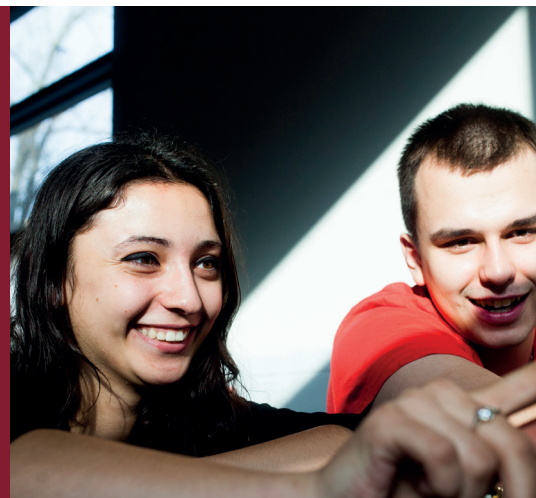
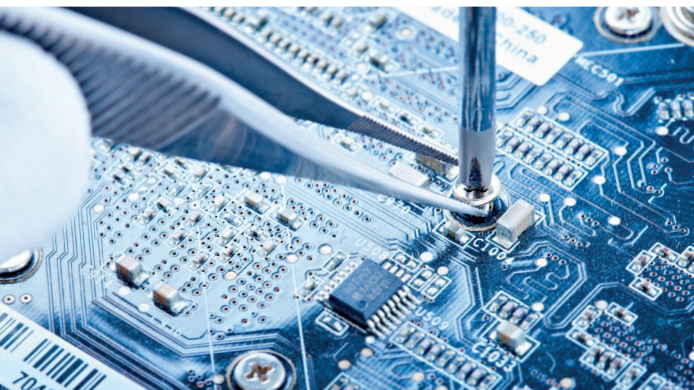
■ **Electronic Equipment** (Bachelor and Master studies) – the curriculum is an attempt to join theory with practice in relation to design, construction, software, implementation, operation and service of electronic equipment using sensors (electrical, optoelectronic, biomedical ones, MEMS, etc.), microprocessors, microcontrollers, signal processors (DSP), specialised electronic devices (such as CPLD or FPGA) and other applications cooperating with computer systems (LabVIEW applications). Students gain knowledge and skills particularly related to: microprocessor systems and controllers (including real time systems), optoelectronics and photonics applications in electronic equipment, acquisition and processing of empirical data and electronic components of smart environment, including widely understood IT skills. Graduates from this programme are prepared for both creative tasks (constructors, consultants) and managerial positions (work organizers), they can also work in the service of consumer electronic systems as well as medical and industrial equipment.

■ **Applied Computer Engineering** (Bachelor and Master studies) – the curriculum encompasses IT methods and techniques, including microprocessor technology, skills related to use of IT techniques in engineering work, development and use of computer and computer systems software, computer techniques use in analysis, design, control, optimisation and simulation of systems (e.g. manufacturing, control and management systems) as well as design and operation of microprocessor equipment. The curriculum encompasses: engineering analysis, including analysis methods and techniques, modelling of complex manufacturing and control processes, operating research applications, models development on the basis of empirical data, data acquisition and

analysis, data bases, numerical methods, technology of information transmission in computer networks, design and start-up of specialised microprocessor equipment.

■ **Advanced Applied Electronics** (Master studies in English) – the curriculum encompasses extensive knowledge in the field of electronics, optoelectronics, high frequency technology and telecommunications. The programme allows to extend practical and theoretical knowledge of advanced analogue and digital electronic systems, lasers and optical fibre, microwave electronics, applications of programmable digital and microprocessor systems in equipment and networks. Thanks to the availability of research laboratories, students have an opportunity to gain elementary experience in research and development necessary for their future work or academic career. By choosing studies in English, students significantly improve their language skills and increase mobility potential.

■ **Acoustics** (Master studies) – the curriculum encompasses knowledge of physical acoustics, digital sound, sound amplifying equipment, noise and vibrations, it also comprises issues related to forecasting in environmental acoustics and development of acoustic maps. Students extend their knowledge of analysis methods and acoustic signal analysis, computer modelling in acoustics, ultrasound technology applications in industry and medicine, bio- and hydro-acoustics, acoustic diagnostics and sound direction. Education in the programme is a continuation of the Acoustic Engineering programme in Bachelor Studies. Graduates are prepared to work as sound engineers for the radio, TV, cinema, phonographic and entertainment industry, drama theatres and opera houses, as designers of sound and amplification systems, as an engineer responsible for sales and service of audio systems, as an engineer in fields related to acoustic measurements and natural environment protection from noise and vibrations. As part of this programme students have an opportunity to extend their knowledge through participation in activities organized by the Audio Engine-



ering Society student group and Radio LUZ – a student radio station.

In the offer of extramural Master studies there are two programmes: **Acoustics** and **Electronic Equipment** with the same curriculum as in full-time master studies.

Graduate profile

A graduate is prepared to independently solve problems related to design, implementation and operation of analogue and digital systems, electronic equipment and systems using modern technological solutions. They have skills related to undertaking independent engineering tasks, teamwork and management of human resources. They are prepared for work in institutions connected with widely understood electronics, including design studios, research and development departments of companies and research institutes. They can also work for companies manufacturing electronic equipment, in jobs related to operation and servicing of electronic equipment.

TELECOMMUNICATIONS

Students of Telecommunications are specialists in design, implementation and operation of data transmission, image and sound signal equipment. The Field of study offers a wide selection of programmes encompassing telecommunications.

The Telecommunications field of study offers the following programmes:

- **Mobile Telecommunications** (Bachelor studies) – the curriculum encompasses all issues related to communication systems between objects (people, equipment, including computers), also when they are in motion. The areas of interest comprise mobi-

le land systems (GSM, EDGE, GPRS, UMTS, LTE), sea and air systems, wireless networks, WMAN, WLAN and sensor networks, which are wireless extensions of land based telecommunication networks. Students gain knowledge on the structure of cellular networks and another wireless solution (ZigBee, WiFi, Bluetooth) their principles of operation, planning and maintenance methods, measurement and properties assessment methods. They learn how to programme mobile applications, provide services in a secure way, manage and operate a network as well as how to assess telecommunication ventures from the economic point of view. Within their programme, students do two levels of courses of the Academy of Computer Networks Cisco and finally they are awarded the international certificate.

- **Teleinformation Networks** (Bachelor studies) – the curriculum encompasses issues related sound, image and data transmission in wired (copper and optical fibre) and wireless teleinformation networks, using various switching technologies. Students gain knowledge of communication protocols (both transport and signal ones) used in these networks and rules of cooperation between their elements. The curriculum encompasses also construction of fixed-line multi-service telecommunication networks, including construction and operation of telecommunication nodes and transmission systems. Except for issues related to wired and radio transmission, including optical fibre and satellite one, students gain knowledge on, construction and principle of operation of electronic, digital communication nodes. Another discusses problem are networks with channel commutation, packet commutation, wideband digital integrated services networks. Some more important items in the curriculum are multimedia systems and equipment, telecommunication traffic engineering, design of teleinformation networks, network management and operation.

- **Multimedia in Telecommunications** (Bachelor studies) – the curriculum encompasses issues related to collection, transmission and processing of digital signals from various physical objects. Students gain knowledge of: design and construction of smart transducers AD/DA, transmission systems of digital signals, advanced programming methods, multi-tasking and multi-user operating systems. In addition to this, the studies comprise issues related to theoretical aspects of digital telecommunications, such as adaptive filtration and array signal processing, human-computer communication, digital image processing, as well as practical aspects such as: interfaces in DSP systems, hardware and software environment, implementation of programming DSP algorithms on DSP processors and in FPGA systems. Within their



programme, students do two levels of courses of the Academy of Computer Networks Cisco and finally they are awarded the international certificate.

- **ICT Mobile Networks** (Master studies) – the curriculum encompasses the extended programme of Mobile Telecommunications which was enriched with new subjects, such as high frequency technology, satellite communication systems (VSAT, Inmarsat, Thuraya), applications for modelling antennas and VHF elements, determination of their electrical parameters, issues related to electromagnetic environment protection, digital radio and TV systems, more problems related mobile networks and their management, skeletal and access optical networks as well as information compression, design and construction of embedded systems. Within their programme, students do two further levels of courses of the Academy of Computer Networks Cisco and they receive an international certificate.
- **Teleinformatics and Multimedia** (Master studies) – within the field of electronics the curriculum encompasses knowledge of programmable digital systems, embedded systems, modern solutions used in systems and multimedia networks, methods of multimedia service quality assessment, network management and teleinformatic system security. In the area of signal processing the course encompasses: contemporary biometrics, lossy compression and construction of an optimum receiver based on the FPGA technology. Another advantage of this programme is an opportunity to gain knowledge enabling to design new wideband solutions and multi-service teleinformatic networks as well as widely understood telecommunication networks. Within this programme, students do two further levels of s of the Academy of Computer Networks Cisco and receive an international certificate.

The programme prepares for work in institutions related to teleinformatics and widely understood telecommunications, including design offices and R&D departments of enterprises and institutes.

- **Modern Telecommunications** (Master studies in English) – the curriculum encompasses modern optical and wireless telecommunications, multimedia networks and security of information transmission. Graduates have skills related to design, construction and management of modern telecommunications. Modern telecommunications is one of the main, fast developing branches of engineering in the world. As a result education in this field is necessary. The programme is carried out in cooperation with the University of Nottingham in England, where students may pursue a part of their planned programme of studies.

In the offer of extramural Bachelor studies there are two programmes: **Teleinformation Networks** and **Multimedia in Telecommunications**.

- **Teleinformation Networks** - the curriculum is the same as in full-time studies
- **Multimedia in Telecommunications** (Bachelor extramural studies) – the curriculum encompasses design, implementation and operation of analogue and digital equipment and telecommunication systems, in particular the ones with wired technology (including optical fibre ones), using modern technology solutions. Graduates are prepared to work in institutions related to teleinformatics and widely understood telecommunications, including design offices and R&D departments of enterprises and institutes.

In the offer of extramural Master Studies there are two programmes: **ICT Mobile Networks** and **Teleinformatics and Multimedia** with the same curriculum as in full-time master programmes.

Studying telecommunications facilitates obtaining a telecommunication contractor licence.

Graduate profile

A graduate is prepared to independently solve problems related to design, implementation and operation of analogue and digital systems, electronic equipment and systems using modern technological solutions. They have skills related to undertaking independent engineering tasks, teamwork and management of human resources. They have skills related to undertaking independent engineering tasks, teamwork and management of human resources. They are prepared for work in institutions connected with teleinformatics and widely understood telecommunications, including design studios, research and development departments of companies and research institutes. They can also work for companies manufacturing IT and telecommunication equipment, telecommunication and



teleinformatic network operators, in jobs related to operation and servicing of IT and telecommunication equipment.



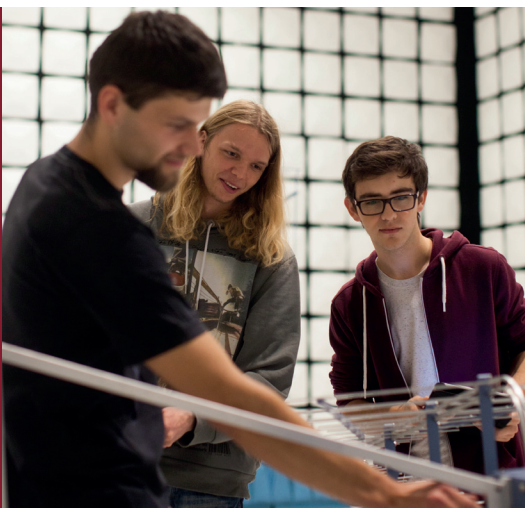
COMPUTER SCIENCE

(THE FIELD HAS BEEN DISTINGUISHED BY POLISH ACCREDITATION COMMITTEE)

Students of Computer Science are specialists in construction and operation of computer equipment, use of computer and microprocessor systems, software engineering, design, management and maintenance of IT systems, creating databases and data warehouses, data processing methods, data transmission systems, IT applications in medicine and various other fields of technology. Students who choose this field of study can do Bachelor and Master studies in one of four programmes in Polish and two programmes taught in English at the second level of studies (emphasis is put on work in international teams and student exchange with partner universities).

- **Internet Engineering** (Bachelor and Master studies) – the curriculum encompasses development of Internet services and applications. Students gain knowledge on management, reconfiguration and security of internet services, development of concurrent and distributed applications. They learn UNIX / LINUX system programming and administration, they also learn how to develop advanced embedded systems. Graduates can later work on development and operation of software systems, economic internet applications (e-business, e-commerce, e-banking), management and administration of military systems. They work as network/system administrators, designers and programmers of internet applications, both mobile and embedded ones.
- **Data Processing Systems Engineering** (Bachelor and Master studies) – the curriculum encompasses software design and implementation as well as IT systems operation, including such systems as artificial intelligence systems with natural language access, IT systems in banking and management, systems with distributed databases, knowledge bases and autonomic systems.

- **Applied Computer Engineering in Medicine** (Bachelor and Master studies) – the curriculum encompasses telemedicine applications of computer science, computer diagnostic imaging (ultrasonography, tomography), computer supported decisions, biomedical signal processing (EKG, EEG), IT systems implementation in medical and healthcare institutions, with special emphasis on modern mobile and wireless technologies. Graduates gain knowledge of construction and operation of computers and networks, design of database systems, multimedia knowledge bases and data warehouses. They have knowledge of computer vision systems, information protection and security, operating systems use, programming tools. In addition to this, students gain skills related to advanced processing of signals, data and images for the needs of computer recognition, control, experiment, modelling and simulation systems, decision process algorithmization and artificial intelligence methods, design of domain-oriented computer expert systems, diagnostic systems, medical systems support and management.
- **Computer Systems and Networks** (Bachelor and Master studies) – the curriculum encompasses issues related to data transmission, architecture, implementation and design of local and wide computer networks, design of internet and mobile systems, software engineering, especially game programming, advanced techniques of computer networks design, design and operation of databases, internet databases and other IT systems. Graduates have general knowledge and practical information (related to e.g. computer networks operation and management, management of IBM server systems, use of UNIX and Windows) necessary in their profession. Graduates of **Computer Systems and Networks** and **Applied Computer Engineering in Medicine** are well prepared to continue studies at the Master level with the **Advanced Informatics and Control** programme taught in English.
- **Internet Engineering** (Master studies in English) – similarly to the programme taught in Polish, the curriculum encompasses development of internet services and applications. It comprises knowledge of management and ways of ensuring security of internet services, development of distributed applications, mobile applications, data warehouses architecture, intelligent processing and data mining. Graduates work on development and operation of software systems and internet applications (e-business, e-commerce, e-banking). A characteristic feature of this programme is emphasis put on preparing students to work in English and to work in international



teams, as these are the skills especially valued by international IT concerns.

- **Advanced Informatics and Control** (Master studies in English) – the curriculum encompasses advanced methods of design and implementation of IT systems needed in the economy, using both classical and innovative methods. In the educational process, special emphasis is put on practical aspects of the discussed IT, control and technology problems. Graduates have experience necessary to pursue their careers in international industry and research centres.

In the offer of extramural Master studies there are two programmes: **Computer Systems** and **Internet Systems Engineering**.

- **Computer Systems** (Master studies) – the curriculum encompasses such issues as computer network design, security, architecture and analysis of IT and teleinformatic systems, architecture of decision support systems. Graduates are prepared to administer network operating systems belonging to the Unix and the Windows families, management of the Power IBM system platform and mass memory systems.
- **Internet Systems Engineering** (Master studies) – the programme provides the ability to individually solve IT problems (their classification with regard to their complexity, specification and solutions implementation) encompassing all hardware and software aspects related to reliable computer networks and systems, distributed systems architecture and multimedia applications, necessary to use internet technologies. The biggest emphasis is put on preparing graduates to use the latest IT tools and to adapt quickly to the dynamically changing IT reality.

Graduate profile

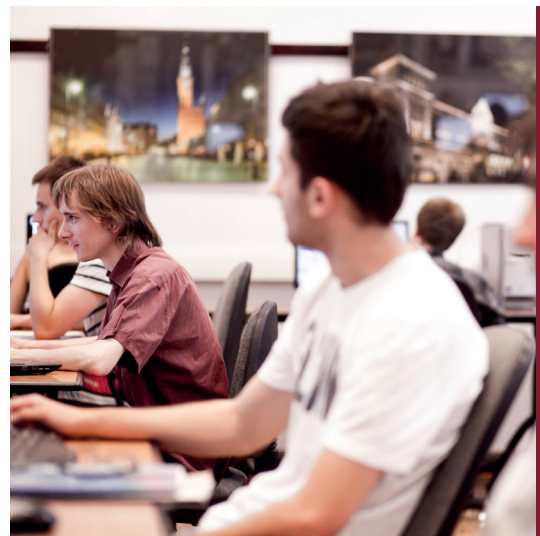
Graduates are prepared to individually solve IT problems (their classification with regard to their complexity, specification and solutions implementation). They have skills allowing them to develop, implement and verify IT projects, practically use IT tools and are proficient programmers. They have knowledge making it possible for them to allowing them to adapt quickly to the dynamically changing IT reality. They can work as software designers, IT projects leaders, system administrators, designers and administrators of computer networks, specialists in IT systems security. Students often start cooperation with their future employer (a Polish or an international one) during their studies. Good theoretical preparation, experience, practical knowledge gained thanks to access to modern computer and network equipment as well as design tools, good knowledge of foreign languages allow our graduates to easily adapt to market needs and to find an interesting and well paid job in Polish and foreign companies.

TELEINFORMATICS

Observing the development of IT and telecommunication techniques in the last decade, the shrinking distance between these two fields cannot be overlooked. It is especially clearly visible in computer networks, also called teleinformation networks. The increasing implementation of IT into telecommunication systems one side and the use of advanced telecommunication techniques in IT systems on the other side, requires well educated specialists with knowledge of telecommunications applications in IT and IT applications in telecommunications, i.e. teleinformation specialists. This new field of study, which is unique on the national scale, was created with a view to educate such specialists who would be able to use their IT and telecommunications knowledge in practice. Education in this field encompasses, e.g. internet engineering, data bases, teleinformation networks whose end users are both IT equipment and people, multimedia networks with particular emphasis on access techniques related to broadband services, business activity carried out using modern electronic and wireless techniques (e-business and m-business). In 2015 the TELEINFORMATICS (ICT) bachelor and master studies were granted the European quality certificate EUR-ACER Label (European Accredited Engineer) by the Accreditation Commission for Technical Universities (KAUT). This certificate confirms high level and compliance of the Teleinformatics training programs with accepted European norms and principles.

The field of study encompasses the following programmes:

- **Teleinformation Networks Design** (Bachelor and Master studies) – the programme prepares students for optimisation, design and construction of teleinformation equipment and systems including transmission aspects, effective use of systems resources, assurance of service quality and security (mainly related to software), programming of applications for networking equipment and mobile devices, use of internet techniques, development and service of data bases, management systems and te-



lemedic systems, use of increasingly popular wireless solutions and methods of effective design process management. Within this programme, students do two levels of courses of the Cisco Academy, CCNA Exploration 1 and 3.

■ **Teleinformation Networks Maintenance** (Bachelor and Master studies) – the curriculum encompasses service, management and advanced diagnostics of teleinformation networks, marketing and technical advisory services related to their design, implementation and maintenance, knowledge of installation services related to network security, methods of development and service of electronic documents. The programme prepares for service and development of complex teleinformation systems used in industry, administration, military institutions, police, healthcare institutions, education, with particular emphasis on internet techniques data base systems. Within this programme, students do two levels of courses of the Cisco Academy, CCNA Exploration 1 and 3.

Graduate profile

Graduates have knowledge of IT and telecommunications, which enables them to find jobs in entities manufacturing teleinformation elements for teleinformatics. Graduates are prepared to design and construct teleinformation equipment (mainly the software) and manage design processes for public operators. They can find work related to network management and maintenance, marketing and technical advisory services as well as design, planning and optimisation of teleinformation networks in a widely understood service sector where they can do services connected with installation, network management, network security, electronic documentation for operators of special teleinformation systems, e.g. state administration, military institutions, police, customs services, etc., and in the area of special teleinformation systems, e.g. medical teleinformation systems, distance learning teleinformation systems, etc. They can find work in companies developing software for network equipment and mobile devices. In addition to this Teleinformatics graduates are well prepared to continue studies at the 2nd level of studies with the Advanced

Informatics and Control programme taught only in English. Students of the faculty of Electronics have a number of opportunities to carry out research, publish and implement their results. The best students – every year several dozen of them – continue their education at the tertiary level (doctoral studies), as the Faculty of Electronics is one of few faculties in Poland which has the right to confer doctoral degrees in 4 disciplines: electronics, computer science, telecommunications, control engineering and robotics.

➤ ELECTRONIC AND COMPUTER ENGINEERING

The program of study of the Electronic and Computer Engineering (ECE) contains all important needs and demands of the modern labor market for modern electronics. This major combines the knowledge of traditional electronics, computer science and automation and robotics. The profile of companies that will benefit from the competence of graduates of the major are mainly manufacturing and service companies. In the wide industrial automation, is already high and is expected only to grow in the future, the demand for professionals, possessing the skills of integration of both analogue and digital electronic equipment and systems (including microprocessor). These skills include, among others, PLC programming, PAC, SCADA systems and robotic systems, commissioning of control systems, local and remote maintenance, remote supervision of production control systems for. Also the ability to design broadly defined control systems, telemetry systems and the measurement will be received very positively on the labor market. Currently, there is seen a significant grow of the number of companies that operate in the field of Internet of Things and integrate these products into complex systems (e.g. Intelligent houses). This sphere of activity at every stage from design through manufacturing to service, requires a combination of engineering knowledge in both the field of electronics and the field of computer science.

Graduate profile

The graduate is prepared to design, implement, test and operate analog, digital and mixed signal electronic circuits



with the use of microprocessors, as well as plan and design circuits and systems, optimize the conditions for measurement, analysis and interpretation of the results. They gain the knowledge necessary to use personal computing for the acquisition of measurements, process control, design, commissioning, maintenance of automation and industrial robotics exchange of information based on the standard data protocols. The graduate is prepared also to solve computing tasks using computer tools, prepare, execute, and analyze computer simulations and experiments, write own computer programs, including programs for DSP algorithms implementation. The graduate of ECE has the knowledge necessary to continue the studies at the second level of studies (Master studies) in the fields of Electronics, Electrical Engineering, Computer Science, Automation and Robotics, Telecommunication and in other related fields.

> CYBERSECURITY

The field of study of CYBERSECURITY assures an education in network security, information and ICT systems security and data protection. The study is closely related to the current needs of the labour market. Students get a comprehensive and thorough education in the fields of information technology and telecommunications, in technical as well as legal and organizational aspects, with particular emphasis on exhaustive knowledge of operation systems security, computer and telecommunication network security and the security of data processed and stored in data centres. The knowledge and skills acquired while studying at this field enable the graduate to actively participate in the processes related to data security in the broad sense of, among others, security audit of systems, networks and data stores as well as monitoring, detection and analysis of threats and violations in IT systems.

The field of Cybersecurity offers to study in two specialisations:

■ **Teleinformation network security** - the education prepares a student for a job of securing access to information at all stages of ICT life cycle, including planning, implementing and keeping a security system ready while using it and making necessary adjustments that adapt the security system to constantly evolving threats that may occur. Particular emphasis is put on the security of relocating information and on the access to information via up-to-date transmission systems. The education includes ways of creating secure mobile applications, information compression, cryptography, electromagnetic system and network security, cloud computing, biometric systems, threat detection and monitoring systems, security in computer networks, the internet of things, ICT network auditing, ways to a secure access to a network as well as legal and ethical aspects in the field of security. The specialisations prepare students to receive the

certificates of CCENT (Cisco Certified Entry Networking Technician), CCNA (Cisco Certified Network Associate) and CCNA Security.

■ **Data security** - the education prepares a student for a job of securing information at all stages of its life cycle, including planning, implementing and keeping a security system ready while using it and making necessary adjustments that adapt the security system to constantly evolving threats that may occur. Particular emphasis is put on the security of storing information and on the access to information via up-to-date transmission systems. The education includes the ways of creating secure multimedia services, processing of large sets of information, the structures and functioning of data processing centres, databases, biometric access security, security in distributed systems, cryptography, electromagnetic system and network security, ICT network auditing as well as secure web services and computer forensics related to post-hack analysis, evidence securing, ensuring digital evidence is solid and undeniable. The specialisations prepare students to receive the certificates of CCENT (Cisco Certified Entry Networking Technician), CCNA (Cisco Certified Network Associate) and CCNA Security.

Graduate profile

A graduate of Cybersecurity will acquire knowledge regarding the construction and functioning of up-to-date information transmission systems and systems used for storing and sharing information. These systems belong to critical infrastructure of every state and business, therefore must be particularly protected. Due to the increasing threats connected with attacks on such systems, it is necessary to educate specialists who will be able to secure them. The need of such specialists on the market is also on the increase. Therefore graduates will be able to find work everywhere security concerns and security policy, especially regarding information systems, are a must, including:

- in institutions related to IT and ICT (Information and Communication Technologies), including corporations, banks, industry, design and development departments in companies and administration units,
- in companies producing hardware and ICT equipment,
- in companies producing software and information systems,



- in companies offering web services,
- with ICT network operators,
- in data centres.

Graduates will be able to find work connected with designing, configuring, using and servicing hardware and ICT equipment, on the positions such as IT security officer, digital transmission system administrator, IT project manager, secure network and IT system implementation specialist, IT security consultant, etc.

Research and scientific activity

Research activity at the Faculty of Electronics is conducted in the organizational units of the Faculty, i.e. the nine Departments.

DEPARTMENT OF ELECTRONIC AND PHOTONIC METROLOGY (K-1)

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The Department of Electronic and Photonic Metrology was established in the belief that the more effort is put to cognition, the more profound will be the awareness of our subjectivity. This Department is a place and a community serving the truth which is found and shared, where scholars and learners, professors and students are united by their desire to teach the young and multiply human cultural values.

*Prof. Janusz Mroczka
Wrocław, March 1998*

In the process of continuous development metrology discovers more and more new cognitive issues, thus revealing new measurement problems to be solved. This stimulates development of new, improved measurement tools using contemporary technology achievements. New cognitive problems and their real cognitive tools set out new directions for metrology. Apart from traditional metrology fields, such as: theoretical metrology basis, benchmarks, measurement methods, measurement data processing, measurement uncertainty assessment, measurement systems technology, etc., there are new areas including: optical metrology, photonic metrology, nano-metrology, biomedical metrology, etc.

The cognitive process metrology uses analysis and synthesis in the abstract domain in real areas expressed by physical and mathematical models. These are the models which allow to easily notice examples of formal analogy between issues which are different as notions and similar from the perspective of phenomenal synthesis.

The main objective of the Department is transformation of physical models – made of concepts of matter, energy and time, into mathematical models, and next in metrological models, which when complemented by information concepts provide qualitative and quantitative data. The basic structure of the Department reflects the structure of a cognitive process, which makes a serial connection of the analysed object, which is the goal of cognition, and its physical, mathematical and metrological models with their feedback processes reflecting verification processes of particular models, conditioned by external assessment criteria.

Mathematical models express cause and effect relationships between quantities describing analysed objects in a quantitative and qualitative way, and some of these quantities are expressed model parameters. Measurements of their values from the conceptual perspective requires drawing conclusions on the basis of effects, i.e. solving an inverse problem, technically it means complex calculations on the results of direct measurements. Theory, application methods and solutions in direct measurements understood in this way are developed in the Department using data recorded in time domain and transformed into frequency and time-frequency domain.

Major objectives of the Department:

- teaching and development of metrological interests among students and PhD students by running the Electronic Equipment specialisation at the faculty of Electronics at the Wrocław University of Science and Technology,



- preparation of teaching materials (books, manuals, experimental set-ups),
- initiation and implementation of scientific works in the field of metrology and cooperation with other technical universities and units of the Polish Academy of Sciences,
- cooperation with national metrological services in implementation of scientific achievements and promotion of other national and international centres, forecasting metrology development and its role in various types of manufacturing,
- establishment of cooperation with foreign centres in the educational process (dual doctorates), joint grants (joint publications), organisation of international conferences.

Scientific activity of the Department:

- methodology of observation and experiment,
- algorithmisation of inverse problems,
- mathematical modelling of physical fields and their practical implementation using optical and impedance tomography methods,
- complex modelling of dynamic technical and biomedical objects including lumped and distributed parameters,
- spectral and polarisation analysis of scattered radiation in disperse systems and their practical use assessment of composite materials properties,
- methods of optical imaging and measurement data processing in three-dimensional space and their fusion for lossless image coding,
- multi-sensor fusion of data with various spatial resolution using deterministic and stochastic methods of their conversion higher quality reconstruction,
- application of time-frequency representation in measurement data processing and their practical implementation using signal processors,
- parametric identification methods of static and dynamic models of complex objects with their practical application in measurements of the properties of human respiratory and circulatory systems,
- application of artificial intelligence to obtain quantitative and qualitative information from measurements data,
- design, development and optimisation of computer measurement and information systems used in scientific research and technological processes,
- design and implementation of intelligent measurement instruments using microprocessor technology,
- development of telemedical systems cooperating with intelligent homes, which supervise safety and health of their residents.

The Department cooperates with following foreign institutions:

- Institut National des Sciences Appliquees, Rouen,
- CNRS unite 6614 DS10, France,
- Department of Engineering and Product Design,
- University of Central Lancashire, Preston, Great Britain,

- Institut Universitaire des Systemes Thermiques Industriels, Marseille, UMR CNRS 6595, France,
- Department of Biomedical Engineering, Boston University, Boston, USA,
- Biomedical Physics Laboratory, Universite Libre de Bruxelles, Brussels, Belgium,
- Auckland Bioengineering Institute, the University of Auckland, Auckland, New Zealand.

and maintains scientific contacts with:

- Centre for Modelling and Information in Medicine, City University, London, Great Britain,
- Dipartimento de Elettronica e Informatica, University of Padova, Padua, Italy,
- Royal Brompton National Heart and Lung Hospital, London, Great Britain,
- Physiologie Respiratoire et Sportive, Hopital Charles Nicolle, Rouen, France.

DEPARTMENT OF SYSTEMS AND COMPUTER NETWORKS (K-2)

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Research entity information

Organisational entities of the Department:

- **Computer Systems Integration Team** (Prof. Andrzej Kasprzak, Ph.D. D.Sc. Eng.) – its activity encompasses design and optimisation of wide area networks, design of local area networks, multi-criteria optimisation problems,



- **Teleinformatics Team** (Jerzy Kisilewicz, Ph.D. D.Sc. Eng., WrUST Assoc. Prof.) – its activity encompasses object-oriented programming and channel correction methods,
- **Computation Intelligence and Medical Computer Engineering Team** (Prof. Marek Kurzyński Ph.D. D.Sc. Eng.) – its activity encompasses work on methods and algorithms of complex objects recognition, decision support systems, image and signal processing, use of computer engineering in biomedicine,
- **Computer Networks Team** (Krzysztof Walkowiak, Ph.D. D.Sc. Eng., WrUST Assoc. Prof.) – its activity encompasses optimisation of computer networks, survivable networks, distributed processing systems, applications of intelligent computing methods,
- **Machine Learning Team** (Prof. Michał Woźniak, Ph.D. D.Sc. Eng.) – its activity encompasses machine learning, compound pattern classification, data stream and high dimension data analysis, ensemble learning algorithms, distributed data processing and their applications in solving real-life problems.
- **Advanced methods of data analysis team** (Robert Burduk, Ph.D. D. Sc. Eng) - the team research interests are focused on wide variety of data analysis methods such as: data mining, in particular classification and clustering, multidimensional analysis in the Business Intelligence information systems, and predictive and statistical analysis.

Specificity of education

The Department offers educational programmes in the field of Computer Science and Teleinformatics. Thanks to practical skills training, graduates of these programmes are sought-after employees in the job market, as they have extensive, interdisciplinary knowledge allowing them to solve unusual, practical problems. A programme which deserves special attention in the Department is *Advanced Informatics and Control*. It is the Polish and English programme, but English is the language of instruction, its programme was developed by the Wrocław University of Science and Technology and the Coventry University in Great Britain. Developing a joint programme was a natural consequence of long-term, exceptionally active cooperation between the Department and the Control Theory and Applications Centre managed by Prof. Keith J. Burnham, who every year delivered series of

lectures for students and PhD students on interdisciplinary issues, linking new development areas in computer science and control engineering. At the same time he acted as a co-organizer and co-chairman of the international programme committee of the Polish-British-Workshops (PBW) on *Computer Systems Engineering: Theory and Applications* – annual workshops and conferences during which the most gifted students from both institution gave papers which were later published by an IEE affiliated publisher.

The educational cooperation became even more dynamic after developing a joint programme. The AIC programme, which involved the most eminent professors of the Faculty of Electronics, e.g. Prof. Ewaryst Rafajłowicz, Prof. Jan Zarzycki, Prof. Marek Kurzyński, Prof. Ryszard Zieliński, has a very attractive curriculum, e.g. a three-semester subject of *Research Skills and Methodologies* preparing students for independent research and publications, appropriate presentation of results and organisation of scientific sessions. The AIC programme allows students to study partly in Poland and partly in England, there are classes in English taught at our university by English specialists, PBW workshops and conferences are part of the curriculum and students obtain diplomas of both universities.

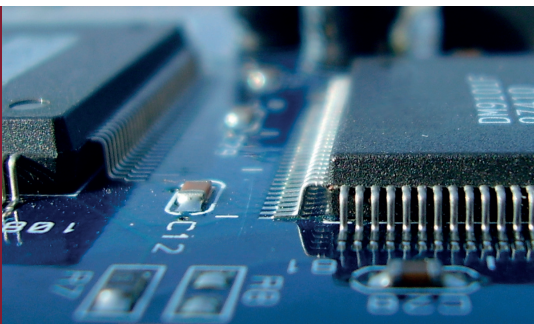
In the educational process, as required by the Polish and English programmes, laboratories at the Department are used for trainings related to network technologies, wireless computer networks, computer network security, data base design, computer simulations, operating systems, data warehouses, expert systems and machine learning, biomedical signal analysis and processing, image analysis and processing.

The Power system by IBM (known as i-series) owned by the Department deserves special attention since it enables students to gain knowledge on modern business platforms which are highly valued at the job market (among others BZ WBK and Volvo) and CISCO network equipment which is used, among others, in the Cisco Certified Network Associate course. In addition to this, thanks to the participation of the Department in the EMC Academic Alliance, students are able to obtain the Certificate of EMC Proven Professional- Information Storage Associate.

Scientific research offer

The scientific research activity of the Department focuses on the following issues:

- design, construction, management and operation of wide and local area networks, data transmission systems and computer systems, including distributed computer systems,
- design and implementation of data base systems, in particular optimisation of data base and data warehouses design,
- computer processing of image information,
- computer simulations, experimentation optimisation and experiment systems design,
- design of domain-oriented computer decision support systems, including systems with knowledge representa-



tion and expert systems, identification, recognition and diagnostics, with particular emphasis on complex recognition problems,

- design and implementation of computer systems used in management and support of medical services and telemedical systems,
- computer control systems and adaptive computer automation systems.

International cooperation

The principal characteristic of the Department is its openness to the world hence international cooperation is its top priority with reference to both research and education. In recent years the cooperation has been focused on:

- presentation of research results in joint publications,
- co-organisation of international scientific conferences,
- membership in Editorial Boards of scientific journals and co-editing conference materials,
- joint doctoral studies and formal doctoral procedures,
- educational programmes and educational materials for new educational specialisations,
- lectures and seminars for our students, PhD students and employees conducted by partners,

The Department organizes cyclical (biennial) international conferences: Computer Recognition Systems – CORES, affiliated by Springer Publishing.

Long-term agreements on international cooperation are executed with numerous partners, among others: Coventry University, United Kingdom, De Montfort University Leicester, United Kingdom, Brno University of Technology and Technical University of Ostrava, Czech Republic, University of Salamanca and University of Burgos, Spain, University Nevada Las Vegas, USA, University of Western Australia, Perth, Australia, Technical University of Gabrovo, Bulgaria.

The Department actively cooperates with international associations and organisations, e.g. IEEE (Institute of Electrical and Electronics Engineers), IARIA (International Academy of Research and Industrial Applications), IBS (International Biometric Society) and companies oriented to implementing new technologies, e.g. Volvo, Nokia, IBM, EMC, Cisco, BZ WBK, Opera Software, Techland, Metagrity.

Achievements

Department staff are very successful abroad, to give only a few examples they received the Best Paper Award for the following works:

- “Survivability of P2P Multicasting” at the 7th International Workshop on the Design of Reliable Communication Networks DRCN’2009, Washington, USA,
- “Evaluation and Comparison of Task Allocation Algorithms for Mesh Networks” at the 9th International Conference on Networks ICN’2010, Mendeires, Franca,
- “Performance evaluation of hybrid implementation of support vector machine” at the 13th International

Conference on Intelligent Data Engineering and Automated Learning, Natal, Brazil.

- “Comparison of Different Data Center Location Policies in Survivable Elastic Optical Networks” at the 7th International Workshop on Reliable Networks Design and Modeling RNDM 2015, Munich, Germany, 2015.
- “Routing and Spectrum Allocation Algorithms for Elastic Optical Networks with Dedicated Path Protection” Fabio Neri Best Paper Award 2014 in Elsevier Journal of Optical Switching and Networking.



DEPARTMENT OF TELECOMMUNICATIONS AND TELEINFORMATICS (K-3)

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The Department of Telecommunications and Teleinformatics is composed of six work-labs and the associated as well as the EMC Centre of Excellence:

■ Work-lab of Electromagnetic Compatibility and Teleinformatic Systems

(Prof. Tadeusz W. Więckowski, Ph.D. D.Sc. Eng.)

Members of this work-lab co-funded the so called Wrocław school of electromagnetic compatibility, which has enjoyed recognition of the national and European scientific community. Since 1972 the employees of this entity have co-organized the International Symposium of Electromagnetic Compatibility held at the Wrocław University of Science and Technology (www.emc.wroc.pl), and since 2010 – the European EuroEMC Conference. The work-lab organizes also cyclical Electromagnetic Compatibility Workshops (www.warsztaty-emc.pwr.wroc.pl) for Polish institutions, research entities and manufacturers of electrical and electronic equipment. It also comprises the certified Laboratory of Electromagnetic Compatibility (LKE) and the Laboratory of Teleinformatic Systems (LST),

Laboratory of Electromagnetic Compatibility (LKE) offers:

- Research in the field of electromagnetic compatibility (EMC) of equipment and systems, including: Measurements of electromagnetic disturbance emissions and disturbance immunity tests – used in conformity procedures (CE mark),



- selected EMC tests at the place where equipment is installed,
- tests of electromagnetic shielding effectiveness,
- long- and short-term monitoring of electromagnetic spectrum,
- measurements of radio, telecommunication and cable TV equipment parameters,
- verification measurements of pulse exposure generators.

LKE is equipped with specialised measurement chambers, i.e. reverberation chamber, GTEM chamber (Gigahertz Transverse Electromagnetic Mode Cell) for electromagnetic compatibility tests (EMC) of electronic equipment, and one of the largest in Poland anechoic chamber. LKE conducts also trainings and provides technical advice related to EMC.

The Work-lab of Electromagnetic Compatibility and Teleinformatic Systems (KEIST) conducts widely understood research on electromagnetic compatibility of wireless systems, encompassing research on new solutions used in these systems, development of simulation models of their operation in various environments, improvement of models describing radio systems and propagation phenomena as well as study works related to satellite communication multimedia services in heterogenic environments,

■ **Work-lab of Electromagnetic Environment Protection** (Paweł Bieńkowski Ph.D. D.Sc. Eng., WrUST Assoc. Prof., Eugeniusz Grudziński, Ph.D. D.Sc. Eng.): along with its independent accredited Laboratory of Electromagnetic Field Standards and Measurements perform both theoretical and applied research in the field of protection of humans and the environment from undesirable exposure to electromagnetic fields.

One of the results of the theoretical research is the first ever monograph, published in the USA about near-field measurement of electromagnetic fields. Others include over 250 publication on this subject as well as over 50 patents for various inventions developed at our workshop. The natural consequence of these works, are also the scientific degrees and titles obtained by our employees. Nowadays major interest is put on modern measurement methods, especially photonics techniques.

Experimental measurements require development and construction of precise sources of electromagnetic fields of known parameters- i.e. reference fields. For this purpose, we have developed a whole range of reference electrical and magnetic field sources, having various frequencies as well as power levels. The accuracy of these sources is confirmed through our participation (as the only partici-

pant from the mid- and eastern- European countries) in the international reference source comparison program. We have also developed several secondary source (exposure system) solutions along with control and measurement instruments.

Electromagnetic field measurement instruments developed by our workshop, are widely used by various national control and measurement authorities, many of these have also been exported abroad. Our laboratory is accredited as both a measurements laboratory as well as calibration laboratory up to 90 GHz. Besides the theoretical and applied research, our employees are actively involved in all forms of teaching activities.

■ **Terahertz Optoelectronics Lab (PTHz)** (Prof. E. Plinski, Ph.D. D.Sc., WrUST Assoc. Prof.): along with its Laboratory of Terahertz Technology (LTHz) performs works related to detection and identification of materials from branches like pharmacy, food industry, biomedicine, and civil as well as military security.

Terahertz Optoelectronics Lab is supported by the Research Terahertz Technique Center at the Wrocław University of Science and Technology

The center is a self-assembled network of research teams operating in Wrocław University of Science and Technology and other Universities and has no administrative structures and institutions. The aim is to integrate the activities CNTT the scientific community and promoting interdisciplinary research and studies in various disciplines in the field of far infrared, or other techniques, and terahertz technology, including gyrotron, and their applications, conducting joint research and the organization of joint seminars or conferences. The center has an open formula and the Scientific Council of the Centre may be appointed from outside the Wrocław University of Science and Technology researchers have full rights on opinions. Director of the Centre is appointed by the Rector of the Wrocław University of Science and Technology Prof. Edward Pliński.

Laboratory of Terahertz Technology is equipped with terahertz spectrometer and offers services consisting in spectral analysis of supplied materials in the range of 0,3-3,6 THz (10-120 cm⁻¹).

■ **Optotelecommunication Laboratory** (Prof. Elżbieta Bereś-Pawlik, Ph.D.D.Sc.): along with its research and teaching the laboratory performs work related to designing and building the amplifiers and lasers, based on rare earth ions doped fibers. Another main field of research activity includes designing and building passive optical networks (multimode and single mode), particularly for optical local area network application, investigations of tissues changes (due to cancer and sickness) with the use of endoscope and especially fiber sensors for medical testing. Laboratory carries out its mission by numerical investigation of fluorescence imaging, fibre optical cou-



plers, design and fabrication, for using in fiber telecommunication and sensor networks and design of photonic crystal fibre optic structures.

The main field of teaching activities includes fibre optic technique, photonic communication components and optical networks and networks elements.

■ **Work-lab of Antenna Theory and Calculation Electromagnetism and Laboratory of Antenna Technology** (Prof. Andrzej Kucharski, Ph.D. D.Sc. Eng.)

The work-lab conducts numerical analysis of EM fields, including antenna design and analysis, work related to EM wave propagation, in particular:

- measurements of radiation characteristics and antenna energetic gain,
- measurements of antenna circuit parameters,
- advisory service and design of antenna systems.

The Laboratory of Antenna Technology has a screen anechoic chamber with an open field position to take antenna measurements in the frequency range from 30 MHz to 30 GHz.

The above mentioned work-labs and laboratories are a part of the EMC Centre of Excellence (www.cd-emc.pwr.wroc.pl). Its goal is coordination of work on widely understood electromagnetic compatibility – harmonious co-existence of technical equipment and their impact on biosphere and especially human beings.

■ **Work-lab of Telecommunication Networks and Laboratory of Integrated Telecommunication Systems** (Janusz Klink, Ph.D. Eng.)

The Work-lab of Telecommunication Networks and Laboratory of Integrated Telecommunication Systems deal with wired and fibre optic telecommunications. The offer encompasses:

- measurements of transmission parameters of wired and fibre optic circuits,
- diagnostics of telecommunication systems and co-working equipment,
- design of new technical solutions,
- telecommunication audits.

In terms of teaching activity, the Department staff is involved in teaching students of: Telecommunications and Teletinformatcs. Graduation from these fields of study greatly facilitates obtaining a telecommunication contractor licence.

➤ **DEPARTMENT OF FIELD THEORY, ELECTRONIC CIRCUITS AND OPTOELECTRONICS (K-4)**

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<http://www.lfeg.pwr.wroc.pl/>

The Department specialises in conducting research and developing applications in the field of related to laser

and fibre optoelectronics and electronics of microprocessor and analogue circuits. In the Department there are the following educational laboratories: Laboratory of Laser Technology, Laboratory of Fibre Optics, Laboratory of Electronic Circuits and LabView Laboratory. In the Departments there are the following research laboratories:

- **fibre lasers** (Paweł Kaczmarek, Ph.D. Eng.),
- **laser microprocessing** (Arkadiusz Antończak, Ph.D. Eng.),
- **laser metrology** (Janusz Rzepka, Ph.D. Eng.),
- **electronic circuits** (Jerzy Witkowski, Ph.D. Eng.).

The Department closely cooperates with numerous reputable scientific research centres in the world, including: Princeton University, Department of Electronics, USA; Rice University, Electronics Department, Houston, USA; Heriot-Watt University, Edinburgh, Physics Department, Scotland; University of Nottingham, Electronics Department, England; Vrije University, Brussels, Belgium; Gersamia, Trondheim, Norway. It conducts projects for the economy related to: laser microprocessing, laser-fibre vibrometry, fibre optic lasers, terahertz technology.

➤ **DEPARTMENT OF ACOUSTICS AND MULTIMEDIA (K-5)**

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The Department is composed of the following units:

- **Work-lab of Fundamentals of Electroacoustics** (Prof. Andrzej Dobrucki, Ph.D. D.Sc. Eng.),
- **Work-lab of Fundamentals of Audio Engineering and Acoustics Research Laboratory** (Krzysztof Rudno-Rudziński, Ph.D. Eng.),
- **Work-lab of Ultrasonic Technology** (Tadeusz Gudra, Ph.D. D.Sc. Eng., WrUST Assoc. Prof.),
- **Work-lab of Acoustic Signal Analysis and Processing** (Stefan Brachmański, Ph.D. Eng.)

The research profile of the **Work-lab of Fundamentals of Electroacoustics** encompasses numerous areas of acoustics, starting with research on electroacoustic transducers, technical vibration tests using laser vibrometry, analysis of sound perception mechanisms up to acoustic modelling. The Work-lab carries out works related to music recordings production and direction. It is very well equipped with modern measurement equipment used in scientific research and educational activity.

The Work-lab has a very well equipped recording studio which is used to perform recording, e.g. for the

“Wratislavia Cantans” festival, JAZZTOPAD festival and for the Wrocław Philharmonic Hall.

Scientific research conducted in the **Work-lab of Fundamentals of Audio Engineering** is related to electroacoustic systems and equipment, protection of human environment against noise and architectural acoustics. It is a scientific unit, however, students often participate in research.

The **Acoustics Research Laboratory**, accredited by the Polish Accreditation Committee, extends measurement facilities of the Work-lab. Its activity comprises: tests and measurements, design, consulting, expert opinions, survey statements, investor supervision reports connected with interior acoustics, noise protection, audio systems.

The primary activity area of the **Work-lab of Ultrasonic Technology** is research on fundamental phenomena related to generation, propagation and reception of ultrasound waves in science, technology and medicine. There is also a research laboratory used which is a part of the Work-lab and is used for educational as well as research related purposes.

The ultrasonic equipment at the Work-lab allows to conduct a wide spectrum of research on ultrasound applications in various branches of science, technology and medicine. Among others there is an operational station to measure spatial distribution of acoustic field generated by ultrasonic transducers working in liquids and gases, there is also a research station for ultrasound transmission tomography which is unique on the Polish scale. The leading study area of the Work-lab is widely understood ultrasound aero-location and ultrasound transmission tomography. Commercial activity conducted in the Work-lab at the request of business entities encompasses:

- examination of physical properties of solid, liquid and gas media,
- non-destructive ultrasound tests of materials,
- velocity measurements of liquids and gases,
- tests and evaluation of suitability of ultrasonic apparatus used in medical therapy and diagnostics,
- spectral analyses of acoustic and ultrasound signals,
- software development for ultrasonic purposes,
- visualisation of internal and surface structure of media.

The research activity of the **Work-lab of Acoustic Signal Analysis and Processing** (AiPSA) is connected mainly to processing of speech signal used in communication between people and in communication with machines. The conducted research pertains to the field of speech synthesis and recognition, voice recognition and particular aspects of speech signal analysis. The largest database of Polish language recordings within the European SpeechDAT project

(project INCO-Copernicus “Eastern European Speech Databases for Creation of Voice Driven Teleservices”) was created here. International cooperation is also carried out as part of projects related to biometric techniques of voice recognition (speaker) (COST275 “Biometric-Based Recognition of People over the Internet”, COST2101 “Biometrics for Identity Documents and Smart Cards”). Currently there are also pioneering works on emotional states recognition in voice and non-verbal aspects of voice communication (COST2102 international project “Cross Modal Analysis of Verbal and Non-verbal Communication”). The Work-lab also conducts photoscopic studies for the needs of criminal and forensic investigations studies related to speech transmission quality in rooms, in analogue and digital telephone circuits and internet networks. The goal of the studies is determination of the relationship between speech quality assessment results obtained by subjective and objective methods.

The Department of Acoustics and Multimedia has got the following laboratories: Anechoic Chamber, Cyber-acoustic Laboratory, Electro-acoustic Laboratory, Laboratory of Noise and Vibration, Audio Engineering Laboratory, Laboratory of Electro-acoustic Systems, Laboratory of Ultrasonic Techniques, Recording Studio and Rehearsal Studio.



DEPARTMENT OF SIGNALS PROCESSING SYSTEMS (K-6)

Head: Prof. Jan Zarzycki, Ph.D. D.Sc. Eng.
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The Department conducts teaching and scientific research activity related to:

- advanced techniques of optimal filtering; adaptive filtering in terms of time and spatial spectrum,
- speech signal processing; practical aspects of automatic speech and speakers’ recognition and speech synthesis,
- object recognition on the basis of signatures data bases, biometrics of face, eyes and palms; multi-criteria biometrics – multibiometrics,
- passive sensing of environment on the basis of thermal, acoustic, seismic and telecommunication signals; intelligent acoustic and seismic sensors; array processing and data fusion,
- practical applications of FPGA technology; practical implementations: algorithms for detection and location of mechanical objects in near and far fields, motion detection and universal systems of transmission and collection of broadband telecommunication signals,
- Image processing from infra-red cameras,
- preparation of projects of large computer networks and expert opinions on computer networks, hardware and operating systems used in large installations.



The Department comprises the following units:

- **Student Computer Laboratory**
(Jerzy Szymbor, Ph.D. Eng.),
- **Work-lab of Digital Signal Processing**
(Krzysztof Kardach, Ph.D. Eng.),
- **Work-lab of Digital Image Processing**
(Jan Mazur, Ph.D. Eng.).

The Department cooperates with Polish and foreign institutions, among others: Military Institute of Engineering Technology (WITI); Radiotechnika Marketing; Neurosoft; Board of Geodesy, Cartography and Land Register of Wrocław; Katholieke Universiteit Leuven, Belgium; NATO NC3A, The Hague; Delft University of Technology, The Netherlands; XII Paris University, Creteil, France.

The Department mainly carries out large research and development projects commissioned by economic institutions.

There are also laboratories used for educational purposes, *Laboratory of Analogue Technology and Laboratory of Computation and Simulation Technology*. The staff working on electronic circuits theory specialise in: designing electrical filters, approximation methods for amplitude and phase characteristics of analog and digital filters, wideband adjustment methods, topological methods and their application in analysis and synthesis of linear electrical circuits, modelling of one and multi-dimensional orthogonal filters.

DEPARTMENT OF CYBERNETICS AND ROBOTICS (K-7)

Head: Alicja Mazur, Ph.D.D.Sc., WrUST Assoc. Prof.
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The Department of Cybernetics and Robotics continues the tradition of the Department of Cybernetics and Robotics Fundamentals established by Professor Jerzy Jaroń in 1973.

Scientific research

The department conducts research on cybernetics and robotics with particular emphasis on modelling, controlling and planning robot motion, theory of discrete event systems, perception, intelligence and operation

of robots, recognition of electro- and mechanomyographic signals and biocontrol, embedded robotic systems as well as human-robot interfaces. A new area of the Department activity is social robotics. Social robots constructed in the Department are ready for commercialisation; currently a new model of the social robot FLASH MKII has been designed for the Robotarium at Heriot-Watt University in Edinburgh as well as the emotive robotic heads EMYS for the Museum of Science and Industry in Chicago, INESC-ID Lisbon, University of Glasgow, and for American society People for the Ethical Treatment for Animals. Recently the Department of Cybernetics and Robotics began research cooperation with Space Research Centre of Polish Academy of Science in Warsaw. It is focused on development of control for non-holonomic satellites in the presence of obstacles.

Scientific Projects

The Department has participated in large European and nationwide projects, such as: LIREC (Living with Robots and interactive Companions, 7th Framework Programme, 2008–2012), ReMeDi (Remote Medical Diagnostician, 7th Framework Programme, 2013–2016), RobRex (Autonomy for Rescue-Exploration Robots, NCBiR, 2012–2015), Development of Jacobian Motion Planning Algorithms for Robots (NCN, 2014–2016), Mobility of Nonholonomic Space Robots in the Presence of Extensive obstacles with Nonzero Momentum (2016–2019).

Domestic and international cooperation

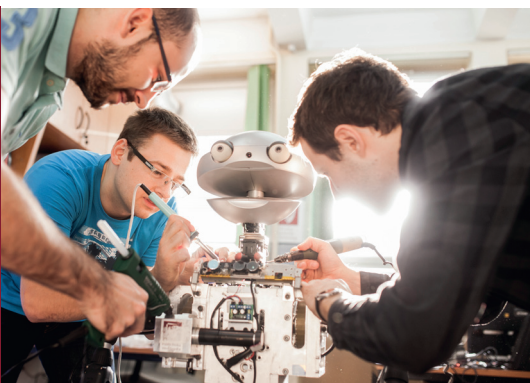
The domestic research cooperation of the Department encompasses the most important robotics centres, Industrial Research Institute for Automation and Measurements (PIAP), Space Research Centre of Polish Academy of Science (CBK PAN), ACCREA Engineering, Medical Universities in Wrocław and Lublin, as well as the Cardiac Surgery Development Foundation in Zabrze.

In international dimension the Department cooperates with such academic centres as Technische Universität München, ETH Zurich, Scuola Superiore Santa Anna, Heriot-Watt University, London South Bank University, INRIA Sofia-Antipolis, Universidad de Politecnica de Catalunya, Eötvös Loránd University, Otto-Friedrich Universität Bamberg, University of Lund, Technical University of Eindhoven, Carleton University, Georgia Tech.

Research and educational laboratories

The Department has three research and educational laboratories:

- **Laboratory of robotics** is dedicated mainly to conduct fundamentals of robotics and control engineering classes and also specialist classes of manipulation and mobile robots as well as sensory systems,



- **Laboratory of mobile robots and biocontrol** conducts research and analysis of electrical potentials and human muscle vibrations, design of palm bio-prostheses, design of mobile robots and navigation systems for autonomous vehicles,
- **Laboratory of Robot Intelligence** is dedicated to conduct classes and project work using computers and software related to: programming, operating systems, real time systems, artificial intelligence, vision systems, and robot control systems.

There is also a new didactic laboratory:

- **Laboratory of Autonomous Robots** in the Technopolis Centre related to education in service and social robotics. The laboratory is equipped with a number of mobile robots, including the Pioneer robot fleet, and the Nao humanoid robot group, which allows you to gain the ability of programming the behavior of a co-operating group of robots.

Educational offer

The Department conducts educational programme in Robotics and Embedded Robotics which is taught in English for students of Control Engineering and Robotics at the Faculty of Electronics. The academic staff of the Department comprises 17 academic employees, including four independent ones. There are nine PhD candidates. The Seminar of Cybernetics and Robotics, conducted continuously for over 40 years, has had more than 1100 meetings.

For over 10 years Department staff caring for Robotics scientific circle within which students can broaden the knowledge acquired during the lectures and to realize their own projects.

DEPARTMENT OF CONTROL SYSTEMS AND MECHATRONICS (K-8)

Head: Prof. Ewaryst Rafajłowicz, Ph.D. D.Sc. Eng.
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- **The Department of Control Systems and Mechatronics** was established in November 2014 in effect of the transformation of the Institute of Computer Engineering, Control and Robotics which was set up in 1968

as the Institute of Technical Cybernetics – as a result of joining the Department of Digital Machines and the Department of Telemechanics Control Engineering. Thus the Department continues the tradition of the first department in Poland with control engineering and also telemechanics (at that time defined as remote interaction) in its name. It was established in the early 50's of the 20th c. It also continue the work of the above mentioned Institute in terms of fundamental research connected with: control theory, system identification, modelling and optimisation (discrete and global – using evolutionary algorithms). The Department takes efforts to remain in the mainstream applied research, including: industrial computer networks, digital controllers, intelligent control engineering systems, sensorics and image processing of images in control systems, biomedical research support and – currently the most popular – mechatronic systems, i.e. drones and multirotor gear (e.g. quadrocopters). The Department research offer is presented below in the information about particular work-labs.

■ Research and educational laboratories

In the Department there are educational and research laboratories including general computer laboratories and work-labs with specialist equipment:

Educational laboratories in Technopolis:

- **Laboratory of Distributed Control Systems - DCS** – with a few experimental setups with DCS of renown manufacturers: Siemens, SAIA, General Electric, Allen-Bradley, Schneider. The equipment allows to learn system integration and configuration, as well as its network cooperation (numerous standards and communication protocols), building redundant and safe systems, process visualisation. The laboratory is equipped with control objects simulators and models. There are also industrial computers, operator panels and engineering stations,
- **Laboratory of Video Systems and Manufacturing Quality Monitoring** is equipped with a range of cameras used to monitor manufacturing quality: starting with infrared cameras, through visible light cameras and finishing with UV cameras, a 3D camera, a high-speed camera and a laser interferometer. In the laboratory there are also simulation setups for: continuous and discreet manufacturing defects, laser metal heating, heat exchanger and a vision security system in a building,
- **Laboratory of Computer Engineering in Technology** conducts activity encompassing system identification and modelling, signal and image processing. Its equipment comprises, e.g. efficient workstations, digital cameras with interchangeable-lens and adaptive optics, ToF sensors, digital generators and oscilloscopes as well as containers and servomechanisms integrated with Matlab.



Other educational and research laboratories:

- **Laboratory of Control Systems and Mechatronics** – its activity encompasses programming and research on PLCs and their network cooperation. It is equipped with professional apparatus and software. There are mechatronic models of plants,
- **Laboratory of Video Systems and Control Theory** carries out numerous didactic classes in control theory and related subjects. Apart from this, the research part of the laboratory is equipped with a set of cameras used for video monitoring of manufacturing quality, including a high precision thermal imaging camera, a camera for fast acquisition of images and various types of industrial cameras. The research offer encompasses, e.g. design of systems and software for continuous monitoring of manufacturing processes (e.g. of metal, paper, pipes), discrete manufacturing processes and correct assembly. We are also interested in the use of various types of cameras in scientific research,
- **Laboratory of Control Equipment and Systems** is used to teach configuration and use of industrial object devices and control systems (measurement equipment, digital regulators, frequency transducers, PLCs, data acquisition systems, regulation systems) and also testing their properties and technical parameters,
- **Laboratory of Intelligent Buildings is certified by KONNEX**, a European organisation. It is a training centre of building control systems. Its activity encompasses running certified trainings in the KNX technology (one of few such centres in Poland). The laboratory equipment comprises didactic setups allowing to create and configure BMS, programme in the KNX/EIB standard, control with the WAGO system, integrate the system of an intelligent building, e.g. burglary and robbery alarm systems, access control, energy and comfort control, remote monitoring systems, illumination control, audio-visual systems,
- **Laboratory of Discrete Systems** is dedicated mainly to teaching such tasks as prioritisation with regard to control systems, IT and logistics, including scheduling in manufacturing tasks and computer integrated manufacturing.
- **Laboratory of Control Engineering Equipment** is dedicated to individual student work aiming at completing the whole cycle: from design to technical implementation and start-up of electronic control equipment. In the laboratory there is equipment for electronic systems assembly, apparatus (feeders, digital measurements devices, digital oscilloscopes, generators, etc.), computers and some spare electronic parts,
- **Laboratory of Control Systems Modelling** is used for simulation tests of object dynamics and control systems. There are 18 computer setups with e.g. Matlab software,
- **Laboratory of Microprocessor Systems in Control Engineering** is used to teach students how to programme

microprocessor systems and use them in control engineering equipment. It is equipped with universal microcontroller sets coupled with computers which enable students to practice individual programming, configuring and integrating with external equipment,

- **Laboratory of Virtual Laparoscopy** is equipped with apparatus allowing to simulate laparoscopic surgery. It is used for research on simulators of this kind of surgery and training in laparoscopic surgery.

The Department sometimes cooperates with the Department of Computer Engineering in conducting the following specialisations:

the course of Control Engineering and Robotics (AiR):

- Computer Control Networks (ARK)
- Computer Systems of Manufacturing Process Management (ARS)
- Information Technology in Control Engineering (ART)
- IT Systems in Control Engineering (ASI) the course of Electronics:
- Applications of Computer Engineering in Technology (EZI)

■ **Work-labs Scientific and implementation research is conducted in work-labs: Work-lab of Control and Optimisation** (Przemysław Śliwiński, Ph.D. D.Sc. Eng. in cooperation with Prof. Zygmunt Hasiewicz, Ph.D. D.Sc. Eng.). Scope of research:

- identification of dynamic systems using non-parametric methods,
- identification of complex systems,
- non-parametric methods of image recognition,
- image processing,
- network systems optimisation – including water supply systems,
- cutting optimisation,
- laparoscopic trainers.

■ **Work-lab of Vision and Control Systems** (Prof. Ewaryst Rafajłowicz, Ph.D. D.Sc. Eng. in cooperation with Krystyna Styczeń, Ph.D. D.Sc. Eng.): Scope of research:

- control theory – fundamentals, control engineering numerical methods, cyclical systems,
- experiment planning for identification – sensor allocation, optimum selection of coercions,
- statistical methods of manufacturing quality monitoring, including the use of cameras and industrial image processing,
- stochastic modelling in complex physical processes and networks.



■ **Work-lab of Discrete Systems** (Wojciech Bożejko, Ph.D. in cooperation with Prof. Czesław Smutnicki, Ph.D. D.Sc. Eng.) – the scope of research encompasses optimisation of discrete manufacturing and logistical systems.

The work-lab research offer encompasses:

- discrete optimisation, parallel and distributed algorithms,
- prioritisation of tasks, division of resources, flexible manufacturing systems, CAM,
- optimisation of manufacturing processes and transport,
- optimisation of logistic processes,
- modelling and optimisation in complex manufacturing systems,
- use of supercomputer architectures (cluster, GPU) in optimisation,
- use of sequential and parallel metaheuristics in solving NP-hard problems,

■ **Work-lab of Control Engineering, Modelling and Mechatronics** (Iwona Karcz-Dulęba, Ph.D. D.Sc. Eng., WrUST Assoc. Prof.)

- modelling and simulation of technological processes and intelligent systems,
- advanced optimisation algorithms, including modern heuristic algorithms, especially evolutionary algorithms,
- advanced adaptive control algorithms, fuzzy and other types,
- complex control systems of industrial processes, including DCS, SCADA, PAC, PLC,
- forecast methodology and application using neural networks,
- modelling and synthesis of control systems in intelligent buildings,
- analysis and synthesis of control systems in multirotor flying systems and mobile systems.

International and commercial cooperation

The Department conducts extensive, active cooperation with numerous centres which results in joint publications and/or international cooperation with such countries as:

Canada (University of Manitoba, Concordia University), USA (Arizona State University w Tuscon), Germany (RWTH Aachen, Otto von Guericke, University Magdeburg), Austria (Johannes Kepler University, Linz), Belgium (Vrije Universiteit Brussel), Spain (Universidad de Las Palmas de Gran Canaria, Universidad de Almeria – mainly student exchange). We also value cooperation with many Polish centres.

The Department has cooperated with numerous companies for many years, including Siemens, KGHM S.A., Cedynia Copper Rolling Mill in Orsk, BIAP, Viessmann, ASTOR, SABUR, SIEDLE and IBM.

DEPARTMENT OF COMPUTER ENGINEERING (K-9)

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The Department of Computer Engineering (K-9/W-4) was established in 2014 as a result of reorganisation of the Faculty of Electronics and division of one of its institutes, the Institute of Computer Sciences, Control Engineering and Robotics (until 2005 it was the Institute of Technical Cybernetics). The Department encompasses 4 research teams working in extensive fields of computer sciences, starting with computer equipment (including microprocessor one), through low-level programming, mobile devices programming and finishing with high level programming and advanced data processing algorithms including imaging, industrial computer sciences, bioinformatics and knowledge extraction. The Department participates in organisation and work conducted by WrUST CWiINT research laboratories. It organises a cyclical, annual international conference Dependability and Complex Systemc RELCOMEX-DEPCOS. It employs about 45 scientific and teaching staff, including 3 full professors and 3 scholars with a postdoctoral degree. Currently there are 9 student scientific centres. Some of them have been active for many years and have achieved significant success. There are also interesting circle projects BARAK and TRAF, organised on the Internet together with student teams from the University of Arizona, Tucson and University of Technology, Sidney.

Research and educational laboratories

The Department has 13 educational laboratories (including 6 in the new facilities of Technopolis) encompassing general computer laboratories as well as workrooms with specialist equipment.



Selected laboratories:

- **Laboratory of Digital Elements and Equipment** – design, implementation and testing digital equipment in the CPLD and FPGA technology, microprocessor controllers,
- **Laboratory of Computer Architecture** – computer architecture, processor architecture, manufacturing technology and components of computer equipment, binary signal transmission and processing,
- **Laboratory of ASIC Systems, Transputers, Multimedia and Microcontrollers** – microcontrollers, ASIC systems, equipment graphics,
- **Laboratory of Computer Sciences** – programming technologies, operating systems,
- **Laboratory of Internet Engineering and Data Warehousing** – data exploration, mass data processing (using SAS tools), Internet technologies,
- **Laboratory of Manufacturing Quality Control** – statistical data processing, quality control, neural networks, fuzzy systems, decision support,
- **Laboratory of Computer Graphics and Image Processing** – analysis, modelling and visualisation of 3D scenes, management of SOA systems;
- **Laboratory of Software Engineering** – software engineering, distributed data base systems, agent systems;
- **Laboratory of Algorithm Design** – algorithm design, artificial intelligence, automats, digital logics.

Scientific research offer

Scientific and implementation research is conducted mainly in Teams' structure:

- **Computer Architecture** (Janusz Biernat, Ph.D. D.Sc. Eng. WrUST Assoc. Prof.):
 - computer architecture, residue arithmetic, VLSI systems design,
 - system/network management, data protection.
- **Software Engineering** (Olgierd Unold, Ph.D. D.Sc. Eng. WrUST Assoc. Prof.):
 - data base systems: relational, object, client-server architecture,
 - software engineering and its applications in system design, distributed and multi-agent systems, symbolic computation,
 - cryptography and security,
 - software engineering: formal description methods of real time systems,

- AI: natural language processing, knowledge classification systems, bimolecular calculations,
- system capacity analysis.

- **Quality Control of Manufacturing Processes** (Prof. Ewa Skubalska-Rafajłowicz, Ph.D. D.Sc. Eng.):
 - control theory, experiment planning and identification, statistical methods,
 - neural networks,
- **Computer Systems** (Prof. Czesław Smutnicki, Ph.D. D.Sc. Eng.):
 - system reliability, analysis, modelling and reliability and functional simulation,
 - distributed systems, soft-computing, cloud computing, data mining,
 - web systems, mobile devices programming,
 - computer graphics, image processing, signal processors, ASIC/ FPGA applications.

The Department has numerous international contacts, some of them confirmed by international agreements and some less formal. However, the most important are joint research projects. In recent years the Department employees have participated in the following projects:

- **DESEREC** – Dependability and Security by Enhanced Reconfigurability (6th Framework Programme),
- **SAFERELNET** – Safety and Reliability of Industrial Products, Systems and Structures (5th Framework Programme).

An especially important research project conducted by the Department to meet the needs of the economy is the real time information system **QUALITY EXPERT** carried out for Cedynia Copper Rolling Mill in Orsk. The project encompassed the development and implementation of a system used for precise monitoring of copper scroll quality, manufacturing parameters control, data archiving and labelling.

*Member of the scientific circle of the *
*Department Cybernetics and Robotics KoNaR *
and social robot Balbina





Wrocław University
of Science and Technology



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