2012-2013
Research Report

University of Split
Faculty of Electrical Engineering,
Mechanical Engineering
and Naval Architecture

RESEARCH REPORT
2012 - 2013

University of Split
Faculty of Electrical Engineering,
Mechanical Engineering
and Naval Architecture

SCIENTIFIC COMMITTEE

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May 2014

TABLE OF CONTENTS

INTRODUCTION

OVERVIEW OF RESEARCH ACTIVITES

TECHNICAL SCIENCES

NATURAL SCIENCES

HUMANITIES

Faculty Management

Clockwise from left: Joško Radić (Vice Dean for Management), Srdjan Podrug (Dean), Damir Lelas (Vice Dean for Education) and Dragan Poljak (Vice Dean for Research)

Message from the Dean

The Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, as one of the largest institutions at the University of Split has continuously played rather important role regarding educational and scientific issues in the area of engineering and high technologies, thus contributing to the benefit of the society.

The robustness of the Faculty research capabilities has been demonstrated through numerous research projects, published papers, link agreements, and, in particular, through a long-term collaboration with internationally recognized research and academic institutions.

In accordance to its research strategy the Faculty continuously not only provides a knowledge basis for industrial, public and private sector, but also ensures efficient mechanisms for knowledge transfer through the organization of international conferences, workshops and symposia covering a broad range of topics and gahtering researchers from all over the world.

Finally, I would like to take this opportunity to express my sincere gratitude to the Faculty staff, students and many valued colleagues and friends who continue to support activities of the Faculty and also participate in various efforts enabling its continuous growth.

Dr. Srdjan Podrug, Associate Prof.

Dean

FESB THROUGH **HISTORY**

The history of the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split (FESB abbreviated in Croatian) begins in 1960 when the Faculty of Electrical Engineering becomes entirely autonomous and independent unit of the University of Zagreb. Five years later Mechanical and Technological Department was founded at the Faculty of Electrical Engineering in Split, offering two first years of study in the area of Mechanical Engineering. Also, this study programme provided students to continue the Mechanical Engineering programme in Zagreb after the fourth semester.

Furthermore, the Naval Architecture study programme was established at the Department of Mechanical Engineering in year 1968.

The Faculty was renamed as the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split in 1971, while in 1974 the Faculty became a constituent part of the newly established University of Split. The Faculty is referred to be as one of the University founders. The full four-year Mechanical Engineering programme of study was established in 1976.

In the meantime, two new undergraduate study programmes were established in 2002: Computer sci-

Founded in 1960

1980

A view of FESB from 1960 to 2013

ence and Industrial Engineering. The Bologna process activities regarding the harmonisation of the higher education systems in Europe were intensified by the end of 2004 and the Faculty eventually introduced new degree programmes at undergraduate and graduate levels in 2005. The ECTS (European Credit Transfer System) concept has been implemented, as well. Five new undergraduate study programmes have been organized and established taking into account the recommendations of the European accreditation agencies: Electrical Engineering and Information Technology, Computer Science, Mechanical Engineering, Naval Architecture and Industrial Engineering, as well as seven graduate programmes: Systems and Control, Electronics and Computer Engineering, Electrical Engineering, Communications and Information Technology, Computer Science, Mechanical Engineering and Industrial Engineering. In addition, four vocational study programmes have been established: Electrical Engineering, Mechanical Engineering, Naval Architecture and Computer Science.

Finally, in 2006, two postgraduate study programmes for obtaining a Doctor of Science degree were established: Electrical Engineering & Information Technology and Mechanical Engineering.

Today

FESB TODAY

The basic activities of the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split involve teaching, research, development, professional work and innovation in the areas of technical sciences, including Electrical Engineering, Electronics, Mechanical Engineering, Naval Architecture, Computer Science, Industrial Engineering and Natural Sciences. With approximately 2500 students and more than 230 employees, FESB has grown into recognized and highly respectable educational and research institution dealing with the advanced technologies and, consequently, contributing to the development of the economy and society.

In particular, the robustness of FESB research capabilities has been confirmed through numerous successful competitive and other research and technological projects, number of scientific and professional papers published in peer-review journals, and through the continuous cooperation with internationally recognized research and academic institutions, respectively.

RESEARCH STRATEGY

The research strategy of the Faculty is directed toward basic and multi-sectoral research and clearly focused on commercialization, innovation and networking with public and private sector and industry. Complementary activities will be related to networking of scientific resources and entrepreneurs, continuous development of human resources aiming to increase the quality of education and enhance mobility.


Svečana promocija
Svečana promocija
FESB
BRODOGRADNJA

Employees, Premises and Equipment

FESB is one of the largest constituents of the University of Split and largest technical faculty outside of Zagreb, capital of Republic of Croatia. Out of 235 full-time employees, over 163 of them are involved in the teaching process: 39 full professors, 21 associate professors, 25 assistant professors, 7 senior lecturers and lecturers, 15 senior assistants and assistants, 38 PhD students. There are 16 laboratory technicians involved in the teaching process, research and professional work. External associates coming from other academic and research institutions are occasionally involved into the teaching process.

The entire Faculty area consists of approximately 29.447 m^2 thus ensuring necessary conditions for educational, research and professional work. The Faculty building has 9 amphitheatres, 10 classrooms, 95 laboratories, 11 computer classrooms, including modern classrooms equipped for long-distance learning.

Amphitheatres and classrooms are equipped with computers, projectors and additional technical devices necessary for modern implementation of lectures and exercises. The Computer Centre is an organizational unit of the Faculty administrating a local network of over 500 computers and a CARNet (The Croatian Academic and Research Network) junction.

The library contains a reading and study room for students and holds about 1700 books and over 350 journal titles. Faculty premises consists of 100 offices for teaching staff, the Dean's office and the Student Registry. Moreover, the Faculty has two student restaurants, a coffee shop and a recreation centre with facilities available to students.

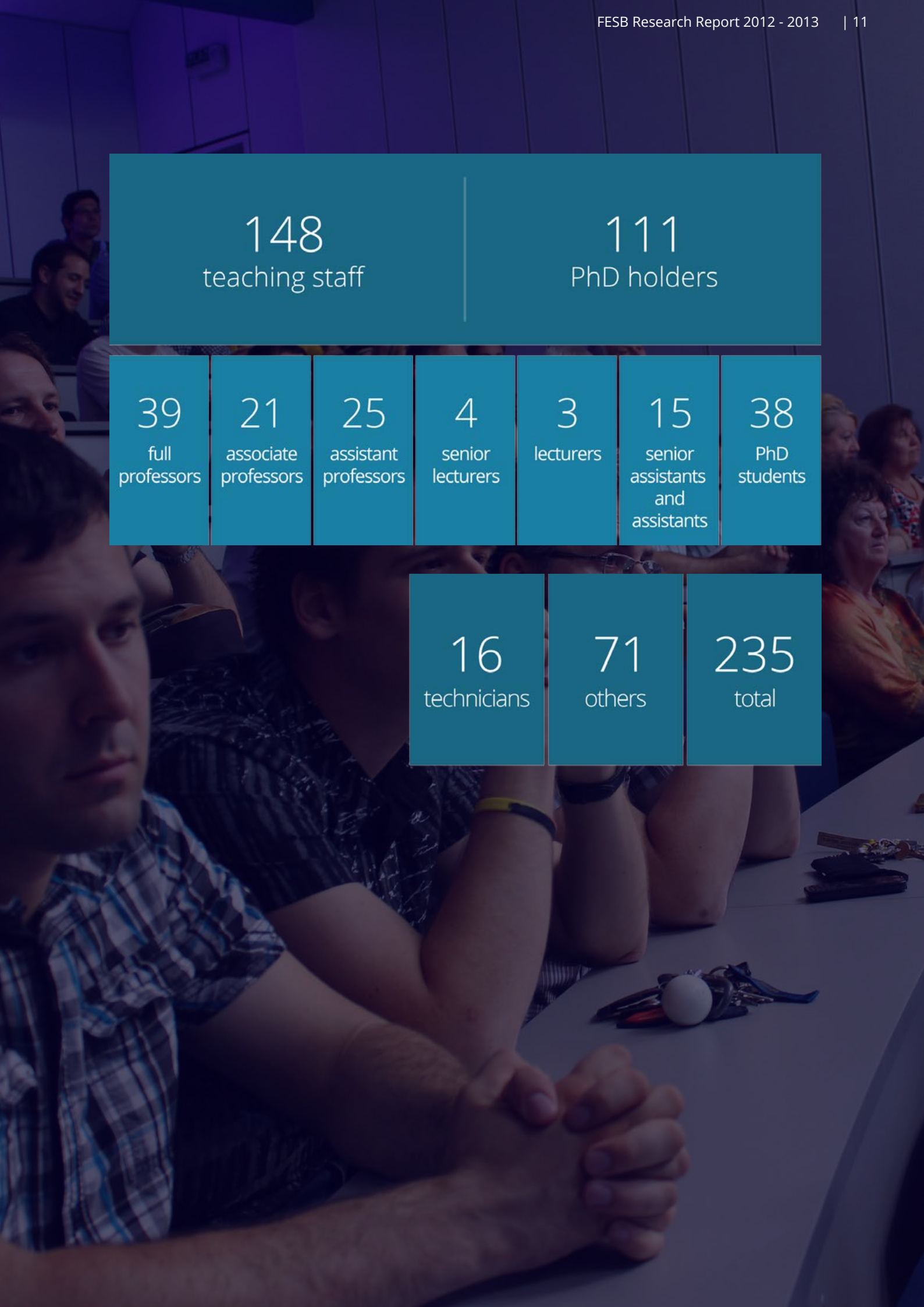
29.447 m^2
premises area

9
amphitheatres

10
classrooms

95
laboratories

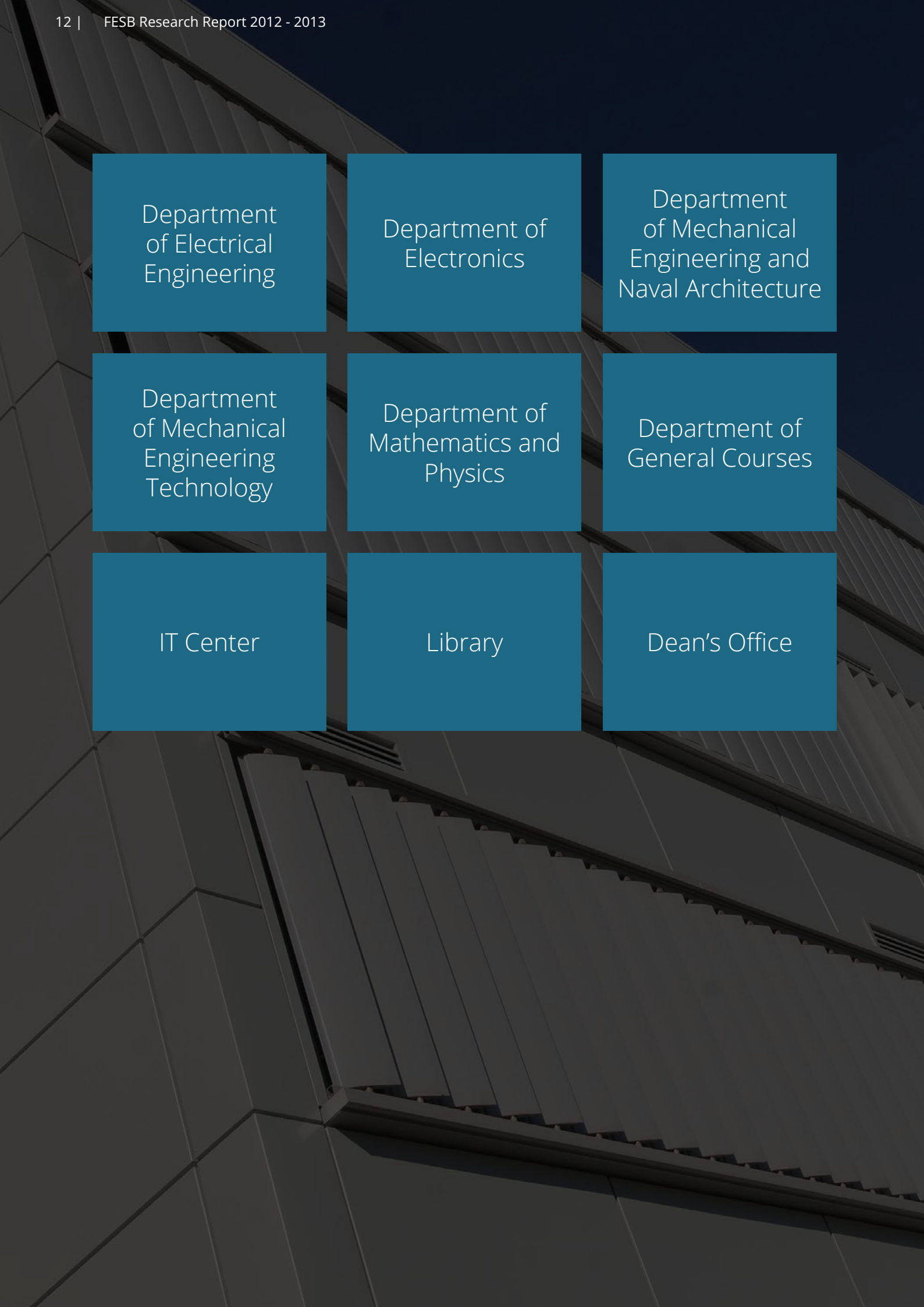
11
computer classrooms



148	111
teaching staff	PhD holders

39	21	25	4	3	15	38
full professors	associate professors	assistant professors	senior lecturers	lecturers	senior assistants and assistants	PhD students

16	71	235
technicians	others	total



Department of Electrical Engineering

Department of Electronics

Department of Mechanical Engineering and Naval Architecture

Department of Mechanical Engineering Technology

Department of Mathematics and Physics

Department of General Courses

IT Center

Library

Dean's Office

Organizational Structure

The Faculty is internally decomposed into units for teaching and research, administrative and technical work. These units are:

- Departments
- Chairs,
- Computer Centre,
- Library
- Dean's Office.

The Department as an academic unit participates in teaching, research and professional work.

The Faculty consists of the following departments:

- Department of Mathematics and Physics,
- Department of Electronics,
- Department of Electrical Engineering,
- Department of Mechanical Engineering and Naval Architecture,
- Department of Mechanical Engineering Technology.

The Chairs are sub-organisational units within departments undertaking mostly educational activities within the scope of a department.

The Computer Centre organizes and integrates activities related to the use of IT for teaching, research and professional work.

The Library is a special unit collecting, processing and providing the teaching staff and students with access to publications, journals and information necessary for research, educational and professional activities of the Faculty.

The Dean's Office is in charge of the administrative, executive, financial, technical and support activities of the Faculty.

Study Programmes

The study programmes, established according to the Bologna declaration, aim to enhance the quality of studying through adopting the European values and European cooperation in higher education.

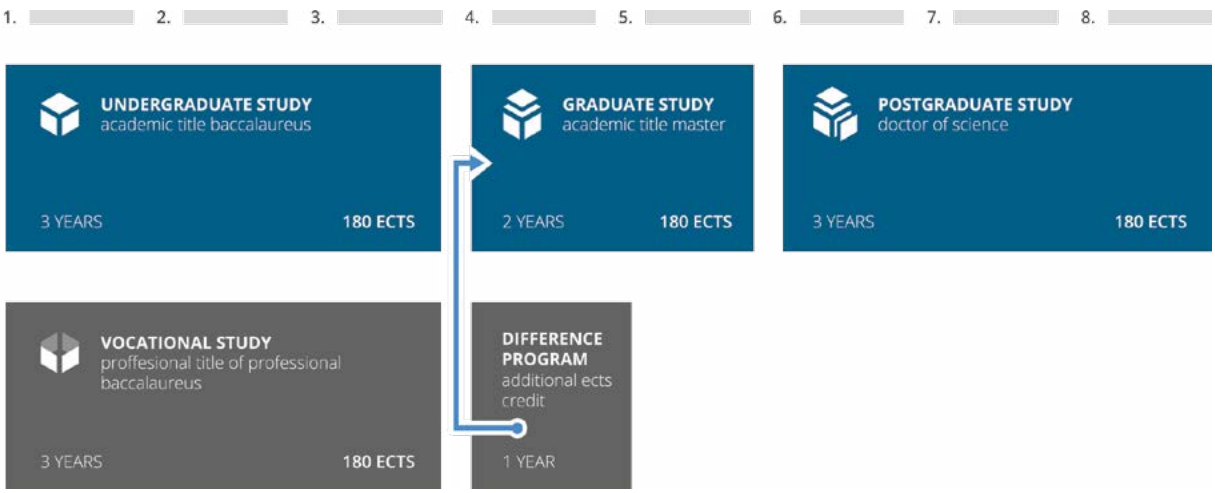
Faculty offers undergraduate, graduate and post-graduate university studies, usually referred to as a model 3+2+3, i.e.:

- undergraduate university study,
- graduate university study,
- postgraduate university study.

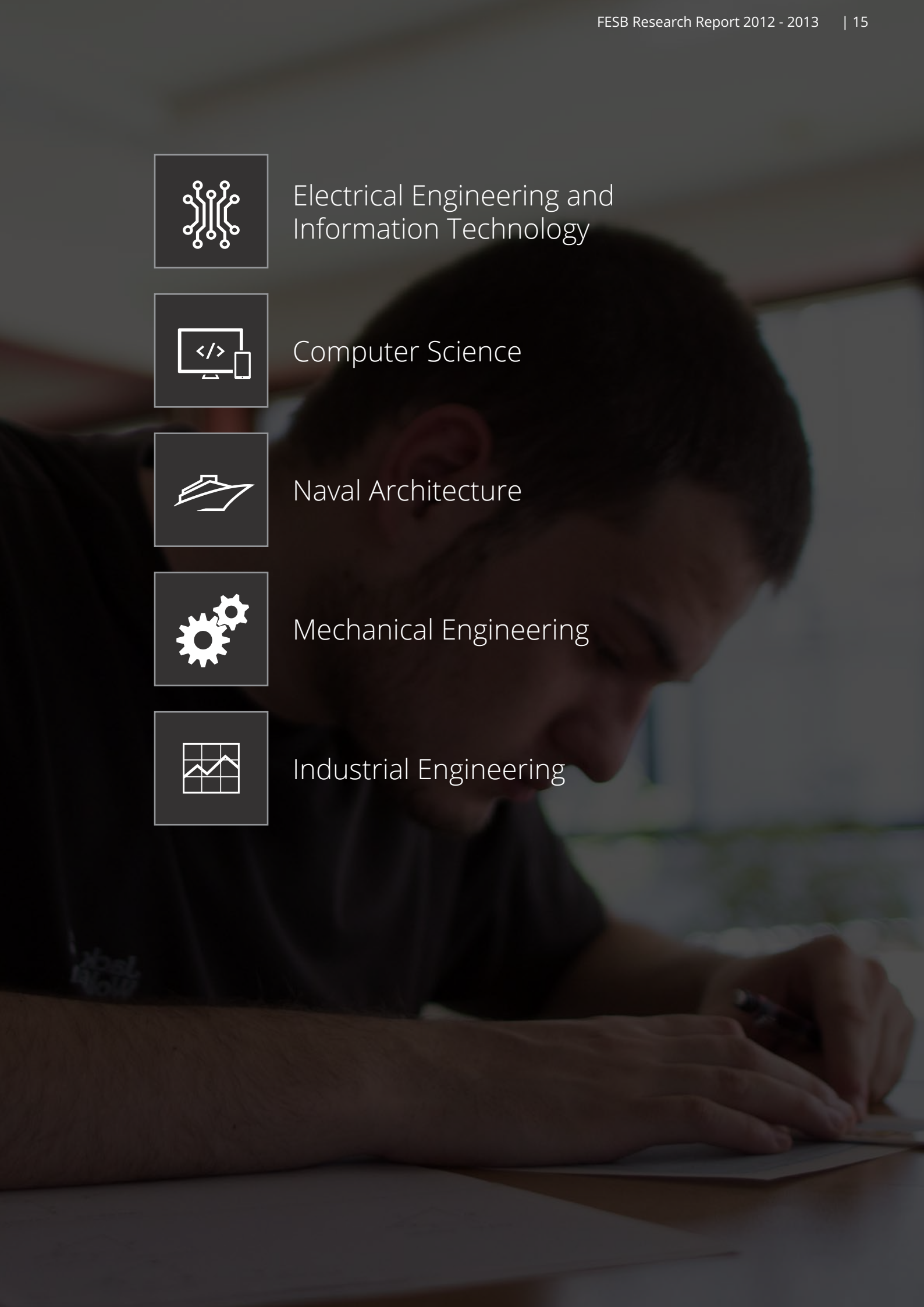
The allocated duration of undergraduate study is three years, resulting in the academic title of Baccalaureus within a given area of specialisation. The second cycle of academic education is related to the graduate study which is supposed to be completed after two years of study.

Students are awarded by the academic title of Master with an area of specialisation. Finally, the third cycle of university education is the postgraduate study which lasts for three years, leading to the academic degree of Doctor of Science.

Duration of vocational studies is 3 years and students obtain the title of Baccalaureus of vocational study with an area of specialisation.



A structure of Bologna process at FESB



Electrical Engineering and Information Technology

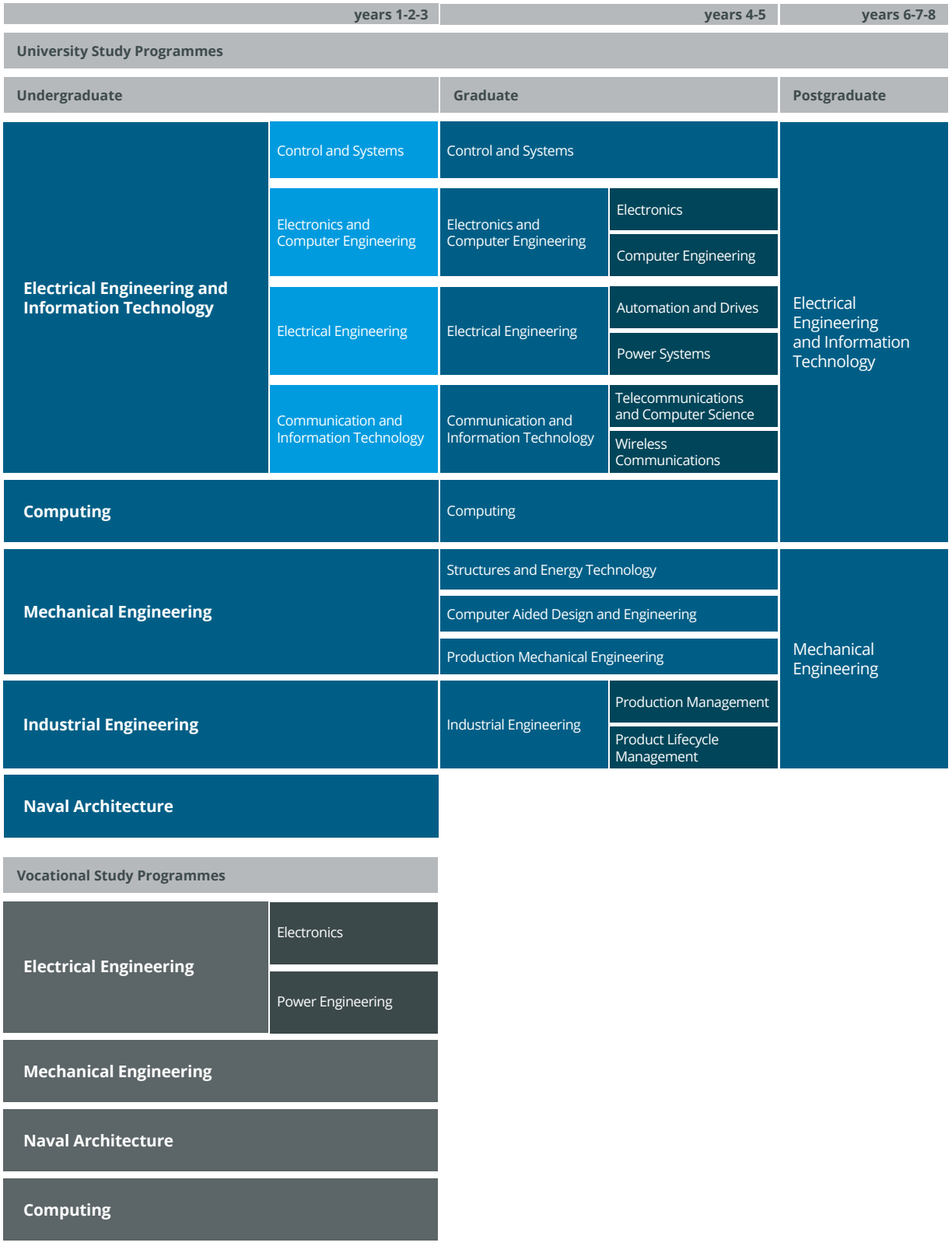
Computer Science

Naval Architecture

Mechanical Engineering

Industrial Engineering

The Faculty also conducts difference programmes, thereby facilitating horizontal mobility and thus providing the students who have completed vocational studies with an opportunity for admission to corresponding graduate programmes.




FAKULTET ELEKTROTEHNIKE,
STROJARSTVA I BRODOGRADNJE

Students

Each year, approximately 2500 students perform their studies at the Faculty and, so far, about 8000 students have successfully completed different study programs.

There are around 900 new enrolments per academic year, about 500 at the undergraduate level, 300 at the graduate level and 100 at the vocational studies.

About 20-30 candidates annually enroll in postgraduate study programs of Mechanical Engineering and Electrical Engineering and Information Technology. Increase in the number of defended doctoral dissertations has been recorded in the recent years and 22 dissertations were completed in each of the past 2 academic years.

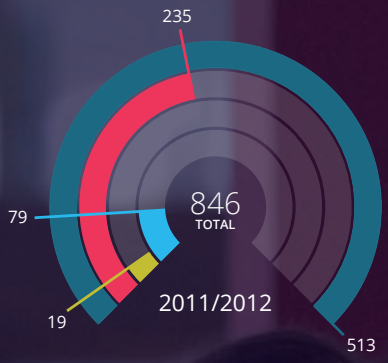
APPROXIMATELY
8000
graduated students

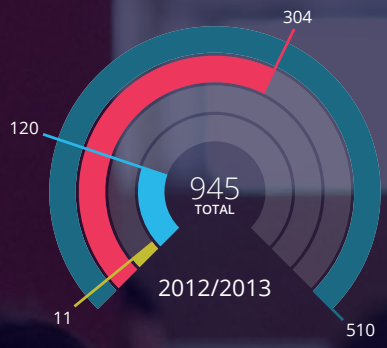
APPROXIMATELY
2500
studies every year

APPROXIMATELY
900
enrolles every year

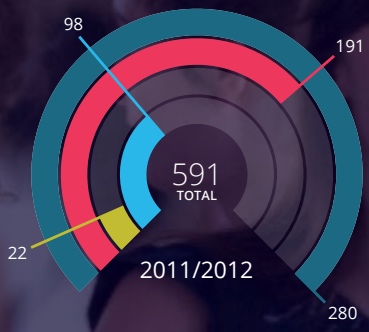
Undergraduate Graduate Postgraduate Vocational

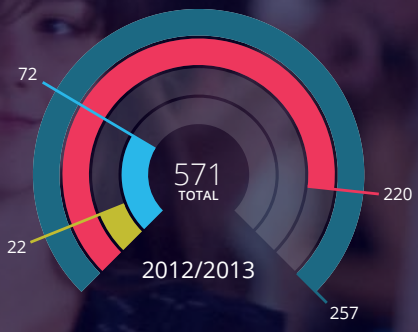
New students enrolled per academic year



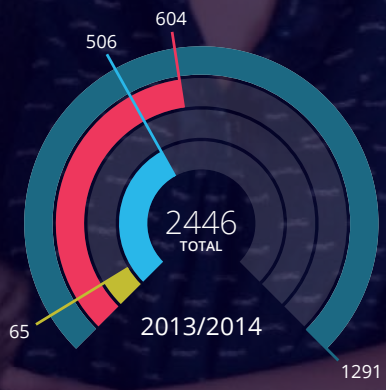


Students graduated per academic year





Number of students in 2013/2014



Undergraduate

MECHANICAL ENGINEERING 241

COMPUTER SCIENCE 271

INDUSTRIAL ENGINEERING 190

ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY 539

NAVAL ARCHITECTURE 50

Graduate

MECHANICAL ENGINEERING 61

COMPUTER SCIENCE 157

INDUSTRIAL ENGINEERING 70

COMMUNICATION AND INFORMATION TECHNOLOGY 84

ELECTRICAL ENGINEERING 101

ELECTRONICS AND COMPUTER ENGINEERING 56

SYSTEMS AND CONTROL 75

Postgraduate

MECHANICAL ENGINEERING 16

ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY 49

Vocational

MECHANICAL ENGINEERING 128

COMPUTER SCIENCE 133

ELECTRICAL ENGINEERING 195

NAVAL ARCHITECTURE 50

Student Activities

Besides learning and fulfilling other obligations, students at the Faculty actively participate in cultural and sport life.

Particularly, through dedicated course, students can engage in football, basketball, swimming, rowing, volleyball, etc. Various sport competitions take place at the University of Split and more widely, like regional student competition "**Elektrijada**" in sports and knowledge domain.

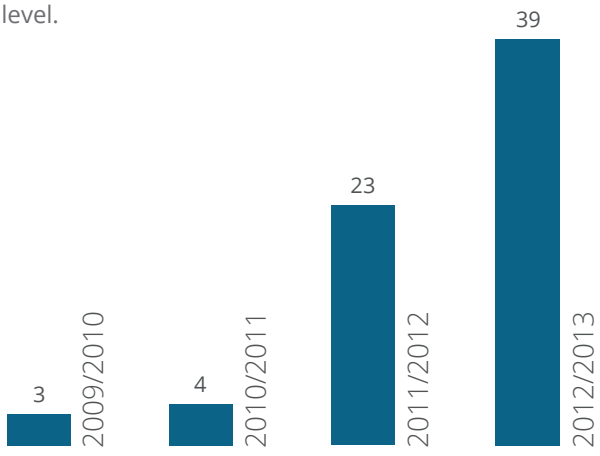
There is other broad range of activities, like work on the student radio "**STOP FM**", student magazine, occasional drama and singing groups.

The Faculty encourages and supports various student projects, like work of association of students of Mechanical Engineering (**UPS**). This group of students had a project to design and build "**Student Formula**". After successful completion of the project, the formula was selected and contested at the international competition of alike student projects. The UPS group have publicly presented the formula in many occasions, contributing to visibility of the Faculty and University of Split. Another example is an **Association of young computer programmers (DUMP)**. This enthusiastic group organizes different courses and competitions for young programmers. DUMP themselves had participated, with excellent results, in competitions like "**Microsoft Imagine Cup**". In collaboration with the Faculty, the group had designed and created various IT systems, like electronic evidence of courses attendance for students, automatic student admission for the following academic year and the Faculty webpages.

Student Mobility

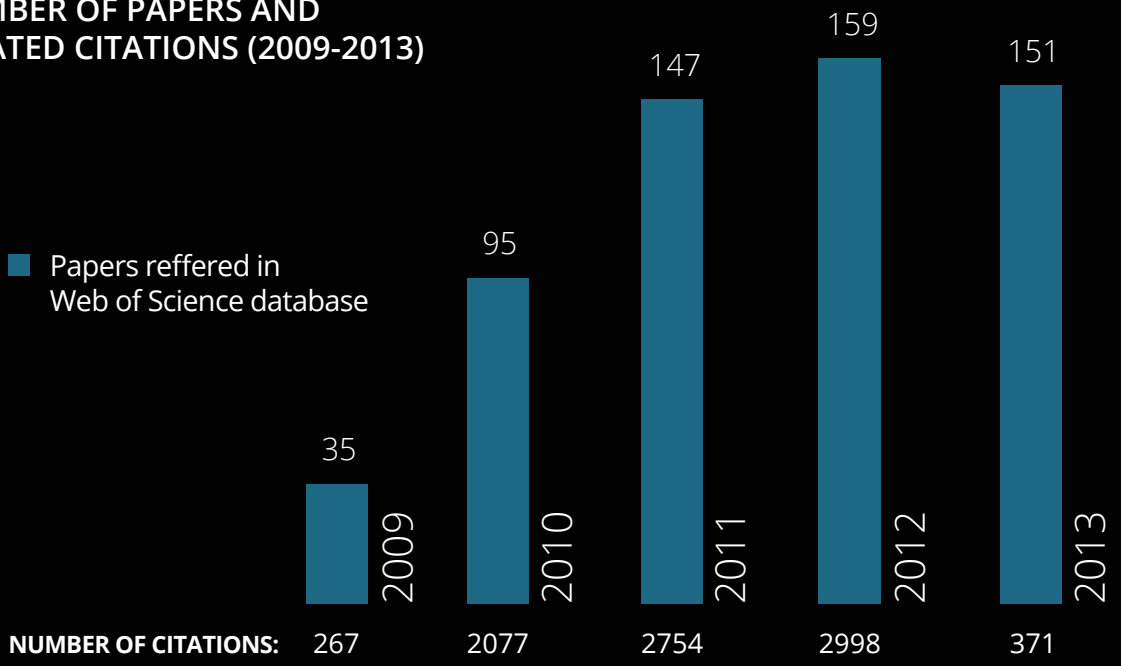
Internal mobility of students at university and vocational studies level is provided by recognizing the ECTS credits earned in some other related courses and curricula. Students having completed related undergraduate studies are eligible for enrolling graduate studies, though they may need to earn some additional credits. Students who intend to continue, upon completing vocational studies, with corresponding graduate university studies, will have to fulfil one-year difference program to acquire additional ECTS credits, knowledge, competences and skills required for studies at the university level.

External mobility is organized, apart from common ERASMUS programme, through the international students' association IAESTE. Every year 10 FESB students spend 6 to 10 weeks abroad through the IAESTE programmes, and, at the same time, 10 foreign students from abroad spend some time at FESB.



Students mobility from 2009 to 2013

NUMBER OF PAPERS AND RELATED CITATIONS (2009-2013)



CONFERENCES IN 2012 AND 2013

SoftCOM	LHC Days in Split	MTSM
BEM / MRM 2012	Heat Transfer 2012	AFM 2012
Renewable Energy Sources New Technologies-Challenges of the 21st Century	IEEE Symposium on Computers and Communications	

Research and Professional Activities

In 2012 and 2013, FESB researchers participated on various national and international research projects, as well as, several technological and professional projects (about 70 projects in total). Furthermore, there is on-going collaboration with many national and international academic and research institutions. Consequently, the results stemming from the intensive research activities have been reported in about 310 scientific papers in journals listed in Web of Science (WoS) with more than 3300 citations.

Furthermore, in 2012 and 2013 the Faculty was a co-organizer of a number of scientific or professional conferences, symposia, workshops, and summer schools, such as:

- 20th and 21st International Conference on Software, Telecommunications and Computer Networks – SoftCOM (organized every year since 1991),
- 18th IEEE Symposium on Computers and Communications
- 8th Large Hadron Collider (LHC) Days in Split (organized every two years since 1996),
- 34th International Conference on Boundary Elements and other Mesh Reduction Methods (BEM/MRM 2012)
- 9th International Conference on Advances in Fluid Mechanics (AFM 2012)
- 12th International Conference on Simulation and Experiments in Heat Transfer and their Applications (HEAT TRANSFER 2012)
- 3rd and 4th International Conference Mechanical Technologies and Structural Materials (organized every two years since 2010)
- Renewable Energy Sources, New Technologies-Challenges of the 21st Century

The results arising from long-term successful and fruitful collaboration with industry are visible through many consultancies, technological projects, studies and reports. Also, a number of long-term cooperation contracts and agreements has been signed in the area of research and development activities with companies and institutions such as: Croatian Electric Power Utility, Ericsson Nikola Tesla, Končar, Siemens, Croatian Telecom, Institute “Hrvoje Požar”, the Split Shipyard, CEMEX, Light Metals Factory in Šibenik, Split-Dalmatia County, City of Split, and many others.

Projects and International Collaboration

FESB has a multidisciplinary profile, offering the studies of Electronics, Electrical Engineering, Computing, Mechanical Engineering, Naval Architecture and Industrial Engineering, thus positively influencing the content and quality of research and technological projects at the Faculty. Some of the projects were supported by national funds available from the Ministry of Science, Education and Sport, or some other financing sources. There have been also some international projects or bilateral projects in cooperation with foreign institutions. This work has resulted in:

- the development of existing and establishing of new research laboratories
- establishing of new laboratories,
- acquisition of equipment,
- scientific publications as follow-ups to these projects.

The projects content and research topics vary from fundamental through applicative to integrative and multidisciplinary ones.

Rather wide range of research topics is covered, from IT projects through biomechanics, bioelectromagnetism, renewable and new sources of energy, wireless communications, impact of modern technologies on the environment, monitoring and environment protection system, to various aspects of power engineering and mechanical engineering and cutting-edge research topics such as the search for the Higgs boson or nuclear fusion as a source of energy related research.

The quality of work and the results achieved on these projects are visible through publications referred in the Web of Science (WoS) database.

Many Faculty employees were engaged or are still active in numerous projects and were visiting professors and researchers at international universities and institutes. Researchers from FESB collaborated or were leaders of various either international or bilateral projects such as the Croatian-Slovenian, Croatian-French, FP6 Marie Curie, FP7 as well as: COST, ALIS STATES, CEEPUS, COGITO; CMS and ALICE at CERN, Code development for integrated modelling within EuroFusion Consortium, EGEE II, MAGIC and several TEMPUS projects.

26 MZOS projects	7 Bilateral projects	5 TEMPUS projects
5 Collaborative	1 CSF project	1 FP7 projects (participants)

Impact on Society

Due to its multidisciplinary nature, through various technological and professional projects FESB has a profound impact on the entire development in the region. In the last few decades FESB research groups have carried out many professional studies for companies such as Croatian telecommunications, Croatian power company, Split shipyard, Split-Dalmatian County, and many others.

Professional and technological studies are related to IT, renewable sources of energy, lightning protection systems, wireless communications, electromagnetic compatibility, mechanical engineering, power engineering, impact of modern technologies on people and environment, monitoring and environment protection systems, etc.

The results of FESB professional projects are related to various projects in mechanical engineering, then for the development of early fire detection system, projects related to acoustics, etc. The production of a larger number of software packages implemented in engineering practice is a natural follow-up of the FESB professional activity.

HEP d.d.
ERICSSON Ericsson Nikola Tesla d.d.
Microsoft
SIEMENS
AD Plastik
spica
trovicor
Adria Winch
profico
MANAS
KRON
Zračna luka Split
GRAD SPLIT
SPLITSKO-DALMATINSKA ŽUPANIJA
HSTec HIGH SPEED TECHNIQUE
EIHP
ABB
BRODOSPLIT

International Links and Staff Mobility

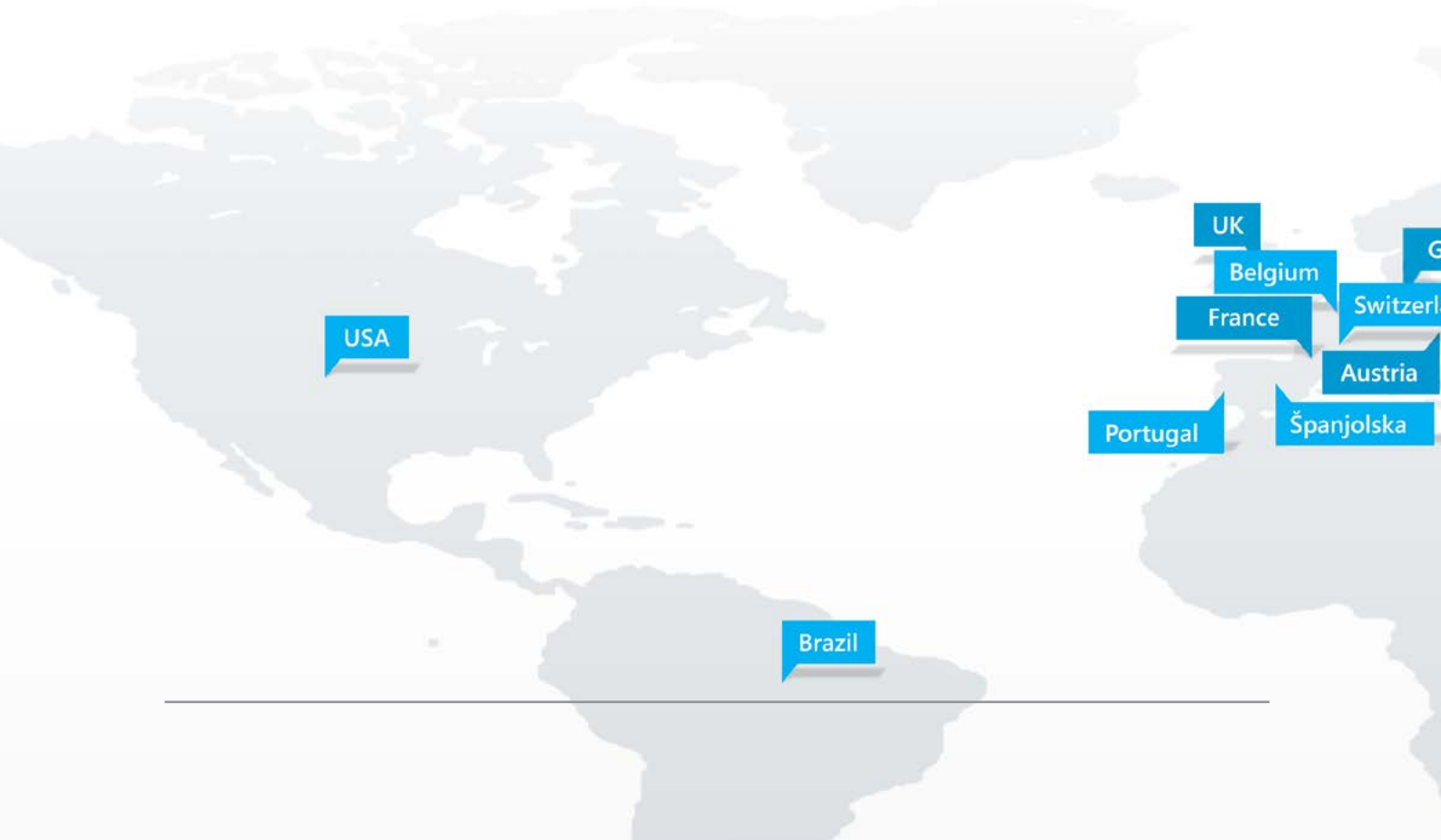
The continuous rise of international collaboration and establishing various international links enables the following achievements:

- opportunity for FESB students to complete a part of their study at foreign universities;
- possibility for foreign students to complete some courses at FESB;
- encouraging the mobility of educational staff by supporting short-term and long-term stay, respectively at foreign institutions;
- providing the transfer of knowledge and technology through collaboration with foreign academic institutions, as well as with foreign industrial strategic partners;
- participating international research projects.

International collaboration has been very active and rather diversified through institution networking, thus continuously contributing to the FESB international recognition.

In particular, there is a lot of highly developed collaboration on the level of individual researchers, which has not been officially established by documents such as Memorandum of Understanding, Collaboration Agreement etc. Such collaboration is visible from a number of relevant publications co-authored by FESB and foreign researchers, respectively.

Also, there are many collaboration agreements being signed between FESB and many respectable institutions.



In particular, in 2012-13 the collaboration agreement was signed with:

- Blaise Pascal University, Clermont-Ferrand, France
- Fraunhofer ISE, Freiburg, Germany
- University of Nottingham, Nottingham, UK
- Politecnico di Bari, Bari, Italy
- University of Aachen, Aachen, Germany

The mobility of the FESB educational staff is achieved through a number of international projects, such as TEMPUS projects, bilateral agreements and mobility schemes (ERASMUS). The cooperation of the FESB employees and foreign academic institutions is traditionally very intensive, particularly at individual level. The majority of FESB researchers are members of international professional and scientific associations (e.g. Institute of Electrical and Electronics Engineers – IEEE, Union of Radio Science – URSI, International Society of Boundary Elements – ISBE, etc.).

OVERVIEW OF **RESEARCH ACTIVITES**

TECHNICAL SCIENCES

NATURAL SCIENCES

HUMANITIES

TECHNICAL SCIENCES

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Advanced Networking Technologies and Systems

GROUP LEADER
Dinko Begušić
Full Professor

Nikola Rožić
Professor Emeritus

Mario Čagalj
Associate professor

Milutin Kapov
Associate professor

Joško Radić
Assistant Professor

Josip Lorincz
Postdoc

Toni Perković
Postdoc

Petar Šolić
PhD student

CONTACT INFO
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RESEARCH INTERESTS AND TOPICS

networking technologies

network and system security

signal processing

communications software

Research interests of the research group for advanced networking technologies and systems include: advanced networking technologies, network and system security, internet of things, wireless networks, optical networks, heterogeneous networks, wireless sensor networks, green networks, signal processing, information processing, communications software, platforms and services, communications software engineering, mobile computing, positioning and location based services, channel coding, multicarrier modulations and protocols.

DESCRIPTION OF LABORATORIES

The group has established 4 research laboratories: Laboratory for advanced networking technologies, Laboratory for network and system security, Laboratory for digital signal processing, and Laboratory for RFID technology. Laboratory for advanced networking technologies is equipped with computers and laptops, communications equipment including routers, switches, and WLAN access points (IEEE 802.11b/g/n). Laboratory for digital signal processing is equipped with computers and laptops, LabView and MATLAB software. Laboratory for RFID technology is equipped with different High Frequency (HF) and Ultra High Frequency (UHF) RFID readers, HF and UHF signal generators, spectrum analyzer, and software defined radios. The group is a cofounder of the joint research laboratory with the company Ericsson Nikola Tesla.

Laboratory for advanced networking technologies

THE GROUP AT A GLANCE

NETWORKING AND INFORMATION PROCESSING

Research activities in the area of networking and information processing during the two last years have been focused on heterogeneous wireless networks, energy savings in wireless networks, and software architecture for telecom systems.

A model of cooperative position determination by combining the estimates obtained in the heterogeneous wireless network based on Bayes method has been proposed. RF localization method for indoor environments has been introduced.

Green networking

We carried out the research in possible energy savings of the wide area cellular networks (2G, 3G, 4G) through development of integer linear programming (ILP) models. Effectiveness of ILP models based on energy-efficient management of network resources has been tested on several cellular network instances. The proposed optimization models offer significant energy savings on a yearly level of complete cellular network. Also, we have analyzed impact of the service data rates and base station switching granularity on the energy consumption of cellular networks.

Furthermore, we have conducted the research in the area of measurements and modeling of base station power consumption under real traffic loads. Proposed models precisely capture interdependence between instantaneous power consumption of macro base station sites and traffic load variations. Possible energy savings based on renewable energy sources for power supply of the base station sites have also been considered. We perform analyses in terms of the area energy efficiency and bit per joule energy efficiency of a heterogeneous macro and micro base station sites.

Communications software

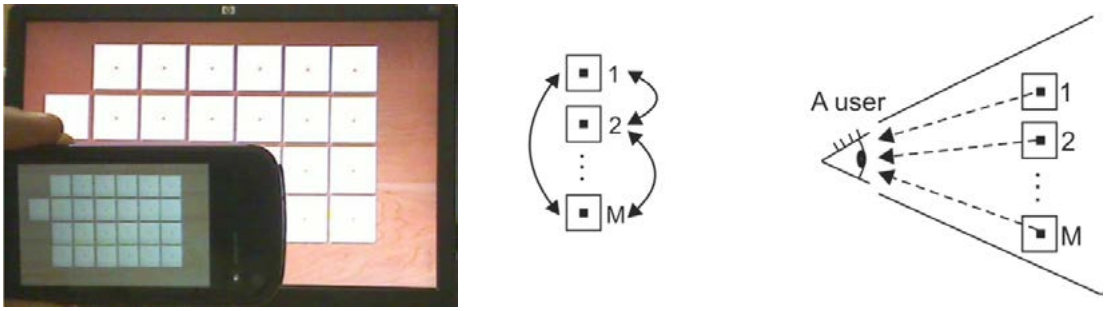
A research in the area of telecommunications management networks has been focused on development of the integrated system for operational and business support (OSS/BSS) based on eTOM architecture. The proposed system has been implemented and tested.

SECURITY

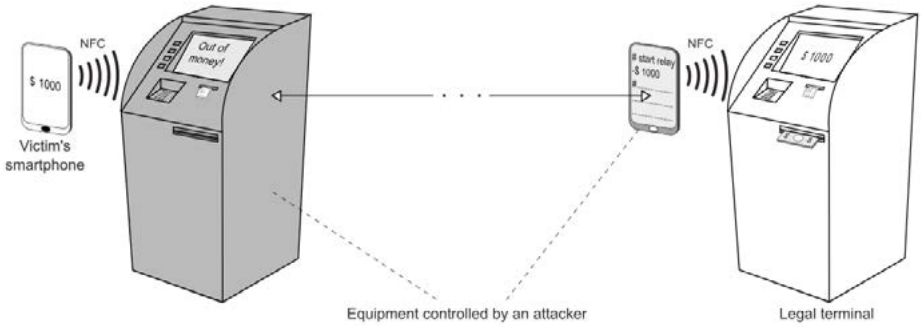
Recent research activities of the security group span the following two major areas: user-friendly authentication and security against relay attacks. We conducted our research in close collaboration with several international groups and researchers, namely, Nitesh Saxena (University of Alabama, Birmingham, USA) and Shujun Li (University of Surrey, Guildorf, UK). WE also have a collaboration with Ericsson Nikola Tesla company in the area of the security of future machine-2-machine (M2M) systems.

Usable and user-friendly authentication services

We created a successful timing attack on a secure authentication method based on nonuniform human behavior. A



A solution that allows user-unaided initialization of a relatively large number of wireless devices



A protocol for relay attacks developed for financial transactions

paradigm was designed that can be followed in the design and performance evaluation of any future secure authentication methods.

Solution against relay attacks

We designed a protocol against relay attacks developed for financial transactions and proved its security in a formal model. The proposed solution presents user-friendly protocol that operates on the application layer and does not require any significant hardware changes to the existing equipment.

WIRELESS SYSTEMS AND THE INTERNET OF THINGS

Multicarrier and multichannel communications

Research includes fundamentals in communications including information theory, channel coding, multicarrier modulations and protocols. Specifically, we investigate Orthogonal Frequency-Division Multiplexing (OFDM) systems. Rigorous performance evaluation of OFDM systems affected by impulse noise is important for different areas, including channel coding in wired and wireless systems, the throughput analysis, rate selection methods and ARQ for OFDM-based WLANs and Multiple-Input and Multiple-Output (MIMO) systems. Research also includes reduction of the Peak-to-Average Power Ratio (PAPR) in OFDM systems includes development of the new iterative algorithms based on Minimum Mean Square Error (MMSE) method for the estimation of the clipped signal. In the area of the synchronization in the OFDM system, research group works on development of the algorithm for estimation of the carrier frequency offset (CFO) and sampling frequency offset (SFO). The research on this subject has been carried out in a close collaboration with the research group from the Polytechnic University of Marche.

Radio Frequency identification (RFID) technologies

In the area of RFID systems the research includes passive and battery assisted RFID tag technologies. We investigate methods for increasing the tag reading range and a confidence in tag reading in a harsh environments. Particularly we consider development and implementation of active backscattering tag technology designed within the current RFID standards which significantly improves tag reading range and confidence. To improve tag reading range we investigate using of HF and UHF remote tag powering and probabilistic modeling of the possible amount of the energy that could be harvested and used for RFID tag powering.

HIGHLIGHTS

The main research activity during the last two years has been pursued within two projects of the Ministry of science, education and sports: “Advanced heterogeneous networking technologies” (project leader Dinko Begušić) and “ICT systems and services based on the information integration” (project leader Nikola Rožić)

A PhD dissertation titled “User Friendly Authentication Mechanisms in User-to- Device and Device-to-Device Interactions” by Toni Perković has been successfully completed under the mentorship of Mario Čagalj.

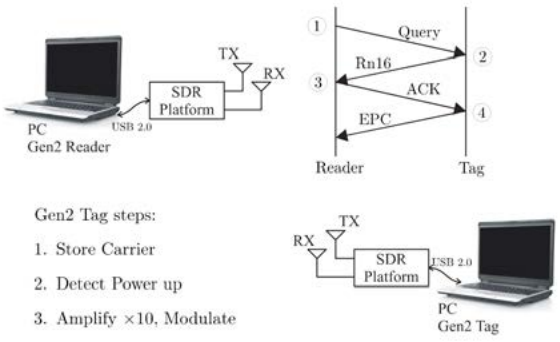
Publications

During the last two years the group has published 7 journal papers referred in CC or SCI databases, 3 other journal papers and 8 conference papers.

Besides that the group contributed to publication of two conference proceedings and three workshop proceedings,

GSM powered RFID UHF passive tag

Measurements setup with the communication system block scheme. For performance measurements, SDR RFID reader was used on one side and the developed SDR tag on another side.



Organization of conferences and journal publishing

Jointly with the group for EMC, the group takes part in organization of the international conference on Telecommunications, Software and Computer Networks SoftCOM. The conference has been technically cosponsored by the IEEE Communications Society. Nikola Rožić and Dinko Begušić serve as co-chairs of the TPC, Joško Radić serves as the finance chair, and Petar Šolić as the conference secretary.

Josip Lorincz has organized special sessions at SoftCOM 2012 and SoftCOM 2013 conferences dedicated to green networking and computing in collaboration with ANT (Advanced Network Technologies) Laboratory of the Politecnico di Milano. He also served as the guest editor for the He also served as the guest editor for the International Journal of Business Data and Communications and Networking.

The group supports publishing of the Journal on Communications Software and Systems (JCOMSS). JCOMSS has been indexed in Scopus, INSPEC, and EBSCO databases. Nikola Rožić and Dinko Begušić serve as Editors in Chief of JCOMSS. Josko Radic was guest editor for the special issue on RFID systems and the Internet of Things. During the two year period 8 issues of the JCOMSS have been published.

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3. J. Lorincz, **Energy-efficient wireless cellular communications through network resource dynamic adaptation**, *International Journal of Business Data Communications and Networking (IJBDCN)* (1548-0631) 9 (2013), 2; 11-26
4. J. Lorincz, I. Bule, **Renewable energy sources for power supply of base station sites**, *International Journal of Business Data Communications and Networking (IJBDCN)* (1548-0631) 9 (2013), 3; 53-74
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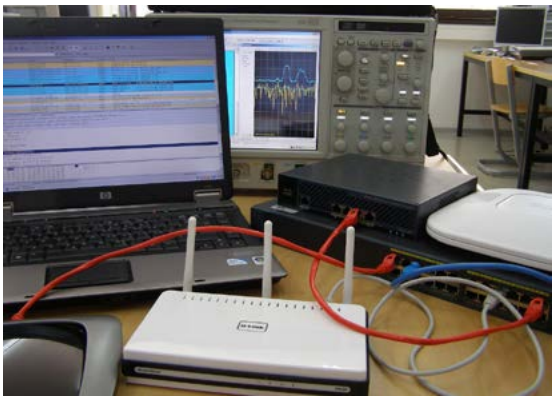
6. M. Russo, M. Stella, N. Rožić, **Noise reduction in speech signals using a cochlear model**, *Advances in Smart Systems Research* (2050-8662) 2 (2012), 1; 7-12
7. J. Lorincz, A. Capone, D. Begusic, **Impact of service rates and base station switching granularity on energy consumption of cellular networks**, *EURASIP Journal on Wireless Communications and Networking* (ISSN: 1687-1499), 2012 (342), 2012, stranice: 1-44
8. T. Perković, M. Čagalj, T. Mastelić, N. Saxena, D. Begušić: **Secure Initialization of Multiple Constrained Wireless Devices for an Unaided User**, *IEEE Transactions on Mobile Computing* (ISSN 1563-1233), IEEE Computer Society, Vol. 11, No. 2, 2012.
9. M. Stella, M. Russo, D. Begušić, **RF Localization in Indoor Environment, Radioengineering**, *Special issue on advanced RF measurements* (ISSN 1210-2512), Vol 21, No. 2, 2012, pp. 557-567
10. P. Šolić, J. Radić, N. Rožić, **Software Defined Radio Based Implementation of RFID Tag in Next Generation Mobiles**, *IEEE transactions on consumer electronics* (0098-3063) 58 (2012), 3; 1051-1055



Experimental setup for WLAN protocol analysis

Cover pages of the SoftCOM 2013 proceedings and Journal of Communications Software and Systems

Development and Implementation of Methods for Bio-Systems and Environments Identification

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RESEARCH INTERESTS AND TOPICS

measurement and analysis of human motion

optical motion capturing systems

3D scanners for anthropometric measurements

EEG signal analysis and classification

machine learning algorithms for bio signal identification

intelligent video based audience measurement system

video tracking and identification

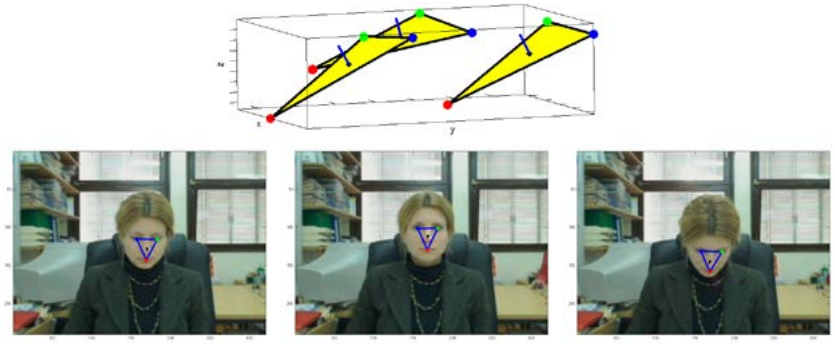
superresolution

vision based robot control

DESCRIPTION OF LABORATORIES

A research group for ***Development and Implementation of Methods for Bio-Systems and Environments*** Identification at the Department of Electronics, with the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split deals with development of measurement and analysis systems for biomedical engineering based on innovative technologies such as optical motion capturing systems, 3D scanners for anthropometric measurements, EEG signal analysis and classification, asthma monitoring, intelligent video based audience measurement systems, video tracking and identification, and vision based robot control.

The group has established 2 research laboratories: **LaMLBI** (*Lab for Machine Learning Based Identification*) and **LaViBC&BCA** (*Laboratory for Vision Based Control and Biomedical Signal Analysis*), and also colaborates with **LABACS** (*Laboratory for Biomechanics and Automatic Control Systems*) and **LARIS** (*Laboratory for Intelligent Systems and Robotics*).



Triangular face model - Head pose recovery for pitch head pose variation

THE GROUP AT A GLANCE

Activities of the Group for Development and Implementation of Methods for Bio-systems and Environments Identification can be divided in following research areas:

Machine learning algorithms for bio-signal identification

The research has been oriented toward various bio signals analysis (EEG, auscultation) in which characteristic features have to be extracted for the classification purpose.

- EEG signal: The aim was to find a feature that represents the time sequence of a signal according to the physical meaning of the sleep stage we wanted to identify the signal with. Our hypothesis was that features that better describe sleep stage specificities could be extracted from a signal if it was decomposed into components that reflected the true physical processing. Thus, the kernel is not known in advance and the nature of the signal is acquired by applying the appropriate decomposition mode. The sleep stage classification, based on the novel feature vectors of a single EEG channel, was applied for the daytime sleep of 20 healthy babies using the Support Vector Machine (SVM) classification algorithm.
- Auscultation signal: accelerometer data have been used for acquiring the signal of breathing in which a specific melodic tones in the respiratory sound called weezing imply the asthma attack and could be successfully classified using machine learning algorithms.

Vision based robot control

There are several schemes for vision based robot control. The main research interests are image based visual servoing techniques applied to calibration and model free robotic system. Such systems have been widely applicable in robot vision due to minimal requirements related to calibration and robot kinematic's parameters.

Other techniques assume gesture based robot control using Kinect as a motion sensing input device and development of a robot control activities using a distributed video monitoring system.

Image superresolution

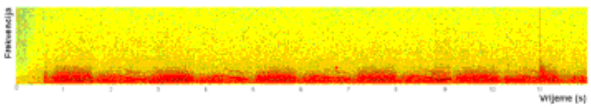
The main interest has been oriented toward a hierarchical Bayesian framework, in which the reconstructed HR image, the acquisition and motion estimation noise for each LR image is estimated simultaneously. Variational inference is applied to estimate the posterior distributions of the unknowns. Of particular interest is that the model parameters are estimated during the reconstruction so that the algorithm is fully automated.

Biomechanics and motion analysis

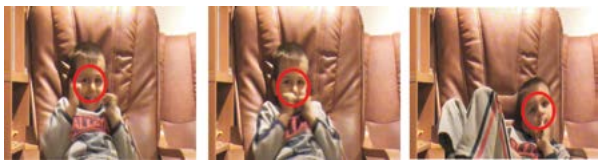
Several systems and methods dealing with biomechanics of human motion have been developed and tested:

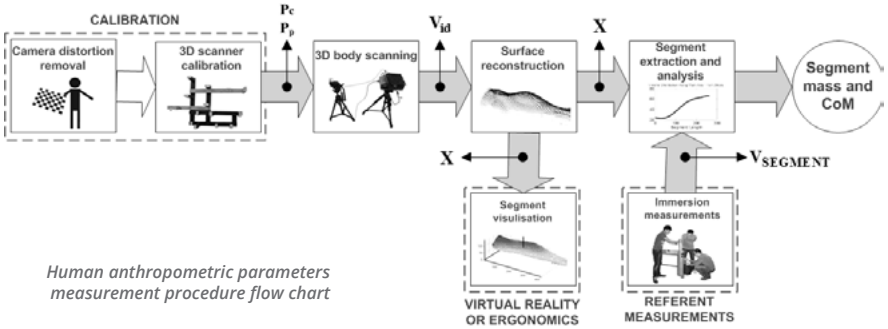
- Computer vision based system for human anthropometry estimation (structured light 3D scanners) which enables personalized approach to human motion analysis and more accurate calculation of joint forces and moments
- Human kinematics optical measurement system which uses high-speed cameras and active markers has been developed. New parameters that would quantitatively and objectively classify human motion, especially human gait, enabling detection and classification of gait abnormalities are proposed and tested.
- A method has been developed that estimates head pose from uncalibrated monocular images. The approach addresses the problem of 3D configuration reconstruction of head using 2D spatial information of locations of facial features in images and anthropometric parameters of face, based on a weak perspective projection model of camera and a triangular face model.

2D spectrogram of the auscultation signal with noticeable specific melodic tones in the respiratory sound called weezing



Automated computer vision-based system for TV viewer's identification





Human anthropometric parameters measurement procedure flow chart

Visual tracking and identification

Vison-based tracking systems are cost-effective counterparts of commercial optoelectronic tracking systems. General purpose video tracking algorithms based on collaborative tracking and machine learning methods are researched, with the aim to provide adaptive and robust tracking results in natural scene environments.

Intelligent video based audience measurement system

In order to provide passive and objective measurements for TV audience rating, an automated computer vision-based system capable of identifying viewers and quantifying the viewers watching behavior is investigated. Research efforts are oriented towards defining adequate measures for quantifying attentive audience behavior and developing illumination invariant detection and tracking algorithms.

INTERNATIONAL COLLABORATIONS

There group maintains strong links with Faculty of Electrical Engineering, University of Ljubljana, Slovenia, as well as several other institutions like University of Roma Tre, Italy, Czech Technical University in Prague, Czech Republic, and University of Reading, UK. Forms of collaboration include joint research work, publishing scientific and professional publications, writing of bilateral and multilateral project proposals, etc.

HIGHLIGHTS

In the last two years the Group was involved in one national project. Also, last year (2013) the group has received the project grant entitled as Asthma alarm attack, approved by Business Innovation Croatian Agency (BICRO).

There were four PhD Viva in the period from the beginning of 2012. to the end of 2013, Maja Cic (July/2012), Ivo Stančić (December/2012), Ana Kuzmanić Skelin (June/2013), Barbara Džaja (July/2013).

SELECTED REFERENCES

The results having come out of the last 2 year period are documented in various publications. Some selected references are given:

Journal papers (CC, SCI, or SCI Expanded) (7)

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Džaja, Barbara; Bonković, Mirjana; Malešević, Ljubomir. **Solving a two-colour problem by applying probabilistic approach to a full-colour multi- frame image super-resolution**. *// Signal processing. Image communication*. 28 (2013), 5; 509-521

Stančić, Ivo; Grujić, Tamara; Panjkota Ante. Design, **Development, and Evaluation of Optical Motion-Tracking System Based on Active White Light Markers**. *// IET Science, Measurement & Technology*. 7 (2013), 4; 206-214

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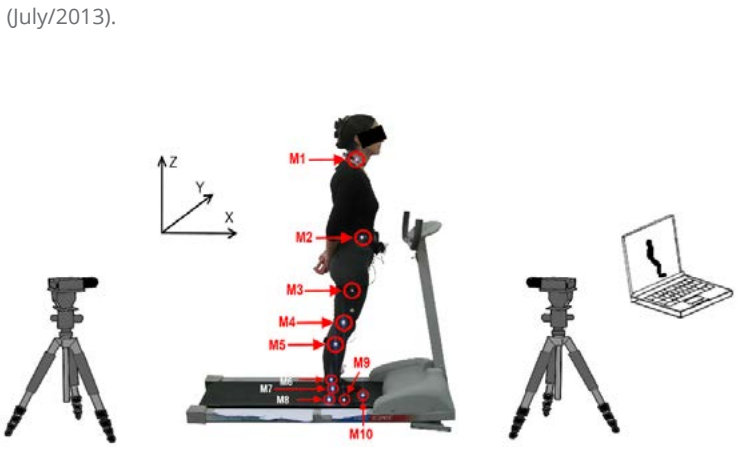
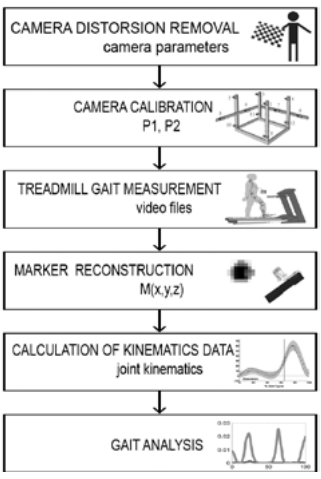
Vucinovic M, Kardum G, Bonkovic M, Resic B, Ursic A, Vukovic J. **Sleep EEG Composition in the First Three Months of Life in Monozygotic and Dizygotic Twins**. *Clin EEG Neurosci*. 2013 Dec 9, in press, DOI:10.1177/1550059413497000.





(left) Optical motion – capturing system consisted of two fast cameras and active markers
(right) flow chart of measurement and analysis of human gait

Computational & Information Systems (CIS)

GROUP LEADER
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Eugen Mudnić
Assistant Professor

Linda Vicković
Assistant Professor

Žarko Rnjak
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RESEARCH INTERESTS AND TOPICS

document management systems

HPC (high performance computing) in science and industry

software development methodologies

software estimation techniques

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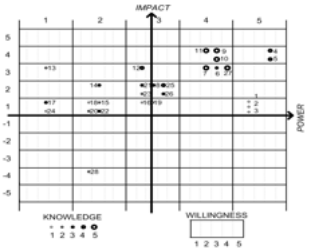
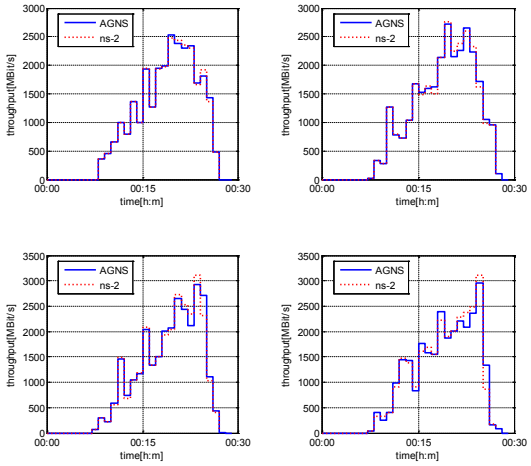
A research Group for Computational & Information Systems at the Department of Electronics, with the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split deals with advanced organizational and architectural concepts of computational and information systems.

In addition to faculty group members, Prof. Gotovac is currently supervising five PhD students (one from university and four from industry), while Prof. Čelar is supervising four PhD students (two from university and two from industry) and Prof. Vicković one from the university.

The Group has established a “Computer architecture and operating systems lab”. Laboratory is equipped with computers with different operating systems and virtualization platforms devoted to research activities on the computer systems interoperability and virtualization platforms.



4D stakeholder analysis (4DSA) for PIVIS ERP project.



Results of ANFT (approximate network file transfer) simulation compared to ns-2 simulator

THE GROUP AT A GLANCE

Activities of the Group for Computational & Information Systems can be divided in following areas of fundamental and applied research areas:

FUNDAMENTAL RESEARCH

Simulation of Emergent Computational Systems

Simulation as a means for modelling, performance analysis as well as implementations and analysis of algorithms before deployment in emerging HPC computational systems (Grid computing, Cloud computing, mass storage systems).

Document management systems for new computing architectures

Research of a new computing architectures and their applicability on document management systems.

Software engineering

Research of advanced software engineering concepts and their influence on business processes. Of particular interest are topics related to software development methodologies and software estimation techniques.

APPLIED RESEARCH

Cooperation with the CERN Alice offline group

The members of this group are active part of ALICE Collaboration at CERN where they are working on parallel and distributed high performance computing systems applied to scientific (physics) problems. As a result they are co-authors of many papers published by ALICE Collaboration.

Cooperation with Government Institution e-Croatia and Local Government

Research group took part in setup of the Croatian e-Government framework in cooperation with Croatian Department for e-Development – e-Croatia. In cooperation with Local Government (Split Dalmatia County) the Group founded centre for software research and development. The main goal of joint projects is to research new software architectures and to develop new software solutions for governmental bodies based on Open Source solutions. Result of three years research is complete implemented distributed Electronic Document Management System based on three tire software architecture and Open Source components.

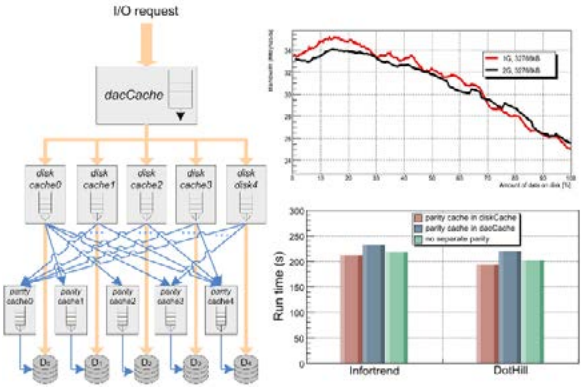
Cooperation with Industry

In cooperation with local large enterprise MIB Pivac the Group is working on the long term project with the goal to basic research in SW engineering relating to development methodologies (SW planning, development methodologies, SW quality). Result of group's research is distributed ERP information system that is installed in some SME companies at almost200 locations across the Croatia and neighbourhood countries. Possibility of cooperation with Infineon Technology Villach Austria in the field of mixed and digital circuits design is also considered.

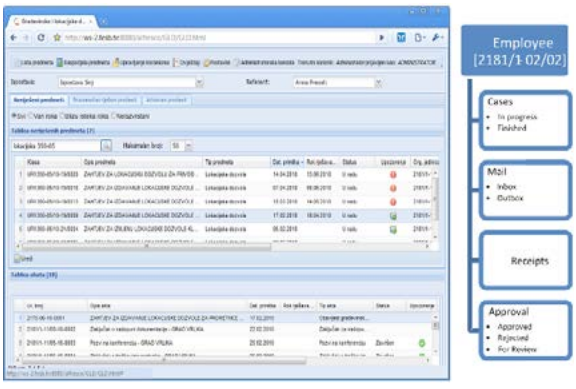
INTERNATIONAL COLLABORATION

The Group has active collaboration with several European research groups. The most intensive collaboration is established with the following institutions:

1. ALICE offline computing group – CERN - The European Organization for Nuclear research, Switzerland
2. Distributed Systems Group, Information Systems Institute – Vienna University of Technology, Austria
3. Software Engineering Group, University of Paderborn, Germany.



Disk array simulation model with parity cache on disk cache level. The simulation runtime comparison between three different simulation models regarding the position of parity cache.



A screenshot of the document management system developed for the Split-Dalmatia county. Besides the electronic mail, each employee has access official documents (grouped in cases), receipts and a set of folders used for document approval workflow. System is based on open source Alfresco DMS, but is highly extended, especially on the presentation layer where completely new GUI is developed.

4. Infineon Technology Villach Austria – Mixed and Digital Circuits Design.

Forms of collaboration include joint research work, co-mentoring of diploma and PhD thesis, publishing scientific and professional publications, writing of bilateral and multilateral project proposals, etc. This is evident from the number of joint publications (papers referenced in CC databases and books), bilateral and multilateral projects.

HIGHLIGHTS

The group members played key roles in organizing "The IEEE symposium on Computers and Communication ISCC 2013 - Split". The group has intensified cooperation with local computing industry in the fields Big Data, document management and SW engineering. Also, it is planned in cooperation with Infineon Villach Austria, a project in the field of digital circuits design.

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The results having come out of the 2 year research period are:

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5. Klarin, Karmen; Čelar, Stipo. **Ontology-based knowledge management approach for information system development** *// Proceedings of Telecommunications Forum (TELFOR)* / George Paunovic (ur.). Beograd: IEEE, 2013.; 805-808
6. Radić, Ivica; Čelar, Stipo. **Prijenos podataka između povezanih poslužitelja u virtualnom okruženju** *// CARNET CUC 2013 Zbornik radova* - ISBN 978-953-6802-96-8. Zagreb, 2013.
7. Abedev, B....; Antičić, Tome; Gotovac, Sven; Mudnić, Eugen; Planinić, Mirko; Poljak, Nikola; Simatović, Goran; Šuša, Tatjana; Vicković, Linda; et al. **Performance of the ALICE VZERO system**. *// Journal of Instrumentation*. 8 (2013); P10016-1-P10016-24.
8. Abedev, B....; Antičić, Tome; Gotovac, Sven; Mudnić, Eugen; Planinić, Mirko; Poljak, Nikola; Simatović, Goran; Šuša, Tatjana; Vicković, Linda; et al. **Energy dependence of the transverse momentum distributions of charged particles in pp collisions measured by ALICE**. *// European physical journal C: particles and fields*. 73 (2013); 2662-1-2662-12
9. Abedev, B....; Antičić, Tome; Gotovac, Sven; Mudnić, Eugen; Planinić, Mirko; Poljak, Nikola; Simatović, Goran; Šuša, Tatjana; Vicković, Linda; et al. **Charmonium and e + e − pair photoproduction at mid-rapidity in ultra-peripheral Pb–Pb collisions at sNN−−−−√=2.76 TeV**. *// European physical journal C: particles and fields*. 73 (2013); 2617-1-2617-18.
10. Abedev, B....; Antičić, Tome; Gotovac, Sven; Mudnić, Eugen; Planinić, Mirko; Poljak, Nikola; Simatović, Goran; Šuša, Tatjana; Vicković, Linda; et al. **Multiplicity dependence of the average transverse momentum in pp, p–Pb, and Pb–Pb collisions at the LHC**. *// Physics letters*. B. 727 (2013); 371-380.
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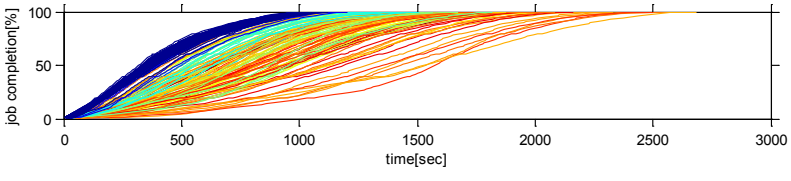

Estimating expected completion times with probabilistic job scheduling

Digital Systems and Computer Networks

GROUP LEADER
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Full Professor

Vesna Pekić
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Ante Kristić
Postdoc

RESEARCH INTERESTS AND TOPICS

flow control and QoS

wireless computer networks and MAC protocols

protocol modeling and simulation

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DESCRIPTION OF LABORATORIES

The research laboratory for Computer Networks Laboratory has:

- Cisco router 1841-SEC/K9
- Cisco switch WS-C2960-24TT-L
- HP switch ProCurve 2626 J4900B
- D-link firewall DFL-200
- Planet switch WSD-800
- Planet AP/router WRT-414
- Planet WLAN WL-u356a

The research laboratory for Digital Systems Laboratory has:

- Xilinx Spartan-3e FPGA
- Xilinx CoolRunner-ii CPLD
- Analog Devices Blackfin BF533 DSP
- Analog Devices Blackfin BF537 DSP
- Tektronix digital oscilloscope
- HP 8012 pulse generator
- ALL-100 programmer
- ALL-11 P2 programmer
- ALL-03 programmer
- DELAB1 laboratory model

THE GROUP AT A GLANCE

Activities of the Group for Digital Systems and Computer Networks can be divided into two main categories: QoS assurance and wireless networks research.

FLOW CONTROL AND QOS

Integration of different kinds of services, from data to real-time services, is the main motivation for enforcing QoS on the Internet. Unfortunately, the most widely spread transport layer protocol of the Internet, TCP, is not suitable for the integration with real-time services. The integration of different kinds of services on the Internet can be solved using QoS strategies on access networks. An alternative flow control (AFC) more suitable for achieving QoS on the access network has been suggested, without changes to the TCP/IP protocol stack on the core Internet network. In order to connect the technology used on the access network with the technology used on the core network, a flow control proxy is introduced to control their interaction. This is a distributed and potentially inexpensive solution, as well as suitable for incremental deployment.

WIRELESS NETWORKS

In modern wireless ad-hoc networks, with a high speed PHY, every collision means a significant loss of useful bandwidth. Reduction of collision rates comes with the price of increased protocol overhead, which includes time spent on medium contention. Furthermore, wireless MAC protocols performance depends on its parameter values and offers optimal results only in some network scenarios (e.g. for a certain number of active stations in the network). It is of interest to develop protocols that offer low collision rates while keeping the overhead small, and provide good results in the various network scenarios.

HIGHLIGHTS

In the period of 2012-13, the research of the Group for Digital Systems and Computer Networks has resulted in two PhD Vivas, V. Pekić and I. Kedžo.

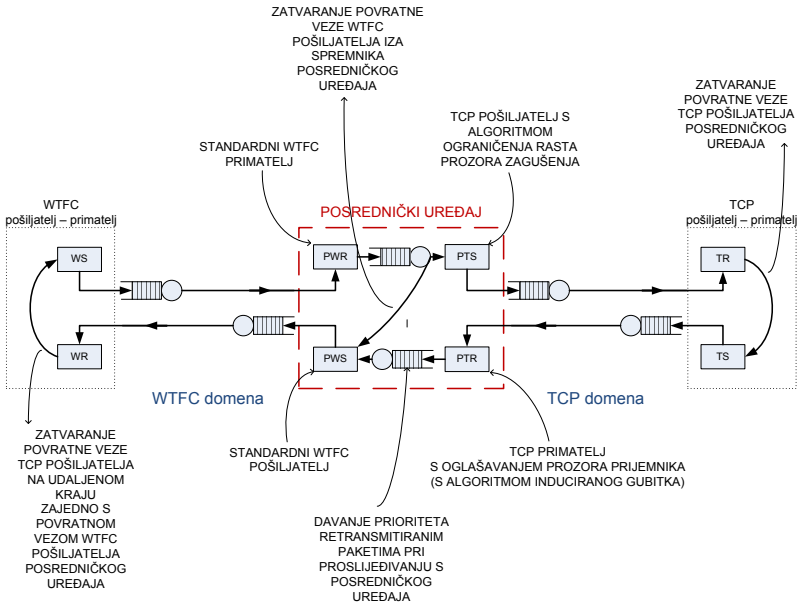
A new Performance Enhancing Proxy was developed that yields similar throughput compared with the standard TCP flow control, while QoS parameters, delay and delay variation, are improved.

A novel binary contention protocol called binary priority countdown (BPC) protocol has been developed. BPC uses a new priority countdown mechanism which exploits the efficiency of binary countdown, but the priority countdown process is not constrained to a single binary countdown round. This way, arbitrary medium access priorities can be decremented through multiple binary countdown rounds if necessary, which introduces new optimization and adaptation possibilities.

Collision memory effect, occurring in DCF-type networks and causing throughput decrease, has been detected and CPCF mechanism, used for limiting this effect, has been introduced.

Mathematical model of MAC protocols with constrained priority freezing has been developed, based on three-dimensional Markov chain.

On-going research of the group is focused on development of MAC protocols which offer good results both in undersaturated and in highly saturated networks.



Model of optimal proxy between an access network and core Internet network

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The results having come out of the 2 year research period are presented in:

1. I. Kedzo, J. Ozegovic, and A. Kristic, "**BPC – A binary priority countdown protocol**," *Ad Hoc Networks, vol. 11*, no. 3, pp. 747–764, May 2013.
2. A. Kristic, J. Ozegovic, and I. Kedzo, "**Mathematical model of simplified Constrained Priority Countdown Freezing protocol**," *ISCC 2013*, Split, Croatia
3. I. Kedzo, J. Ozegovic, and A. Kristic, "**Contention overhead — adaptive binary priority countdown protocol**," *SoftCOM 2013*, Split, Croatia
4. A. Kristic, J. Ozegovic, and I. Kedzo, "**Improved mathematical model of simplified Constrained Priority Countdown Freezing protocol**," *SoftCOM 2013*, Primosten, Croatia
5. V. Pekic, J. Ozegovic, and I. Kedzo, "**Adaptive Algorithm for WTFC to TCP Flow Control Proxy**," *SoftCOM 2012*, Split, Croatia
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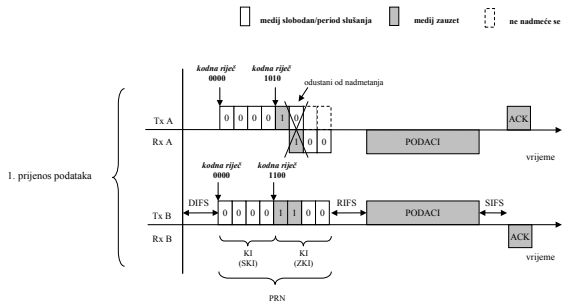
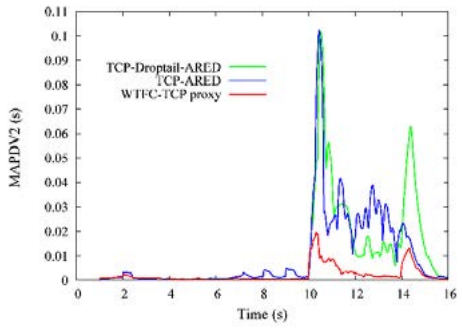
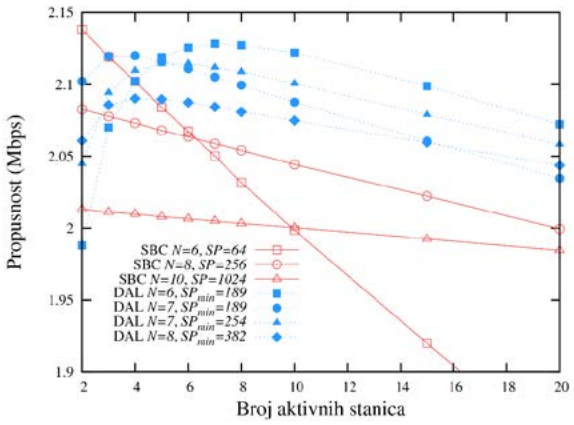
7. V. Pekic, A. Kristic, and J. Ozegovic, "**WTFC to TCP flow control proxy**," *ACCESS 2012*, Split, Croatia
8. I. Kedzo, J. Ozegovic, and V. Pekic, "**Constrained Priority Countdown Freezing - A Collision Memory Avoidance Algorithm**," *ICWMC 2012*, Venice, Italy



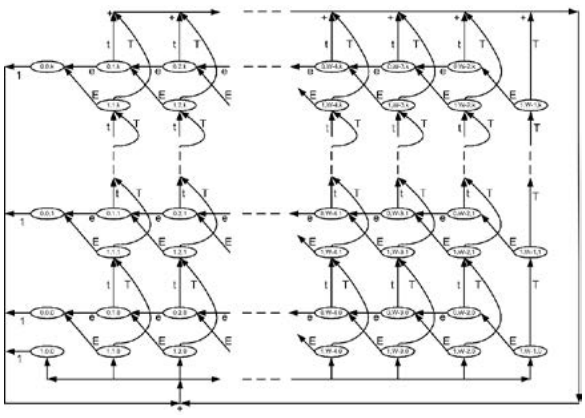
BPC medium contention



MAPDV2 jitter with and without proxy



Throughput of BPC-DAL and Simple Binary Countdown (SBC) compared



Markov chain model for the simplified CPCF protocol

Computer Intelligence in Recognition and Support of Human Activities

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DESCRIPTION OF LABORATORIES

The group has four laboratories: Laboratory for biomechanics and control systems, Laboratory for modelling and operational research, Laboratory for multimedia systems and virtual reality and Laboratory for expert systems and sports analysis. Laboratories are equipped with various image acquisition devices (force, plate, standard camcorders, 3D cameras and high speed cameras,...), other multimedia signal acquisition devices (data glove, accelerometers, Kinect), 3D displays and CAVE system (virtual reality environment). Also various small robotic systems and educational sets for students are available for students and researchers.

The group continuously works on improving and developing new hardware and in-house built systems which cover broad range of applications within scope of the group's research focus but are not necessarily limited to it. Software solutions for the targeted applications are based on the development using both open source software (e.g. OpenCV) and commercial software environments (e.g. Matlab, LabView).

RESEARCH INTERESTS AND TOPICS

biomechanics

information extraction from images and video

sports analysis

object detection and tracking

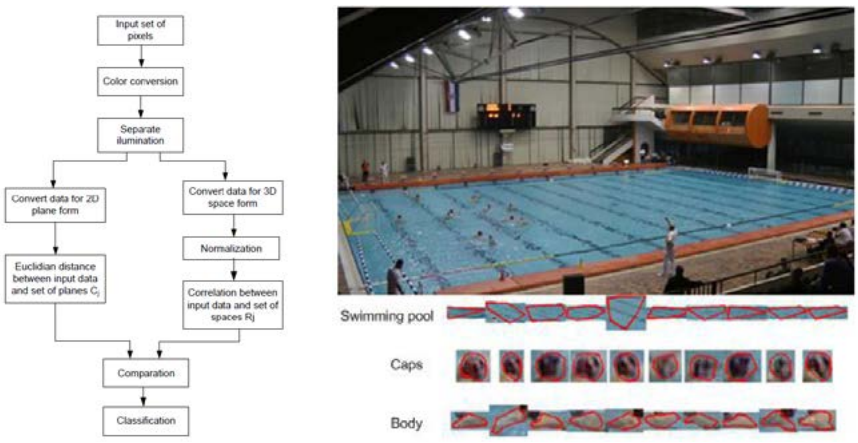
gestures recognition

control and optimization

machine learning

virtual reality systems

GPGPU accelerated image processing



Water polo playground and categories (right). Classification flow chart (left)

THE GROUP AT A GLANCE

Group maintains strong links with other research groups on FESB such as Group for Development and Implementation of Methods for Bio-systems and Environments Identification and Group for Communications and Information Systems within the Department of Electronics but also with research groups on Faculty of kinesiology and Faculty of Science and also with Croatian Mountain Rescue Service. Also, contacts and developed active cooperation with international research groups.has been established (University of Ljubljana, Glasgow University,...). Forms of collaboration include joint research work, publishing scientific and professional publications, writing of bilateral and multilateral project proposals, etc.

Recent activities of the for Computer Intelligence in Recognition and Support of Human Activities can be divided in the following applied research areas:

Image processing for surveillance and measurements

- artificial and natural object detection and classification
- fast processing of large natural images
- algorithms parallelization and GPU programming
- 3D scanner development

First parallel implementation of IFGT-MS segmentor based on many core GPGPU platform was presented. The emphasis is placed on adaptation of the core algorithm to efficiently exploit benefits of underlying GPU hardware architecture. Numerical experiments have demonstrated considerably faster segmentation execution compared with alternative CPU and GPU based mean shift variants.

Also, a novel structured light pattern for 3D structured light scanner was proposed. During development, accuracy and robustness of the proposed system were tested on artificial objects with known surface configurations, after which measurements were performed on human subjects. Simultaneous measurements with standard structured light pattern were achieved and obtained results compared. Volumetric parameters of both artificial object and human body segment obtained by 3D scanning were compared to the immersion method and were found to be in a good agreement and were used for segment mass estimation.

Text extraction and document understanding

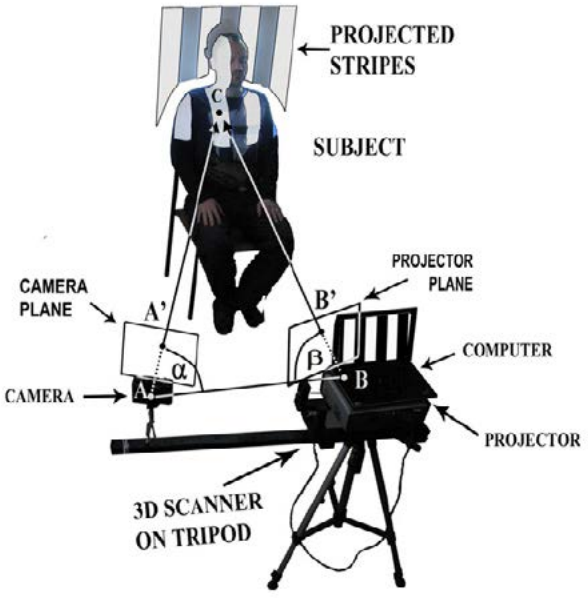
- image segmentation methods for text extraction
- video magnifier to help visually impaired people read printed documents
- adaptive color spaces

Research was also focused on scene text extraction. Text extraction method based on k-means clustering with modified cylindrical distance in HSI color space has been introduced. Performance of this distance is analyzed depending on different degrees of chroma reliability. For purpose of result comparison, K-means text extraction is also performed with cylindrical distance in HSI color space and Euclidean distance in RGB color space. Complementarity of tested distances is also analyzed.

Sports analysis

- image feature detection
- player tracking algorithms
- fuzzy expert systems
- knowledge-based approach

3D scanner measurement and proposed projected frames scheme



A framework for novel, adaptable knowledge-based system for player tracking has been proposed. According to given framework and based on commonKADS methodology, system uses novel CbCr-OB method for background separation implemented on waterpolo example. For object classification is proposed new Fuzzy-SVM method.

Gestures and movements recognition

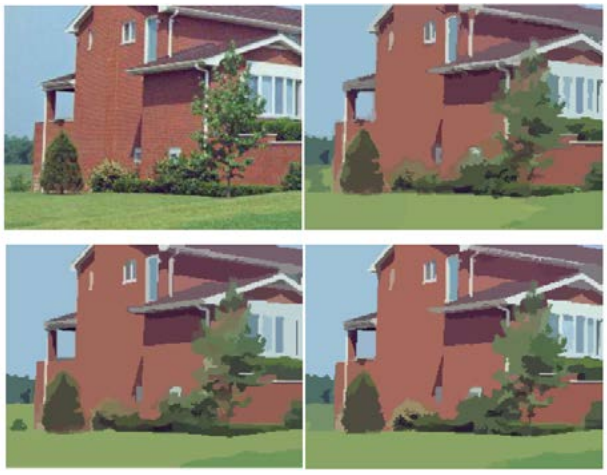
- signal processing and characteristic features proposal
- pattern recognition for novel human-machine communication methods
- optical tracking algorithms
- body and body parts tracking through data gloves, orientation sensors, Kinect

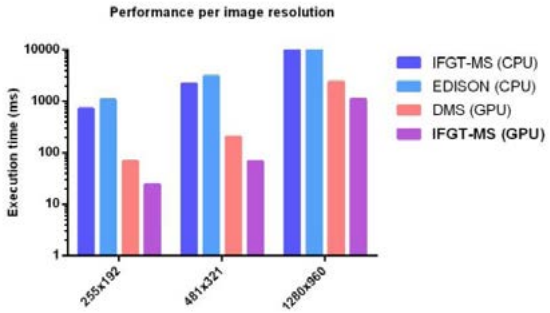
Hand movements as additional or alternative modality for interaction with mobile devices has been investigated. Novel concept for gesture recognition system based on processing of signals from smartphone built-in accelerometer has been proposed. Set of features for a robust gesture recognition, using a single 3-axis accelerometer and a novel feature extraction scheme, that allows the gesture form to be clearly discriminated, is proposed. Fuzzy k-Nearest Neighbor classifier is used for recognition of gestures in transformed feature space. Android application for recognition has been developed and system showed almost perfect recognition for chosen set of 9 gestures.

HIGHLIGHTS

In last two years the Group was involved in five national projects and one national program. There were three PhD Viva in the period from the beginning of 2012 to the end of 2013, Vladimir Pleština (February/2013 - mentor V.Papić) with thesis title: "Tracking team players by fuzing dynamic and static data from knowledge base", Tea Marasović (December/2013 - mentor V.Papić) with thesis title: "Design and development of an accelerometer-based gestural interface using distance metric learning" and Davor Mance (May/2012) – mentor J. Marasović) with thesis title: Development of electronic system for sensing and actuation of test mass of the inertial sensor LISA".

Several advances were achieved in fast image segmentation, object tracking, movement and gesture recognition, 3D scanning. Group members were active in organization of the international conference (IEEE ISCC 2013).





LOPEC Learning Content (E Original test image from Berkeley database (top left), segmentation results produced by our IFGT-MS (GPU) (top middle), DMS (GPU) (bottom left) and EDISON (CPU) (bottom middle) methods. Performance scaling per image resolution for all considered algorithms (right). U project „LOPEC - Logistics Personal Excellence through continuous Self-Assessment")

SELECTED REFERENCES

The results having come out of the 2 year research period are: 6 journal papers and 10 papers at various international conferences. Some selected references are given:

1. Stančić, Ivo; Musić, Josip; Zanchi, Vlasta. **Improved structured light 3D scanner with application to anthropometric parameter estimation**. *Measurement*. 46 (2013), 1; 716-726.
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3. Foretić, Nikola; Rogulj, Nenad; Papić, Vladan. **Empirical model for evaluating situational efficiency in top level handball**, *International Journal of Performance Analysis in Sport*. 13 (2013); 275-293.
4. Cecić, Mojmil; Krajči, Vesna; Bonković, Mirjana. **Optimization of Model-Reference Variable-Structure Controller Parameters for Direct-Current Motor**, *Journal of Computations and Modelling*. 2 (2012.), 3; 67-88.
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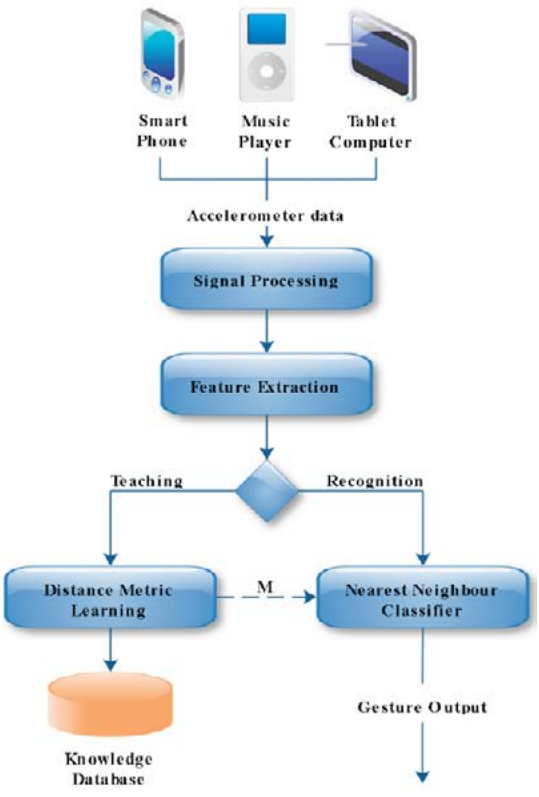
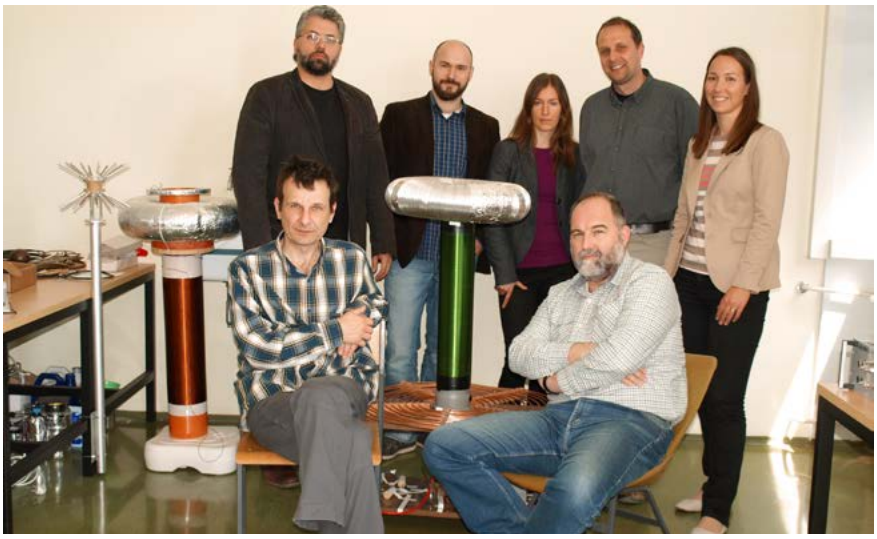
6. Pleština, Vladimir; Papić, Vladan. **Object classification in water sports**, IEEE ISCC 2013 Proceedings. Split, 2013.
7. Sirotković, Jadran; Dujmić, Hrvoje; Papić, Vladan. **Accelerating Mean Shift Image Segmentation with IFGT on Massively Parallel GPU**, Mipro 2013. 301-306.
8. Marasović, Jadranka; Marasović, Tea; Đapić, Marija. **Fair Division Methods Approach as the Option of Learning Process Modeling**, Proceedings of 18th IEEE International Symposium on Computers and Communications (ISCC 2013), 2013.
9. Marasović, Tea; Papić, Vladan. **Accelerometer Based Gesture Recognition System Using Distance Metric Learning for Nearest Neighbour Classification**, Proc. 2012 IEEE International Workshop on Machine Learning for Signal Processing (MLSP 2012), 2012.
10. Musić, Josip; Stančić, Ivo; Zanchi, Vlasta. **Is it Possible to Detect Mobile Phone User's Attention Based on Accelerometer Measurement of Gait Pattern?** Proceedings of 18th IEEE Symposium on Computers and Communications (ISCC) 2013, Split: IEEE, 2013.



The gesture recognizer system architecture

Electromagnetic Compatibility and Numerical Methods in Electrical Engineering



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A research Group for Electromagnetic Compatibility (EMC) and Numerical Methods in Electrical Engineering at the Department of Electronics, with the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split deals with an advanced computational electromagnetics and related applications in areas of EMC, antennas and propagation, human exposure to electromagnetic fields, magnetohydrodynamics and plasma physics.

The group has established 2 research laboratories: Lab for EMC and Numerical Methods in Electrical Engineering and Lab for Antennas and EMC.

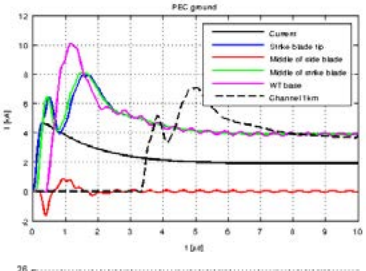
RESEARCH INTERESTS AND TOPICS

electromagnetic compatibility

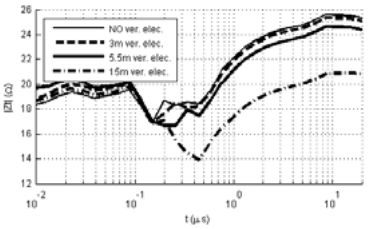
computational electromagnetics

magnetohydrodynamics and plasma physics

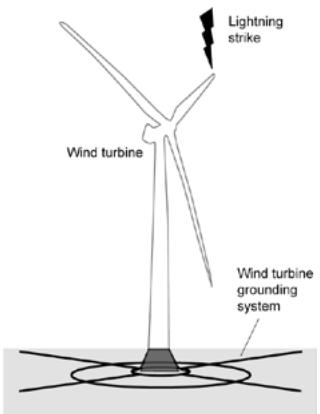
human exposure to electromagnetic fields



Current waveforms at different points of WT for PEC ground



Transient impedance for different lengths of additional vertical electrodes



Wind turbine subjected to a lightning strike

THE GROUP AT A GLANCE

Activities of the Group for EMC and numerical methods in engineering can be divided in following areas of fundamental and applied research areas:

FUNDAMENTAL RESEARCH

Advanced formulations in electromagnetics

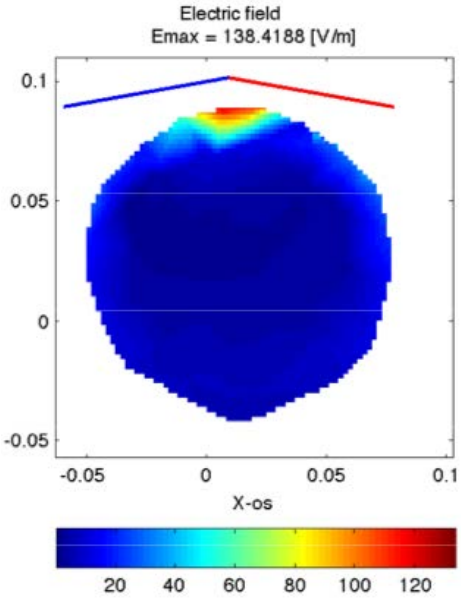
The group main activity is a development of advanced formulations in electromagnetics (classical electromagnetic field theory) based on several space-frequency and space-time differential, variational, integral and integro-differential equations, respectively. Of particular interest are topics related to antenna theory, three-dimensional scattering, transmission line models and magnetohydrodynamics.

Advanced numerical methods in engineering

Of particular interest is a development of several efficient schemes of Finite Element Methods (FEM), Boundary Element Methods (BEM) and Finite Difference Methods (FDM) for the solution of various types of differential and integral equations, respectively. Several research codes and user friendly software packages have been developed.

Radio-channel modeling

Channel models for various frequency bands have been analyzed. Besides the classical wide-band modeling based on deterministic methods and channel statistics as in mobile networks, of special interest are the narrow-band radio-channels for transmission of power and the development of spherical mode theory (SMT) based channel models.



Electric field distribution in the coronal cross-section of the human brain due to a TMS coil

APPLIED RESEARCH

Electromagnetic compatibility of thin wire structures

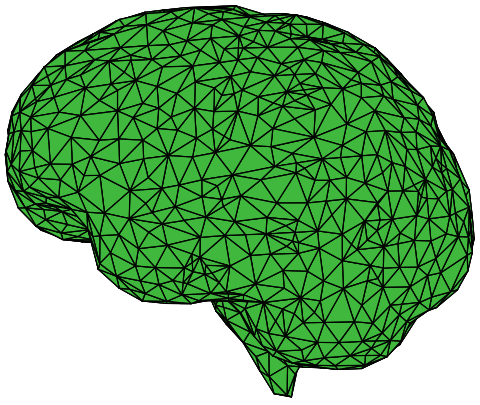
Various antenna and transmission line models for antenna systems, overhead wires, lightning channel, lightning rods and buried cables have been developed in either frequency or time domain. These models are based on related systems of integral equations. The corresponding equations of interest have been solved via originally developed numerical methods based on Finite Element Methods (FEM), Boundary Element Methods (BEM) and Finite Difference Methods (FDM).

Analysis and design of grounding system

Stationary and transient analyses of realistic grounding systems of highly complex geometries placed in inhomogeneous media have been carried out with a particular emphasize to wind turbine grounding systems being highly vulnerable to lightning strikes. Namely, to reduce potential damage that may occur due to lightning strike, it is necessary to design an efficient lightning protection system, with a particular emphasis on accurate electromagnetic modeling.

Human Exposure to electromagnetic fields

Many techniques of incident field dosimetry and internal electromagnetic-thermal dosimetry methods have been used to assess human exposure to electromagnetic fields from extremely low (ELF) to microwave range. A number of human body models from simplified canonical geometries to anatomically based realistic representations have been developed. In particular, some dosimetry methods for the analysis of biomedical applications of electromagnetic fields have been developed.



The adult human brain model

Wireless power transmission

Analysis of wireless power transmission to moderate distances by electrically small antennas (ESAs) has been carried out with special attention to the possibilities of decreasing transmission frequency and antenna size. It has been proven by means of spherical mode theory antenna model (SMT-AM) that the radiation efficiency is a decisive factor for achieving the best transmission performances. Hence, the methods of increasing the radiation efficiency of ESAs while maintaining proper antenna impedance and mode ratio have been developed. The power transmission to multiple receivers and the adjustment related problems are to be dealt with thoroughly.

INTERNATIONAL COLLABORATION

The Group has established contacts and developed a long-term active cooperation with many international research groups. The most intensive on-going collaboration is achieved with the following institutions:

1. Université Blaise Pascal, Clermont-Ferrand, France (EMC of antenna systems and transmission lines)
2. Wessex Institute of Technology, Southampton, UK (modeling of human body exposed to electromagnetic fields)
3. Technische Universität Ilmenau, Ilmenau, Germany (Transcranial Magnetic Stimulation Modeling)
4. Ecole Polytechnique Fédéral de Lausanne, Lausanne, Switzerland (grounding systems)
5. Otto-von-Guericke Universität Magdeburg, Magdeburg, Germany (advanced formulations in electromagnetics)

Forms of collaboration include joint research work, publishing scientific and professional papers, writing of bilateral and multilateral project proposals, etc.

HIGHLIGHTS

In last two years the Group was involved in one international, one bilateral project and one professional project. There were one PhD Viva in the period from the beginning of 2012 to the end of 2013, M. Cvetković (December/2013).

In last the period 2012-2013 several advances were achieved in modeling of complex wire configurations related to EMC problems (antennas, lines, cables, lightning channel, grounding systems), human exposure to electromagnetic fields and biomedical applications of electromagnetic fields.

Of particular importance were EMC aspects of the analysis and design of wind turbines (WTs). Sophisticated models pertaining to WT struck by lightning, grounding systems for WTs and EMI impact of WT's for radar systems have been developed.

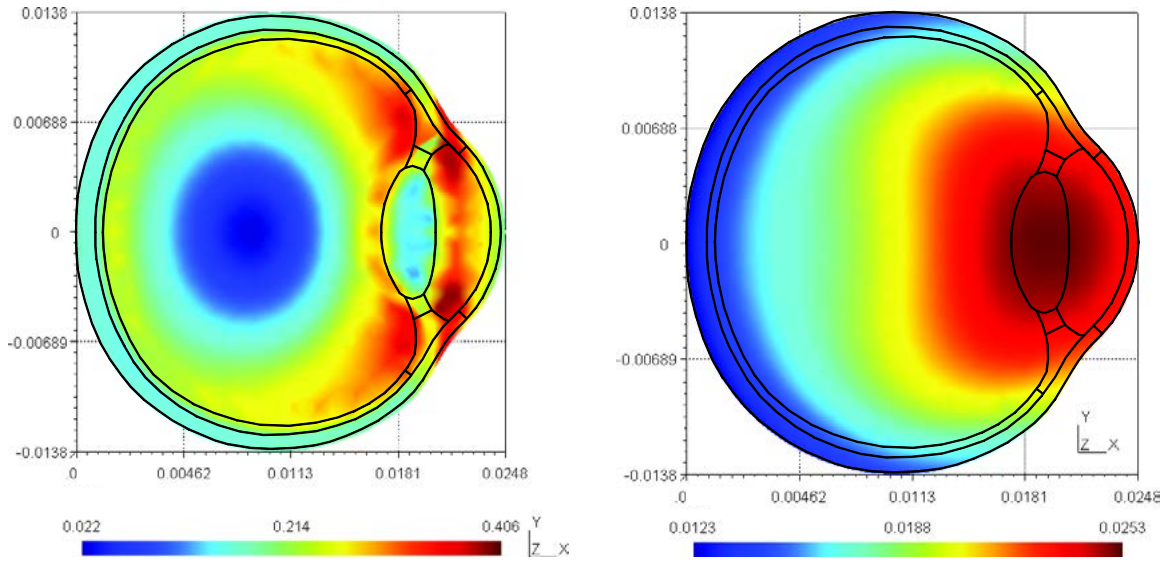
Furthermore, realistic modeling of the human eye and brain, respectively has been undertaken based on the corresponding boundary integral equation methods.

The radio-channel models based on SMT-AM for wireless power transmission have been investigated and efficient ESAs design for the purpose has been considered.

The Group has developed and upgraded several research codes:

- SoAPLinCS (Software for the Analysis of Power Line Communications Systems)
- STAGE (System for Transient Analysis of Grounding Electrodes)

Note: These codes can be considered to be extensions of the TWiNS (Thin Wire Numerical Solver) code developed by early 2009 and published in UK and USA together with the related book.



SAR and temperature increase in the eye due to EM wave with power density 10 W/m2 at: f=1 GHz.

- TrAnSolBS (Transient Analytical Solver for Buried Structures)
- SoHuBraD (Software for Human Brain Dosimetry)
- RSD (Diffraction Loss Calculations by Approximate Methods)
- THELMA (Thermal-Electromagneic Analysis code for human brain dosimetry)

The intensive on-going group activities deal with magneto-hydrodynamic based fusion related research activities. In particular, significant efforts of the group are devoted towards the solution of current diffusion equation and Grad-Shafranov equation for plasma equilibrium in tokamak.

SELECTED REFERENCES

The results having come out of the last 2 year period are documented in various publication. Some selected references are given:

Journal papers (CC, SCI, SCI Expanded) (8)

1. Antonijevic, Sinisa; Poljak, Dragan. **A Novel Time-Domain Reflection Coefficient Function: TM Case.** *// IEEE Transactions on electromagnetic compatibility.* PP (2013), 99; 1-7
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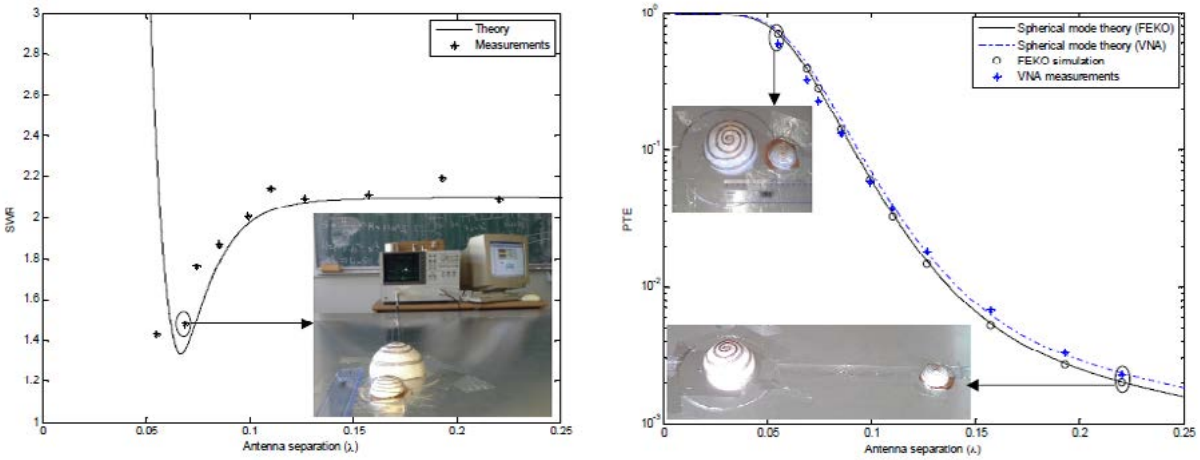
8. Poljak, Dragan; Shoory, Abdolhamid; Rachidi, Farhad; Antonijević, Siniša; Sergey, Tkachenko. **Time-Domain Generalized Telegrapher's Equations for the Electromagnetic Field Coupling to Finite Length Wires Above a Lossy Ground.** *// IEEE Transactions on electromagnetic compatibility.* 54 (2012), 1; 218-224

Measurements of wireless transmission between different spherical helical monopole antennas at 163 MHz vs. theory and numerical simulations: standing-wave ratio (left) and power transmission performances (right) for 50-Ω vector network analyser loading



Modelling and Intelligent Systems

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A research Group for Modelling and Intelligent Systems deals with modelling, design and control of complex systems, particularly using methods and techniques of intelligent technologies. The Group consists of researchers in the fields of Computer Science, Control Engineering and Electrical Engineering. Official Group Web page is *http://laris.fesb.hr*

DESCRIPTION OF LABORATORIES

The group has established 6 research laboratories and one research center:, **CIPOP** - *Center for Wildfire Research (Chair Darko Stipanicev)*, **LaAIT** - *Laboratory for Advanced Internet Technologies (Chair Maja Štula)*, **LaMoOR** - *Laboratory for Modelling and Operational Research (Chair Jadranka Marasović)*, **LaViBC&BCA** - *Laboratory for Vision Based Control and Biomedical Signal Analysis (Chair Mirjana Bonković)*, **LaIS** - *Laboratory for Intelligent Systems and Artificial Perception (Chair Ljiljana Šerić)*, **LaADIA** - *Laboratory for Advanced Digital Image Analysis (Chair Damir Krstinić)*, so our current research interests are mostly connected with them.

Group Web portals related to few of our research topics: *http://laris.fesb.hr*, *http://cipop.fesb.hr*, *http://wildfire.fesb.hr*, *http://vatra.fesb.hr*

RESEARCH INTERESTS AND TOPICS

intelligent systems

application of ICT and intelligent technologies in environmental protection

advanced digital image analysis

advanced internet technologies

complex systems modelling and control

agents and multi-agent systems

fuzzy cognitive maps

Reconstructed HR image from 4 LR images

THE GROUP AT A GLANCE

Activities of the ***Group for Modelling and Intelligent Systems*** cover both fundamental and applied research areas. Current research interests of the group members could be divided in four areas:

ENVIRONMENTAL INTELLIGENCE

(Research and Application of Intelligent Systems and Intelligent Technologies in Environmental Protection)

Our recent research interests in this area are related to the application of advanced Information-Communication Technologies (ICT) (particularly intelligent technologies) in environmental protection. Such integration of technology and environment, result in (artificial) environmental intelligence that could be realised as a particular case of Future Generation Communication Environment (FGCA) where application and services are focused on the user. In our case the "user" is the environment itself and the final goal of these new applications and services is to enhance the environment protection. The 'environmental intelligence' is not the same as an 'intelligent environment'. The intellingent environment is focused on habitants that live in that environment and who try to increase their comfort level. On the other hand, environmental intelligence serves the environment, it is the property of the environment (enhanced with technological devices), and its main task is the protection of the environment from both natural and human hazards.

These research activities are primarily conected with Center for Wildfire Research, Laboratory for Intelligent Systems and Artificial Perception, Laboratory for Advanced Digital Image Analysis and Laboratory for Advanced Internet Technologies. Our main research interest is further development of the idea of environmental intelligence on wildfire protection and prevention, because wildfires are natural catastrophes that cause significant economic damage and threat to human lives in our region (Adriatic coast and islands). In this area both fundamental and applied research are carried out.

FUNDAMENTAL RESEARCH

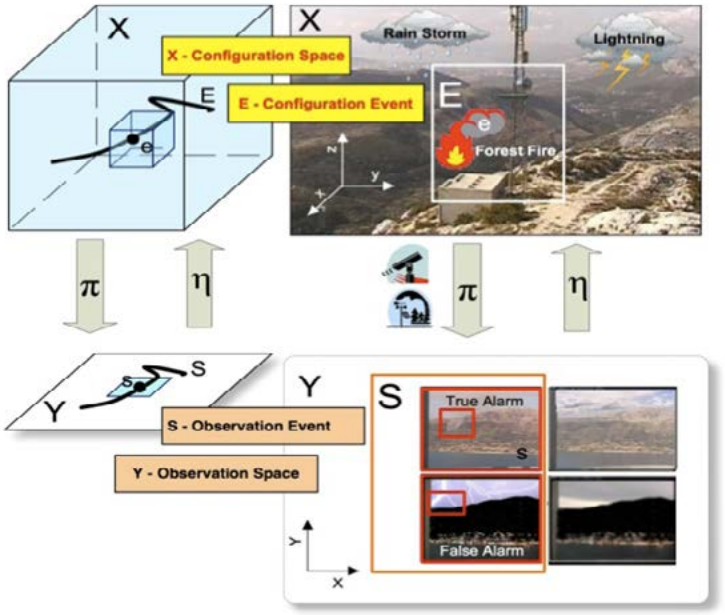
Artificial perception and environmental intelligence

Our principal research interest is in the development of artificial perception systems as a man-made copy of human perception. In psychology and the cognitive sciences, human perception is defined as the process of acquiring, interpreting, selecting, and organizing sensory information. It is a complex process, not yet fully explained, thus in our theoretical work we are concentrated on various simplified formal theories of perception and its application in artificial perception systems. Our primarily research interest on both, theoretical and applied level, is in environmental observers, devices conceived as advanced ICT systems capable of detection and recognition of various environment phenomena, particularly those that could harm the environment like wildfire.

APPLIED RESEARCH

Wildfire observers and wildfire observers networks

Wildfire observers are advanced ICT units capable of automatic detection of wildfires in incipient stage. Its theoretical background is formal theory of perception. Perception of environment in our wildfire observers is done in two steps. The first step is proprioception - or self-perception that must be done in order to validate that the data from senses is val-



Conceptual structure of our wildfire observer

id and that could be taken into account for further processing. If everything is in order with the senses than sensations the system experiences can be used in making conclusions about environment. That is the second step called exteroception. Our wildfire observers are based on data fusion from vision sensors (video cameras sensitive in visible and/or IR spectra), various meteorological sensors and results of meteorological simulations, GIS data and GIS based simulation, particularly those connected with micro-location wildfire risk index calculation and wildfire behavior and spread simulation.

Advanced image analysis and image recognition algorithms

As the vision sensor is one of the most important human (and animal) sensors, our important research topics are in the field of image and video parsing and recognition, particularly static and dynamic image sequences of natural scenes. Various algorithms were developed or are in the developing stage, and in most cases are applied to wildfire smoke detection (for example Spatial Context Smoke Detection Method, Fast Two Step Histogram-Based Image Segmentation, Histogram-Based Smoke Pixels Classifier, Temporal–Spatial Natural Scene Image Parsing Techniques, etc). Our particular research interest is also in the testing of detection algorithm accuracy and quality, based on the formal theory of perception and detection theory. Therefore a standard database of wildfire smoke images and video sequences was established and continuously maintained. More details can be found on our Web site dedicated to wildfire observers and smoke recognition at http://wildfire.fesb.hr.

Integration of Augmented Reality in Environmental Observers

Our new research interest is integration of Augmented Reality in wildfire monitoring and surveillance systems. This research is primarily connected with our cooperation with Universidad de Las Palmas, Spain.

SOFTWARE ENGINEERING AND WEB ENGINEERING

(Complex Software Systems and Web Based Systems Design)

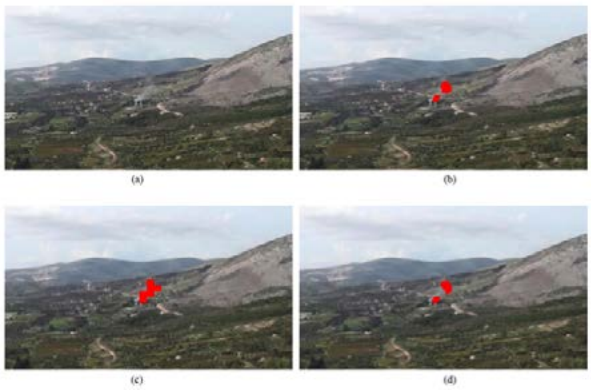
The Group members are pioneeres at the University of Split in research and development of Internet-based systems and Internet technologies, so our today's research interest is also in this field, particularly connected with activities of Laboratory for Advanced Internet Technologies. Two research topics are of our prime interest:

Sentence retrieval using local context and sentence length

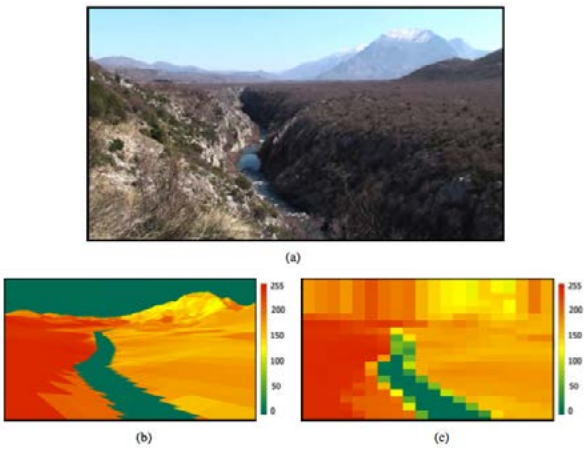
As a result of this research improved variants of the sentence retrieval method TF-ISF (a TF-IDF or Term Frequency – Inverse Document Frequency variant for sentence retrieval) was proposed. The improvement is achieved by using context consisting of neighboring sentences and at the same time promoting the retrieval of longer sentences. The new modified TF-ISF methods to the TF-ISF baseline, was compared to an earlier attempt to include context into TF-ISF named tfmix and to a language modeling based method that uses context and promoting retrieval of long sentences named 3MMPDS.

Reusability, maintainability and performance of client-side web applications

Web applications are one of the fastest growing types of software systems today. Structurally, they are composed out of two parts: the server side, used for data-access and business logic, and the client-side used as a user-interface. In recent years, with developers building complex interfaces, the client side is playing an increasingly important role. Unfortunately, the techniques and tools used to support development are not as advanced as in other disciplines. From the user's perspective, the client-side offers a number of features that are relatively easy to distinguish. However, the same cannot be said for their implementation details. This makes code understanding, maintenance, and reuse



Example of various algorithms for wildfire smoke detection comparison



Wildfire risk index prediction and Augmented Reality application in wildfire monitoring and surveillance system

difficult. The goal of the work presented in this paper is to improve reusability, maintainability and performance of client-side web applications by identifying the code that implements a particular feature. This research is primarily connected with our multilateral cooperation with Mälardalen University, Sweden and University of Zagreb.

COMPLEX SYSTEMS MODELLING, CONTROL AND OPTIMISATION

The main research topic is this area were:

Modelling and optimisation of complex systems faced with condition of uncertainty

Our research interes is modelling of complex systems particularly electronic system developed to support measurements in space environment. The inertial sensor electronics, developed for the space mission LISA Pathfinder, were confronted with the greatest design challenges mostly in the field of low noise at ultra-low frequency not imposed on any electronic before. This research is coonected with cooperation on PhD level with Institute for Geophysics, ETH Zurich Switzerland.

VISUAL BASED CONTROL AND BIOMEDICAL SIGNAL ANALYSIS

The main research topics is this area were:

Image superresolution

Reconstruction based algorithms play an important role in the multi-frame super-resolution problem. A group of images of the same scene are fused together to produce an image with higher spatial resolution, or with more visible details in the high spatial frequency features. Demosaicing algorithms interpolate missing pixels in a raw image taken from one Charged Coupled Device (CCD) array, upsampling the number of the pixels present in the image. Since super-resolution (SR) and demosaicing are the two faces of the same problem it is natural to address them together.

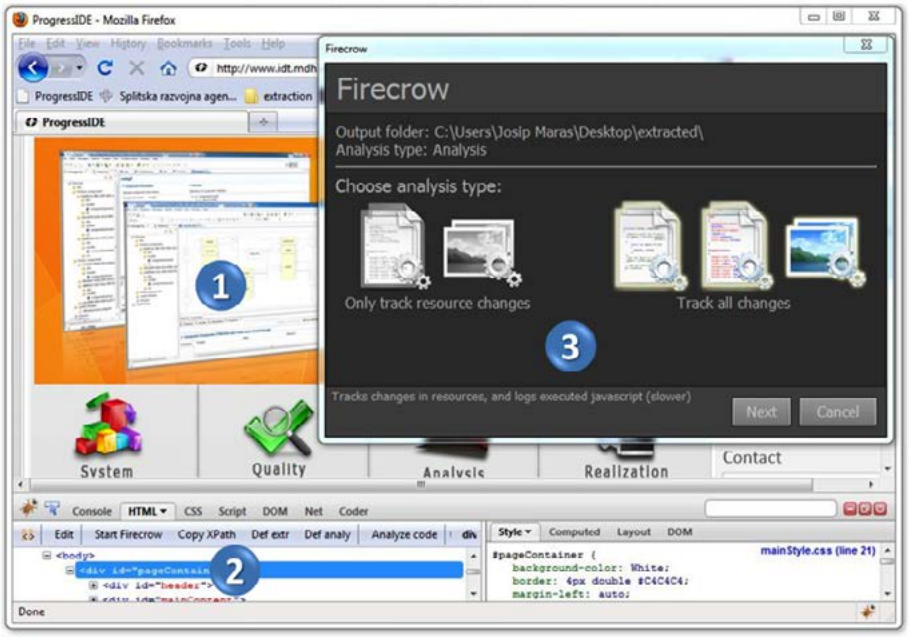
Biomedical signal analysis

The research was focused on automatic classification of infant sleep based on instantaneous frequencies in a single-channel EEG signal. This study presents a novel approach for electroencephalogram (EEG) signal quantification in which the empirical mode decomposition method, a time-frequency method designated for nonlinear and non-stationary signals, decomposes the EEG signal into intrinsic mode functions (IMF) with corresponding frequency ranges that characterize the appropriate oscillatory modes embedded in the brain neural activity acquired using EEG.

HIGHLIGHTS

In the last two years the Group was involved in national, international project, and professional projects.

Over this period, we continued to work on research topics in the past, particularly on application of ICT in environmental protection, modelling of complex systems, augmented reality and various application of advanced digital image processing and analysis, but also few new research topics were introduced connected with sentence retrieval, reusability, maintainability and performance of client-side web applications and biomedical signal analysis based on machine learning and artificial intelligence.



Index Reusing web client-side application with developed Firecrow tool

Our particular research interests in this period were again wildfire observers. We have worked on establishment of ground truth image database suitable for development and testing of wildfire smoke recognition systems, but also on development of new algorithms for wildfire smoke and fire detection, with significant improvement of detection features, fusion of video detection in various electromagnetic ranges, as well as fusion of video detections with other sensor types, close integration of wildfire observers with Geographic Information Systems (GIS), resulting in new features in both fire detection and distant video presence modes, fusion of few wildfire observers in wildfire observer network working together in cooperation and introduction of new measures for quality control and monitoring of wildfire networks. More details could be found on specialised Group Web portals.

There were six PhD Vivas in the period from 2012-2013, Davor Mance (2012 - Development of electronic system for sensing and actuation of test mass of the inertial sensor LISA), Darko Kovačević (2012 – Hardware modelling of newspaper distribution and sell process control based on intelligent agent network realisation), Ivan Ćurak (2012 - Multi-agent system for timetabling), Barbara Đaja (2013 – A probabilistic model for full-colour image super- resolution), Alen Doko (2013 - Local Context and Document Level based Sentence Retrieval) and Marin Bugarić (2013 - Wildfire Surveillance Systems Enhanced by Geographic Information System (GIS) and GIS-based Augmented Reality).

SELECTED REFERENCES

The results from the 2 years of research (in the period from 2012-2013) are presented in 9 journal papers indexed in CC, SCI, SCI Expanded data base, 2 other journal papers, and 13 regular contributions at various international conferences (more details on ***http://bib.irb.hr/lista-radova?projekt=023-0232005-2003***).

Journal papers (CC, SCI, SCI Expanded) (9)

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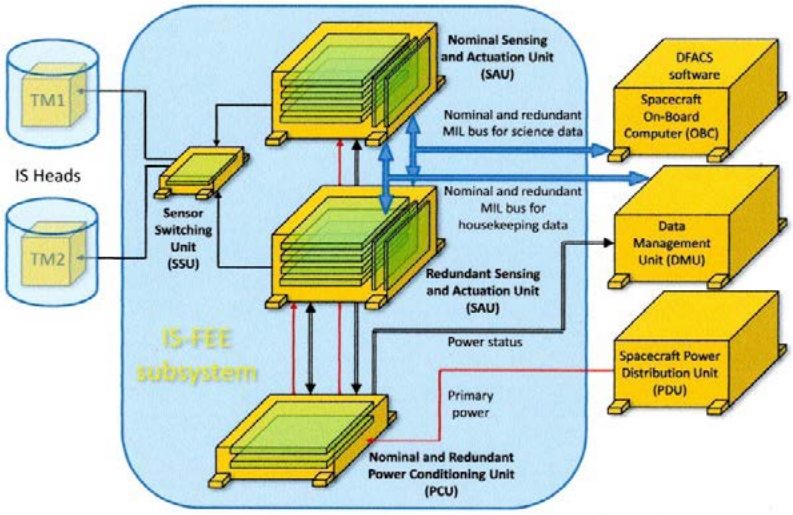
2. Čić, Maja; Šoda, Joško; Bonković, Mirjana. **Automatic classification of infant sleep based on instantaneous frequencies in a single-channel EEG signal**, *Computers in biology and medicine*, 43 (2013), 12; 2110-2117
3. Doko, Alen; Štula, Maja; Šerić, Ljiljana. **Improved sentence retrieval using local context and sentence length**, *Information processing & management*, 49 (2013), 6; 1301-1312
4. Džaja, Barbara; Bonković, Mirjana; Malešević, Ljubomir. **Solving a two-colour problem by applying probabilistic approach to a full-colour multi- frame image super-resolution**, *Signal processing. Image communication*, 28 (2013), 5; 509-521
5. Jakovčević, Toni; Stipaničev, Darko; Krstinić, Damir. **Visual spatial-context based wildfire smoke sensor**, *Machine vision and applications*, 24 (2013), 4; 707-719
6. Maras, Josip; Štula, Maja; Carlson, Jan; Crnković, Ivica. **Identifying Code of Individual Features in Client- side Web Applications**, *IEEE Transaction on Software Engineering*, 39 (2013), 12; 1680-1697
7. Šerić, Ljiljana; Stipaničev, Darko; Štula, Maja. **Engineering of holonic multi agent intelligent forest fire monitoring system**, *Ai communications*, 26 (2013), 3; 303-316
8. Štula, Maja; Stipaničev, Darko; Maras, Josip. **Distributed Computation Multi-agent System**, *New generation computing*, 31 (2013), 3; 187-209
9. Štula, Maja; Krstinić, Damir; Šerić, Ljiljana. **Intelligent Forest Fire Monitoring System**, *Information systems frontiers*, 14 (2012), 3; 725-739



Electronic system developed to support measurements in space environment

Applied Electromagnetics

GROUP LEADER
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Vesna Roje
Professor Emeritus

Damir Senić
PhD student

Zlatko Živković
PhD student

RESEARCH INTERESTS AND TOPICS

antennas and antenna systems

wireless communications (specializing in maritime radiocommunications)

electromagnetic compatibility (EMC)

bioelectromagnetics

biological effects of electromagnetic fields

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The group represents the Chair of Applied Electromagnetics, teaching the graduate students of Communication and Information Technology and Electronics and Computer Engineering the following courses: *Antennas and Antenna Systems, Electromagnetic Compatibility, Wireless Communications, Maritime Radiocommunications, Bioelectromagnetics, Simulation and Measurements of Electromagnetic Quantities.*

DESCRIPTION OF LABORATORIES

The group has established 2 research laboratories:

- EMlab - Laboratory for EMC and EM research/testing
- Laboratory for antennas and wireless communications

Laboratories are equipped with high-tech measurement equipment: signal generators, RF amplifiers, spectrum analyzers, power sensors, broadband antennas, ELF and RF field probes, etc. In addition to the commercial GTEM cell, several other controlled environments are available for electromagnetic measurements from ELF to RF range. Besides the measurement instrumentation, the laboratories are equipped with powerful computer software packages for electromagnetic modeling and simulations using FDTD and MoM numerical methods.

When needed by the project-driven research, the group is joined by additional researchers or experts. The research activities are supported by the technical staff. Each year several graduate students work on high-tech graduation theses on the previously mentioned topics.

THE GROUP AT A GLANCE

The activities can be divided into three main topics:

Electromagnetic compatibility (EMC) and human exposure to electromagnetic fields (EMFs)

This research area encompasses the measurements and calculations of EMFs using modern measurement equipment and computer simulation software. Within this topic, assessments of human exposure to EMFs are performed for various scenarios. Various EMC problems are analyzed: radiated and conducted emissions and immunity, interference reduction, etc. with special interests in shielding effectiveness measurements of resonant enclosures using reverberation chamber and GTEM cell. The design, improvement and calibration of EMF probes and sensors, based on laboratory setups, also present the important part of our research.

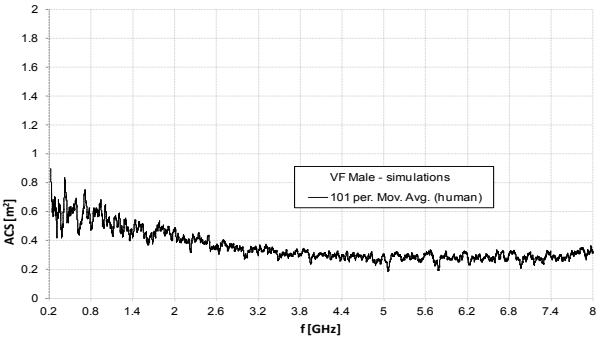
Antennas and antenna systems

The group is involved in antennas and antenna systems research, analysis and planning of antennas and antenna systems on ships and other fixed and mobile platforms. The measurements and simulations of radiation pattern, gain, antenna factor and antenna impedance are commonly performed.

Wireless communications, maritime radiocommunications

Various measurements and analyses in radiocommunications (signal coverage, intersystem interference, propagation, spectrum analysis, and other communication aspects) are performed. Specific analyses include: propagation and coverage over sea or near sea, indoor coverage prediction, road tunnel coverage, radar cross section (RCS) analysis, etc.

Human absorption cross section measured inside a reverberation chamber



HIGHLIGHTS

In last two years the group participated in several research projects that shaped our research goals.

National projects

- ***Measurements in EMC and EM health effects research***, research project funded by the Croatian Ministry of Science, Education and Sports, project leader: Antonio Šarolić, the project involved 10 researchers from several institutions (2008 - 2013);
- ***Electromagnetic compatibility – environment protection***, research project funded by the Croatian Ministry of Science, Education and Sports, lead by FER Zagreb, with Antonio Šarolić as the research partner (2007 - 2013);
- ***Integral system for radiocommunications and vessel surveillance in marinas***, innovation project funded by Business Innovation Croatian Agency – BICRO, project leader: Antonio Šarolić (2013 – ongoing);
- ***Enhancement of science-business cooperation for intraoperative neurophysiologic technology in Croatia*** – CortexSTIM, IPA IIIc grant - Science and Innovation Investment Fund (SIIF), lead by the School of Medicine of the University of Split, with Antonio Šarolić as the research partner (2013 – ongoing);
- ***Measurement in bioelectromagnetics*** – M-BEM, faculty research grant, project leader: Antonio Šarolić (2013 – ongoing).

Human subject during measurements of human body absorption inside a reverberation chamber

International research projects

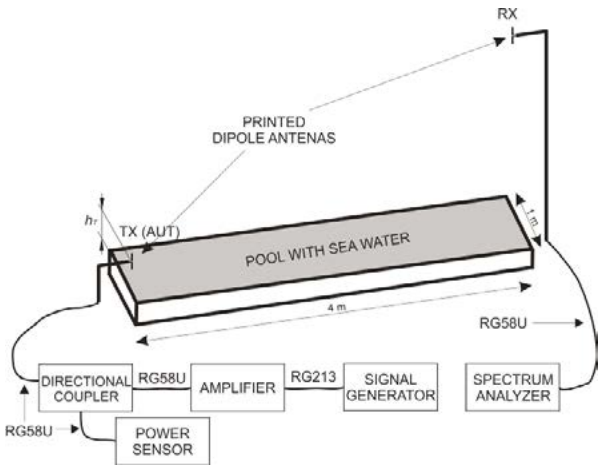
- ***COST Action BM 0704: Emerging EMF Technologies and Health Risk Management***, EU funded project, with Antonio Šarolić as the Management Committee Member (2008 - 2012);
- ***COST Action IC1102: Versatile, Integrated, and Signal-aware Technologies for Antennas (VISTA)***, EU funded project, with Antonio Šarolić as the Management Committee Member Substitute (2012 - ongoing):
- ***COST Action IC1004: Cooperative Radio Communications for Green Smart Environments***, EU funded project, with Antonio Šarolić as the Management Committee Member (2012 - ongoing);

International cooperation that included staff exchange or joint authorship of papers

- National Institute of Standards and Technology (NIST), USA
- Wroclaw University of Technology, Poland
- Austrian Institute of Technology GmbH (AIT), Austria
- Federal Office for Radiation Protection, Germany

In the period 2012-2013, the research group continued with the assessment of the human exposure to RF radiation in different scenarios (human eye exposure, pregnant woman exposure, human exposure near RFID antennas). Special interest remains on the topic of human body absorption in reverberating environment. A PhD student is investigating the proposed innovative methods for SAR estimation in such environments. The broadband electric field probe improvements regarding the probe response to the modulated signals was also studied. The physiological importance of such modulated, arbitrary waveform signals is being investigated through the project M-BEM. A PhD student will use the results to propose a novel design of the electric field probe. Both PhD studies are near completion, promising exciting new contributions and future publications. Regarding the topics of antennas and wireless communications, we studied the antenna parameters above the ground plane (infinitely and finitely conductive, specifically the sea surface), using analytical, simulation and measurement methods. An innovative setup for such measurements was engineered, realized and tested. In the field of maritime radiocommunications, innovative method of signal coverage near sea was proposed and is still being studied.

For the last two years, the group leader Antonio Šarolić has intensively worked on his proposal of a new European COST Action “European network for innovative uses of EMFs in biomedical applications”, for which he has gathered the support of researchers from more than 25 EU countries and USA. The proposal has recently been approved and the project is scheduled to start in 2014.



Setup for measuring radiation pattern of a vertical dipole over sea

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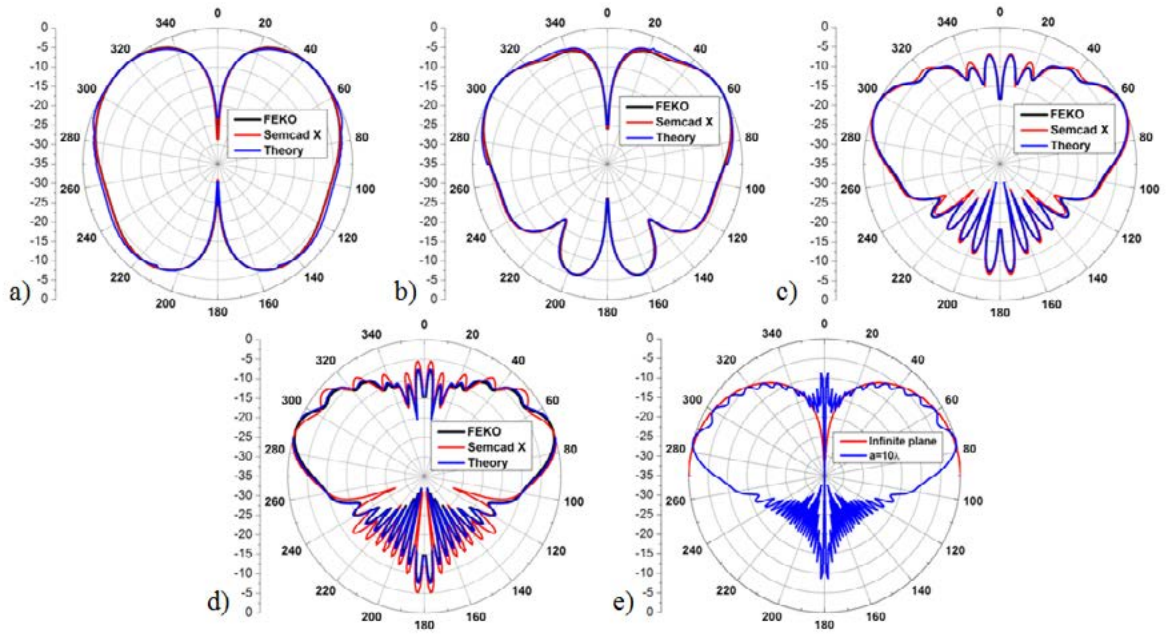

Vertical radiation patterns of the quarter wavelength monopole above the circular disc with radius: a) a=0.5λ, b) a=λ, c) a=3λ, d) a=5λ and e) a=10λ

Automation and Electric Drives

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Danijel Jolevski
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RESEARCH INTERESTS AND TOPICS

AC electrical machines and drives

power electronics

industry automation

advanced control systems

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DESCRIPTION OF LABORATORIES

The group has established 2 research laboratories for electrical machines and drives, and one laboratory for automation and control systems. The laboratories for electrical machines and drives differ according to size of electrical machines and converters which can be tested in them.

The laboratory for testing machines up to 50 kW has the ability to supply different power sources (variable DC voltage, AC voltage with variable frequency and amplitude). There are several motor-generator groups (slip-rings and squirrel cage induction machines, DC machine and synchronous machine) equipped with different power converters that enable comprehensive 4-quadrant testing of various drives. For measuring electrical and other operating variables the various measuring equipment is used, such as voltage and current probes, encoders and tachometers, multimeters, oscilloscope, dynamic signal analyzer, accelerometers, temperature sensors and thermal imaging.

The second research laboratory is used to test machines and drives up to 350 kW. There are two motor-generator groups realized by squirrel cage induction machines (125 kW and 315 kW) which are supplied and controlled by frequency converters that enable various experiments in 4-quadrant mode of operation.

The research laboratory for testing machines and drives up to 50 kW

The laboratory model of bridge crane

The laboratory for automation and control systems is partially used for research and lectures of students. For research activities the laboratory is equipped with the laboratory model of bridge crane, measuring devices, and control platforms. The bridge crane is used for development and testing of control algorithms.

THE GROUP AT A GLANCE

APPLIED RESEARCH

Off-line induction machine parameter identification

The main objective is the parameter identification of squirrel cage induction machine for the purpose of a self-commissioning scheme of induction motor drive with the rotor flux oriented control. The stator and rotor resistance, and transient inductance are determined at rotor standstill, while the main inductance and magnetization curve are obtained at no-load and low-load conditions. Identification results for large machines of different sizes (22 kW, 125 kW, 315 kW) are obtained and validated by comparison with the results obtained by the standard blocked-rotor test and the free deceleration test.

Optimization of three-phase PWM converter with LCL filter taking into account the system nonlinearities

Three-phase PWM converters are connected to the grid through LCL-filters. For the purposes of the LCL-filter design and optimization procedures usually all nonlinearities of the converter are neglected. Altough many different models exist, they often neglect copper and iron losses as well as the saturation effect of inductors. Detailed model of a three-phase voltage source converter is used to analyze the influence of system nonlinearities on the overall system performance and especially on the current harmonic spectrum at PCC. Nonlinearities which is included in the model are: dead time, voltage drop across the semiconductors, delays during IGBT on/off and propagation delays of converter's electronic circuits. The results is used to develop a method to optimize the LCL filter parameters. This method should be straightforward and based on existing standards. Verification of simulation models will be carried out on laboratory setups with nominal powers from 40 kW to 315kW.

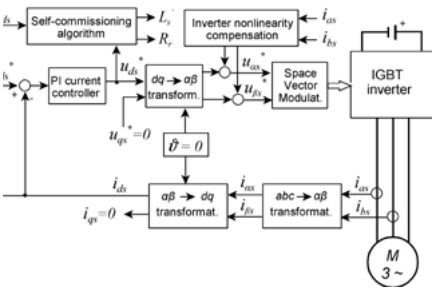
Predictive control of crane system with algorithm for sway reduction

The laboratory model of bridge crane is made for analysis of dynamics and control algorithms. The classical control algorithms of crane system are implemented for study and comparison with other control algorithms. Two types of the crane control methods are analysed: feedforward and feedback. The main interests of research are the feedback methods. Two types of cargo dynamics are considered: cargo with a fixed and variable centre of mass. Mathematical models of the bridge crane are developed for identification, prediction, and easy implementation in platform with limited resources (DSP – Digital Signal Processor). The criterion functions of predictive control algorithm are developed to achieve faster transfer of the cargo and sway reduction on target location or during transfer. The dynamics of hoisting are analysed and the impact of dynamics of hoisting on control of the bridge crane is taken into consideration with the use of adaptive predictive control.

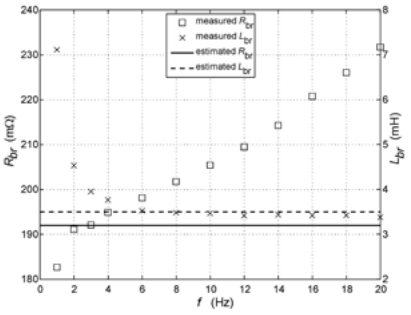
DEVELOPMENT PROJECTS

Electric drives for crane systems in heavy industry applications

In the last two years, the group mainly works on the project *„Electric drives for crane systems in heavy industry applications"* in cooperation with the Swedish company ABB AB Crane Systems. The main task is the development of frequency converters for AC squirrel cage motors especially designed for heavy industry applications. The converters are designed to fulfill all the industry standards for heavy duty operations, safely and cost effectively. The requirements are set by the demanding conditions in the steel making environment with temperatures up to +70°C and conductive



Block diagram of d-axis current control for single-phase standstill tests



Experimental results of the standard blocked-rotor test

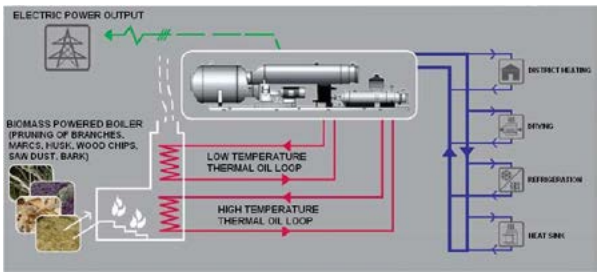
Prototype of 60A frequency converter

dust. The drives are designed utilizing the latest digital signal processors and component technology that guarantee safe and reliable service throughout a long service life.

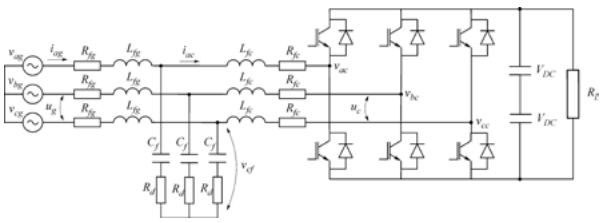
State-of-the-art technology is used in the development and design of the frequency converters:

- **Power electronics** – IGBT module (1200 V, 1000 A);
- **Microelectronics** – SMD technology, multilayer boards;
- **Microcontroller technology** - Texas Instruments TMS320F28335 floating point digital signal controller;
- **Industrial communications** – CAN and PROFIBUS protocols;
- **Sensors** – current, voltage, temperature, vibration;
- **TINA Software Package** – Designing, simulation and analyzing of analog, digital and MCU electronic circuits;
- **Matlab Software Package** - Mathematical modeling and simulation of power electronics converter and vector controlled induction machine;
- **eDRAWINGS** – 3D mechanical layout design software;
- **Code Composer Studio** - Development software (C++)

The main activities of Group on the project are: electronic boards designing and testing, designing application software, implementation of control and protection functions, optimization of layout and efficiency of power circuits in frequency converter (IGBT module, inductors, capacitors, layout), testing and analyzing various drive mode of operations, type testing of the prototypes, reports writing, documentation preparation, taking part in first drive installations.



Block diagram of cogeneration plant



Three-phase PWM converter with LCL-filter

Control of ORC cogeneration plant with high speed PM generator

Last year the group started new development project "Control of ORC cogeneration plant with high speed PM generator" in cooperation with Croatian company Banko d.o.o. In the cogeneration ORC plant the waste heat is converted to electrical energy using organic oil as working fluid. From the point of maximum efficiency the high speed turbine with directly coupled PM generator are preferred. Because of high and variable frequency of generator voltage it is necessary to use frequency converter between generator and grid. The main tasks of research group are:

- Investigation of optimal control structure in order to achieve maximum safety and efficiency of plant
- Development of frequency converter that enables transfer of energy from the high-speed PM generator to the grid.

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The results having come out of the 2 year research period are presented in:

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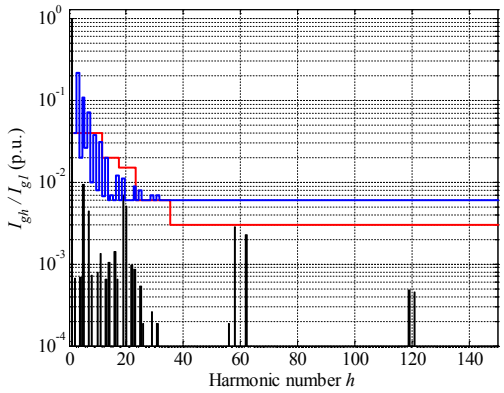
2. Terzić, Božo; Despalatović, Marin; Slutej, Alojz, **Magnetization Curve Identification of Vector-Controlled Induction Motor at Low-Load Conditions**. *// Automatika*. 53 (2012)
3. Majić, Goran; Despalatović, Marin; Terzić Božo; Slutej Alojz., **Influence of Dead-time on Design of LCL-filter for Three-phase Voltage Source Converter** *// EDPE 2013*, Dubrovnik, 2013.
4. Jadrić, Martin; Terzić, Božo; Despalatović, Marin; Majić, Goran; Slutej, Alojz; Šimić, Toni. **Identification of Rotor Resistance and Transient Inductance of Induction Motors Using Frequency Selection Criterion** *// Proceedings of the 2012 XXth International Conference on Electrical Machines* / Marseille, Francuska



Grid current harmonic spectrum at PCC related to fundamental current harmonic

Numerical Modeling of Electromagnetic Phenomena in the Electric Power System

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Research Group for Numerical Modeling of Electromagnetic Phenomena in the Electric Power System at the Department of Power Engineering, with the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture deals with development of new algorithms and improvement of previously developed algorithms for numerical modeling of low and high frequency electromagnetic phenomena in electric power systems.

The group has established three research laboratories: Lab for Testing of Electrical Installations, Lab for Electromagnetic Compatibility and a Research Lab. 2)

RESEARCH INTERESTS AND TOPICS

time-harmonic and transient analysis of complex grounding systems

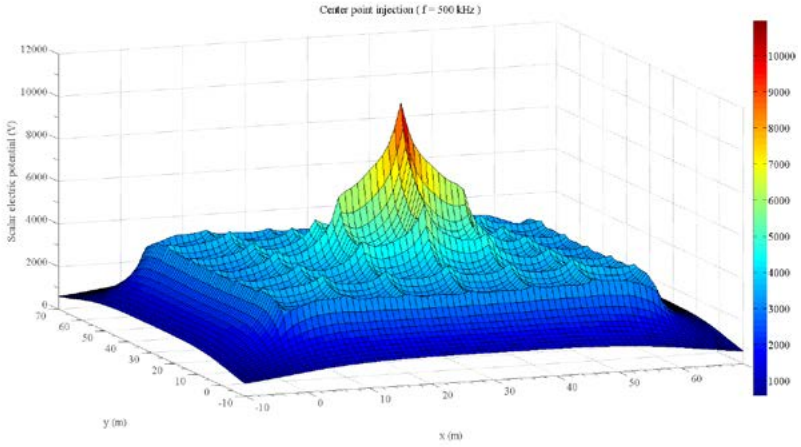
3D computation of electric and magnetic fields of electric substations and transmission lines

computation of electromagnetic transients in linear and nonlinear electrical networks

computation of ground-fault current distribution in electric power system

computation of electromagnetic transients in wind farm electrical systems

lightning interaction with transmission lines and electric power substations



Earth surface scalar electric potential at 500 kHz (center point injection)

THE GROUP AT A GLANCE

Activities of the Group for Numerical Modeling of Electromagnetic Phenomena in the Electric Power System can be divided into the following areas of research:

Time-harmonic and transient analysis of grounding systems in horizontally stratified multilayer earth

The Group deals with advanced electromagnetic models of grounding systems in horizontally stratified multilayer earth. The main computation is performed in the frequency domain, so sophisticated time-harmonic model of the grounding system was developed based on the application of finite element method to the integral problem formulation in the frequency domain. For transformation purposes between the time domain model and frequency domain model a sophisticated method for transformation, dubbed the Continuous Numerical Fourier Transform and Inverse Continuous Numerical Fourier Transform, were developed, which enable reliable and fast computation. This procedure even enables the computation of soil ionization in the frequency domain, which most other models that perform the main computation in the frequency domain can not take into account.

3D Computation of electric and magnetic fields of electric substations and power lines

The Group also deals with the development of a three-dimensional, advanced, quasistatic electromagnetic model for the computation of electric and magnetic fields of electric power substations and electric power (transmission) lines.

Computation of electromagnetic transients in linear and nonlinear electrical networks

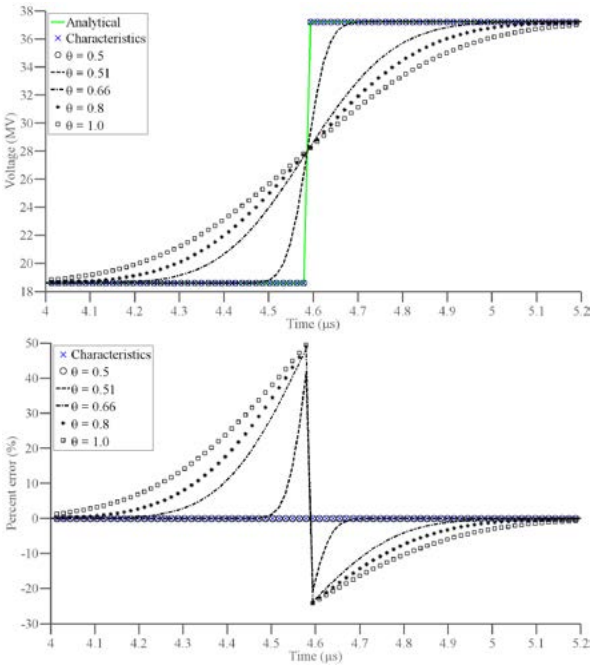
The Group has developed an advanced numerical model, based on the finite element method, for computation of electromagnetic transients on multi-conductor transmission lines including frequency-dependent parameters. The finite element model of electromagnetic transients has been done both in the time-domain and frequency-domain and for linear and nonlinear networks.

Computation of ground-fault current distribution in electric power system

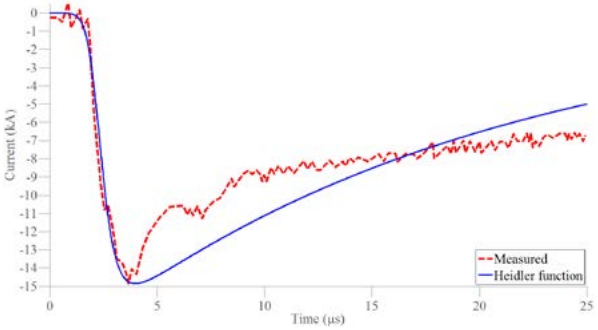
The Group has developed a finite-element based advanced electromagnetic model for the computation of the ground-fault (i.e. single-pole short-circuit) current, which enables more accurate computation of ground-fault current necessary for the design of the substation grounding systems.

Computation of electromagnetic transients in wind farm electrical systems

The Group has developed a detailed model for the computation of electromagnetic transients in wind farm (and wind turbine) electrical systems, by means of extending the EMTP-ATP computational environment using the models language and interfacing it with the external tools (Matlab, Python). The model is suited for the analysis of electromagnetic transient arising from the direct and indirect lightning strikes in the wind farm (e.g., backsurge propagation), switching transients, temporary overvoltage calculations, capacitor bank switching transients, selection and numerical testing of metal-oxide surge arresters (risk of failure, energy withstand capability, protection level), etc.



Voltage wave front and percent error of voltage wave front at x = 25 m



Heidler function approximation of a triggered lightning return-stroke current waveshape (stroke FPL0315-2)

Lightning interaction with transmission lines and electric power substations

The Group has developed models which simulate interaction of lightning with high voltage transmission lines and power substations (switchyards). The model allows the computation of the expected number of lightning strikes to transmission lines, transmission line shielding failure rate (SFR), transmission line shielding failure flashover rate (SFFOR) and backflashover rate (BFR) of transmission lines. It estimates lightning surge parameters of the traveling wave incoming on the power substation, as seen necessary for the design of the substation overvoltage protection (and selection of metal-oxide surge arrester parameters). The model also allows for the efficient design of the electric power substation lightning protection system (LPS), by means of optimizing the system of lightning rods (position and length). Model interacts with the EMTP-ATP computational environment.

HIGHLIGHTS

In the last two-year period the Group was involved in two national projects funded by the Ministry of Science, Education and Sports. There were two PhD Vivas in the period from the beginning of 2012 to the end of 2013 – A. Bernadić (2013) and D. Lovrić (2013).

In the last two-year period the Group has developed advanced time-harmonic and transient electromagnetic models for analysis of grounding systems in horizontally stratified multilayer earth. These models are based on the application of finite element technique to an integral problem formulation. These models enable analysis of bare cylindrical and rectangular conductors and metal screens of single-phase and three-phase cables. For transformation between the time and frequency domain and vice versa a Continuous Numerical Fourier Transform (CNFT) and Inverse Continuous Numerical Transform (ICNFT) were developed. These advanced algorithms enable fast, accurate and reliable computation and even enable the inclusion of the soil ionization effect which is not the case in similar models available in the literature.

In the 2012-2013 period the Group also dealt with the development and advancement of numerical models for computation of electromagnetic transients in linear and nonlinear networks in the time domain using the finite element method and the method of characteristics.

The Group has also developed a hybrid model for computation of ground-fault current in electric power systems and a sophisticated 3D quasistatic electromagnetic model for computation of electric and magnetic field of electric power substations and electric power lines. Furthermore, advanced algorithms were developed for numerical analysis of overvoltages in wind turbines and on overhead and buried electric power lines.

SELECTED REFERENCES

The results having come out of the 2 year research period were published in a number of publications. Some selected papers are given here:

Journal papers (CC, SCI, SCI Expanded) (11)

1. Lovrić, Dino; Vujević, Slavko; Modrić, Tonći. **On the estimation of Heidler function parameters for reproduction of various standardized and recorded lightning current**. *// International Transactions on Electrical Energy Systems*. 23 (2013), 2; 290-300.
2. Jurić-Grgić, Ivica; Lucić, Rino; Dabro, Mate. **A coupled nonuniform transmission line analysis using FEM**. *// International Transactions on Electrical Energy Systems*. 23 (2013), 8; 1365-1372.
3. Lucić, Rino; Jurić-Grgić, Ivica; Balaž, Zdenko. **Grounding grid transient analysis using the improved transmission line model based on the finite element method**. *// International Transactions on Electrical Energy Systems*. 23 (2013), 2; 282-289.
4. Sarajčev, Petar; Vasilj, Josip; Goić, Ranko. **Monte Carlo analysis of wind farm surge arresters risk of failure due to lightning surges**. *// Renewable Energy*. 57 (2013), 626-634.
5. Lucić, Rino; Jurić-Grgić, Ivica; Lovrić, Dino. **A characteristics-based finite element method for transmission line**. *// Electric power systems research*. 84 (2012), 1; 152-158.
6. Vujević, Slavko; Sarajčev, Petar; Lovrić, Dino. **Time-harmonic analysis of grounding system in horizontally stratified multilayer medium**. *// Electric power systems research*. 83 (2012), 1; 28-34.
7. Sarajčev, Petar. **Analysis of Electromagnetic Influences Concerning Two Adjacent Parallel High-current Bus Ducts**. *// Electric power components and systems*. 40 (2012), 8, 829-844.
8. Sarajčev, Petar; Goić, Ranko. **Assessment of the backflashover occurrence rate on HV transmission line towers**. *// European transactions on electrical power*. 22 (2012), 2, 152-169.
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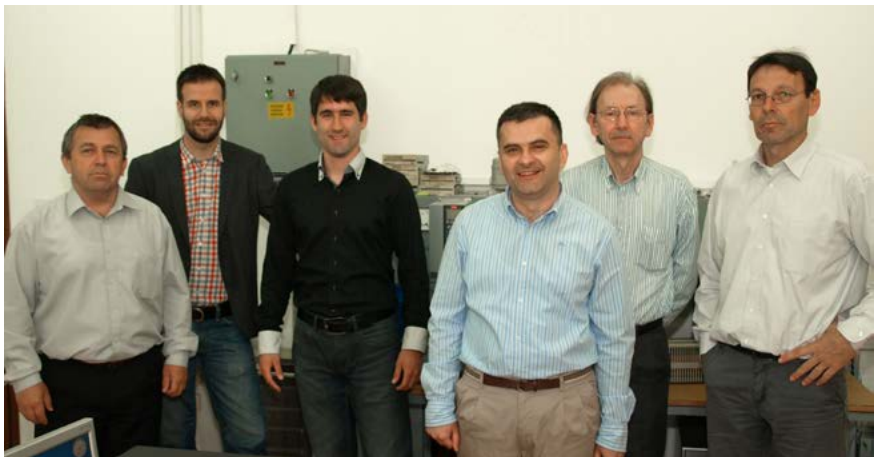
10. Boras, Vedran; Vujević, Slavko; Lovrić, Dino. **A hybrid algorithm for computation of rectangular conductor internal impedance**. *// Tehnički Vjesnik-Technical Gazette*. 19 (2012), 2, 341-346.
11. Vujević, Slavko; Balaž, Zdenko; Sarajčev, Petar; Modrić, Tonći. **Hybrid Model for Analysis of Ground Fault Current Distribution**. *// International Review of Electrical Engineering-IREE*. 7 (2012), 2, 4035-4045.

Power Electronics and Automation



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RESEARCH INTERESTS AND TOPICS

power electronics

induction machine control systems

switched reluctance machine control systems

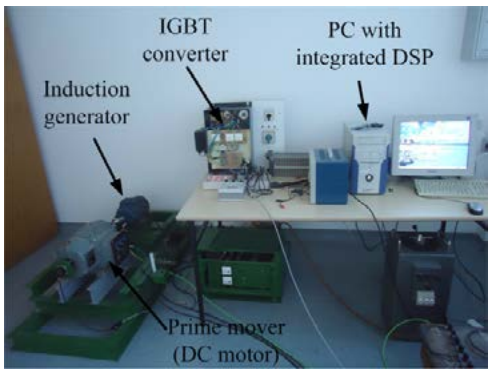
applications of artificial intelligence in control

long-term/mid-term hydrothermal scheduling

The Research Group for Power Electronics and Automation at the Department of Power Engineering, with the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split deals with advanced control systems for induction and switched reluctance machines, including investigation of related power converter topologies, losses and switching schemes, real-time application of artificial-intelligence-based algorithms for efficiency optimization and long-term/mid-term hydrothermal scheduling.

The group has established one research laboratory: Research laboratory for Power Electronics. The objective is rapid prototyping of control systems through Hardware-in-the-Loop simulations. Research laboratory for Power Electronics is equipped with the following major laboratory equipment:

- two dSpace DS1104 boards
- two scopes Tektronix TDS 1002
- three current clamps 80i-110s, manufactured by Fluke
- four-quadrant DC converter rated at 52.5 kW, manufactured by Siemens
- torque transducer TMB 308, manufactured by Magtrol
- programmable DC power supply rated at 1.5 kW, manufactured by Magna-Power Electronics
- three double-tube resistors rated at 3.39 kW



Experimental setup of the SEIG vector control system

THE GROUP AT A GLANCE

Activities of the Research Group for Power Electronics and Automation can be divided in the following research areas:

FUNDAMENTAL RESEARCH

Advanced modelling of the induction machine

The Group's activities in this field are focused on the development of an advanced induction machine model which is based on the accurate determination of the machine's parameters. The emphasis is placed on proper measurement and presentation of the iron losses followed by their inclusion into the induction machine model. The iron losses are known to be nonlinear and dependent on the magnetizing flux magnitude and frequency. Such approach to induction machine modelling should lead to a more accurate dynamic and loss analysis and, more importantly, to a more reliable control algorithm.

Advanced modelling of the switched reluctance machine

Activities in this field are to a great extent similar to those above and are hence focused on the accurate experimental determination of the switched reluctance machine's parameters. In particular, the iron losses are shown to be nonlinear and dependent on three different parameters, making their incorporation into the machine model a bit more difficult task. Anyway, by accomplishing it, a more accurate dynamic analysis and a more reliable control of the switched reluctance machine should naturally follow.

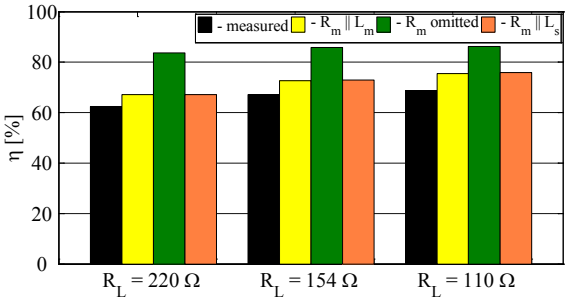
APPLIED RESEARCH

Induction machine control systems

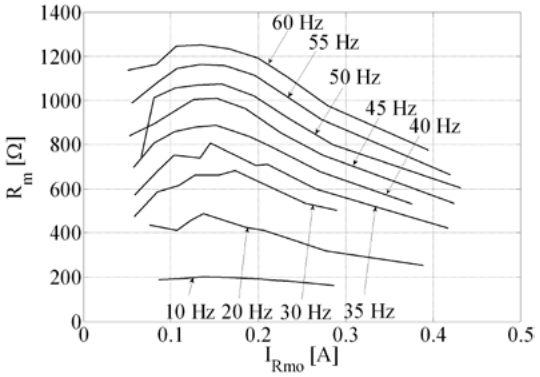
The Group's activities are mainly focused on the development of new control algorithms for the induction machine. One of the recent achievements in this field is the development of an advanced vector control algorithm for the self-excited induction generator (SEIG). The control algorithm takes into account both the magnetic saturation and the iron losses. Except for the extensive simulation-level testing of the developed control algorithms, great attention is paid to their real-time application and testing with an aid of the cutting-edge signal processing tools. It should be also noted that the real-time application and testing sometimes require designing and constructing of the power converter prototypes.

Application of artificial intelligence in control

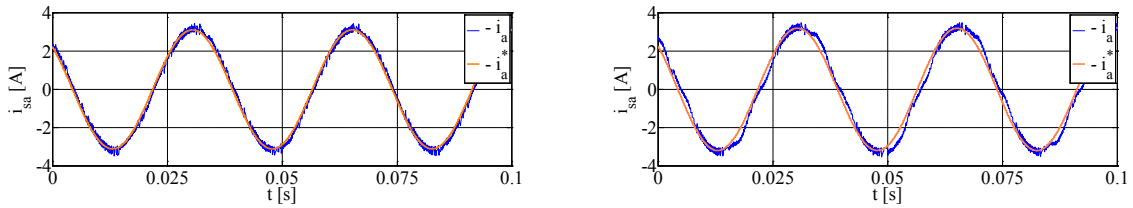
A good part of the Group's efforts is invested in development of artificial-intelligence-based algorithms aimed to achieving maximum efficiency and/or better control of the induction and switched reluctance machines. Examples are fuzzy-logic-based flux optimization (maximum efficiency) and hedge-algebra-based voltage control (better control), the latter being developed through collaboration with the Research and Development Center at the Duy Tan University in Da Nang, Viet Nam.



SEIG efficiency variation with load (n = 1200 rpm, C = 50 μF)



Measured equivalent iron loss resistance characteristics (proposed SEIG model)



Steady-state stator phase current (experiment): (left) control system with iron losses and (right) control system without iron losses

Statistical analysis and modelling of basin inflows for hydrothermal scheduling

For optimal hydrothermal scheduling, natural inflows into reservoir systems present one of the major uncertainties of the planning process. The main goal was to find the appropriate inflow model for the long-term/mid-term hydrothermal scheduling that accurately represents the real conditions. The statistical analysis of observed inflows aims to explore how well the inflow model describes the actual data.

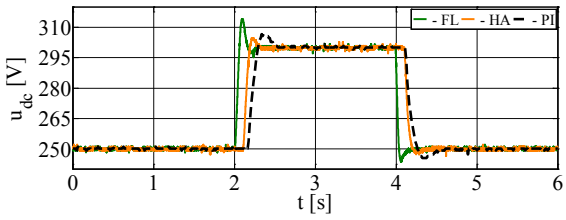
INTERNATIONAL COLLABORATION

The Group has established contacts and developed a fruitful cooperation with the Research and Development Center at the Duy Tan University in Da Nang, Viet Nam. The collaboration with the Research and Development Center has so far resulted in the development of the hedge-algebra-based controller for the vector controlled self-excited induction generator, which is the first recorded application of the hedge algebra in electrical engineering. Research results were submitted to the Control Engineering Practice journal of Elsevier.

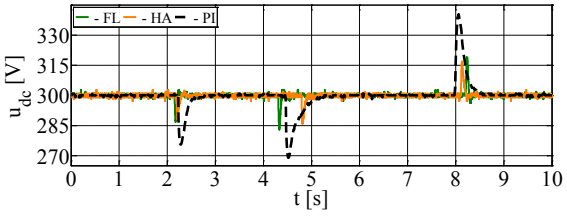
HIGHLIGHTS

In the last two years, several advancements were achieved in modelling and control of the induction and switched reluctance machines. Namely, two new dynamic models of the squirrel-cage induction machine were developed in which the iron losses are accounted for as dependent on both the frequency and magnitude of the magnetizing flux. These models differ with respect to the placement of the equivalent iron loss resistance within the machine's equivalent circuit. This development was followed by another one, i.e., that of a new vector control algorithm for the self-excited induction generator (SEIG), which was in fact derived from one of the two newly developed models of the induction machine. As part of the control algorithm development, several different approaches to voltage control have been tried and experimentally verified, including applications of the fuzzy logic and hedge algebra. The latter one involved a development of a completely new type of voltage controller. Also, several different approaches to efficiency optimization have been developed and experimentally verified, one of which involved a wind turbine as the prime mover for the induction generator. In addition, a new experimental approach to determining the parameters of the switched reluctance machine has been tested. Although there is still plenty of work left to be done, the results obtained so far are promising to such extent that it is not unreasonable to assume that new advancements in this field, e.g. development of the corresponding advanced dynamic model and control algorithm, are just waiting around the corner.

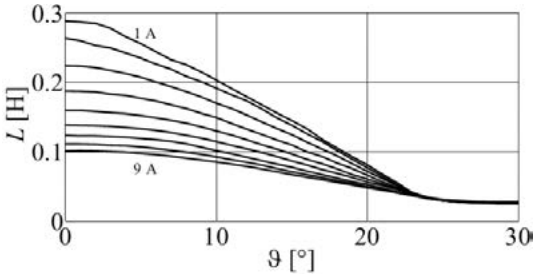
In February 2013, a PhD Viva involving the member of the Research Group, M. Bašić, was held at the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split



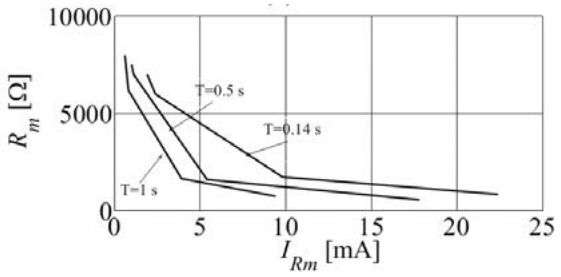
Response of the actual SEIG voltage to step changes in the reference value (experiment) - Fuzzy-Logic, Hedge-Algebra and PI voltage controller



Response of the actual SEIG voltage to step changes in load resistance (experiment) - Fuzzy-Logic, Hedge-Algebra and PI voltage controller



Measured phase inductance profile with respect to phase current and rotor position (switched reluctance machine)



Measured iron loss resistance versus iron loss current for various switching periods (switched reluctance machine)

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The results having come out of the last 2 year period are documented in various publications as follows:

1. **Fuzzy Logic - Applications, Systems and Technologies** / Vukadinović, Dinko (Ed.). New York: Nova Science Publishers, 2013

2. **Fuzzy Control Systems** / Vukadinović, Dinko (Ed.). New York: Nova Science Publishers, 2012

3. Bašić, Mateo; Vukadinović, Dinko. **Vector control system of a self-excited induction generator including iron losses and magnetic saturation.** *// Control engineering practice*. 21 (2013), 4; 395-406

4. Bašić, Mateo; Vukadinović, Dinko; Petrović, Goran. **Dynamic and Pole-Zero Analysis of Self-Excited Induction Generator Using a Novel Model with Iron Losses**. *// International journal of electrical power & energy systems*. 42 (2012), 1; 105-118

5. Bašić, Mateo; Vukadinović, Dinko; Polić, Miljenko. **Fuzzy DC-Voltage Controller for a Vector Controlled Stand-Alone Induction Generator**. *// INTERNATIONAL JOURNAL OF CIRCUITS, SYSTEMS AND SIGNAL PROCESSING.* 7 (2013), 1; 181-190

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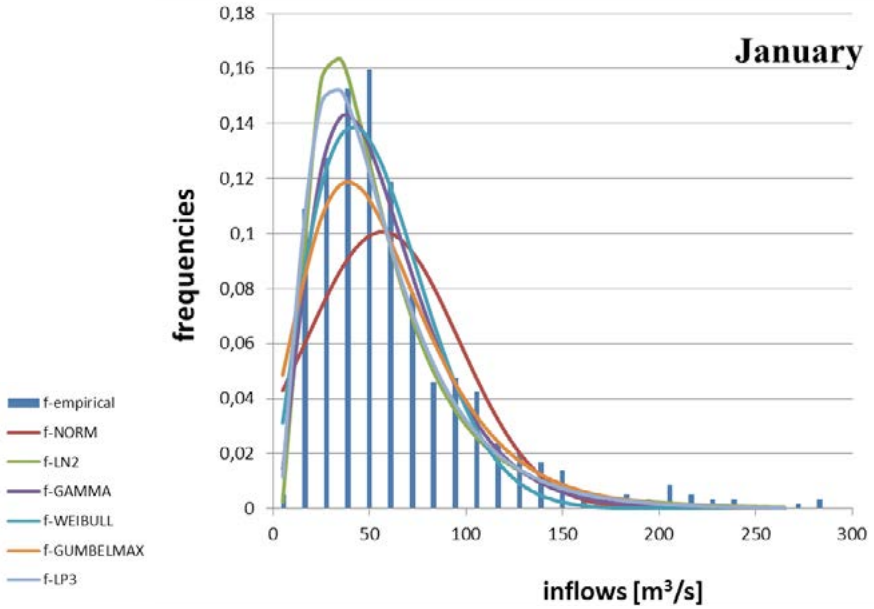

Statistical analysis of inflows

Nanoelectronics and Photovoltaics

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RESEARCH INTERESTS AND TOPICS

electronic devices and circuits

digital instrumentation and signal processing

optoelectronics and photovoltaics

nanoelectronics

Research group for Linear and Nonlinear Analysis of Thin-Walled Structures at the Department of Mechanical Engineering and Naval Architecture, University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture deals with advanced theories of bending and torsion of thin-walled beams with applications in analyses of thin-walled structures, modelling of thin-walled structures subjected to enviromental loads (wind, waves and other operational loads) and development of phenomenological elasto-plastic constitutive models for orthotropic metal sheets.

The group has established 2 research laboratories: Lab for Mechanics and Lab for Fluid Power.

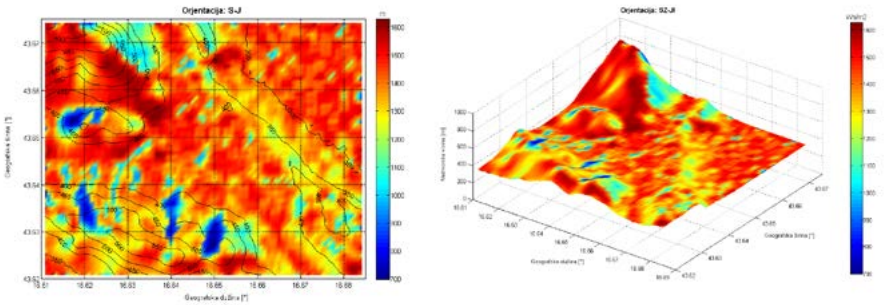
THE GROUP AT A GLANCE

Activities of the Group for Nanoelectronics and Photovoltaics include several fundamental and applied research areas:

FUNDAMENTAL RESEARCH

Semiconductor nanostructures for optoelectronic devices

The main activity is related to semiconductor nanostructures modeling. The focus is given to silicon nanostructures, especially to ensembles of silicon quantum dots embedded in an insulating matrix (SiO2, Si3N4, SiC). Percolation-based models are developed to



Computed 2D and 3D distribution of solar radiation for analyzed microlocation.

study transport mechanisms in such systems. Furthermore, the models were adopted for studying noise in any partially or completely disordered systems. It was shown that such study can give useful information related to the electrical properties of the system and this method was successfully applied to failure analysis of medical electrodes.

Solar radiation measurement and modeling

A number of available models for estimating global horizontal radiation from sunshine duration were analyzed and their validity for Croatian climate was studied. Another activity is related to development of 3D solar radiation maps for precise estimation of solar energy potential on any micro-location.

APPLIED RESEARCH

Stand-alone and grid-connected photovoltaic systems

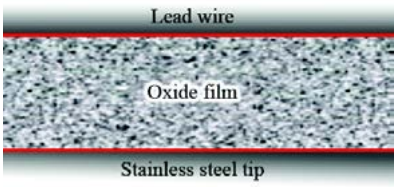
The group continuously works on theoretical and experimental research on both stand-alone and grid-connected photovoltaic systems. Theoretical study includes analysis of available and development of novel models for all components comprising a photovoltaic system (solar cell, photovoltaic module, inverter, batteries, etc.). Furthermore, some practical issues related to grid-connected photovoltaic systems are analyzed like operation in mismatched conditions, optimal sizing and positioning of photovoltaic modules and land use in case of fixed or tracking systems. Experimental study includes PV module testing under real operating conditions as well as combining photovoltaic and solar thermal systems for energy efficient solar heating/cooling.

INTERNATIONAL COLLABORATION

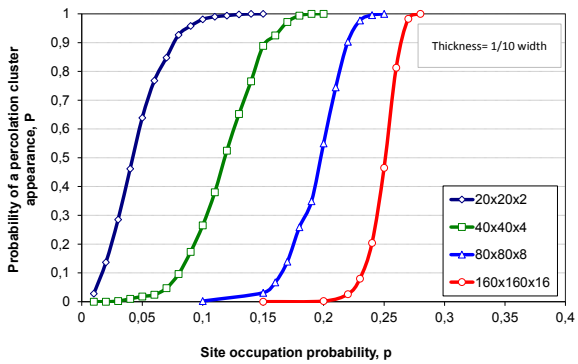
The group has established collaboration with a number of international research groups. The majority of the international collaboration is related to experimental part of the studies. Currently, the collaboration is most intensive with the following institutions:

1. CENIMAT/I3N, Lisbon, Portugal (Si quantum dots in an insulating matrix for photovoltaic applications)
2. Sinchrotrone “Elettra”, Trieste, Italy (SAXS/GISAXS measurements)
3. Fakulteta za elektrotehniko, Ljubljana, Slovenija (noise measurements in disordered semiconductor quantum dot ensembles)
4. Institut “Jožef Stefan”, Ljubljana, Slovenija (hybrid polymer-nanoparticle solar cells)

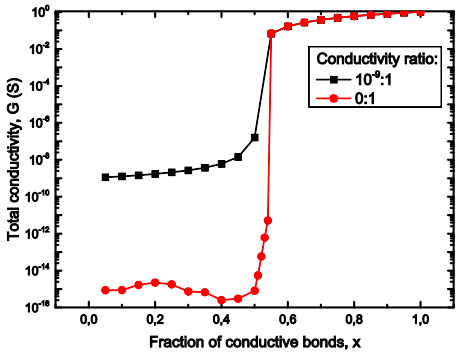
Schematic representation of solder joint microstructure.



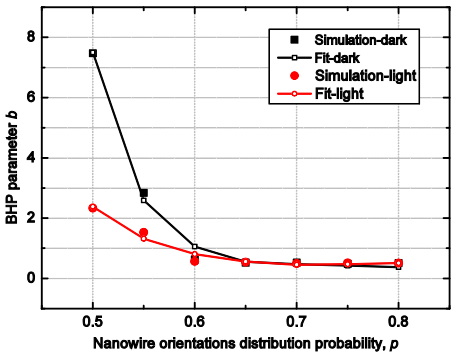
Percolation probability on thin films.



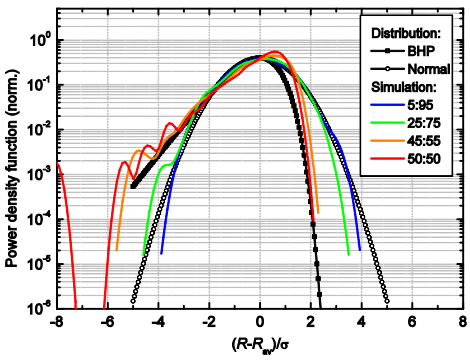
Conductivity of random resistance network of size 100 x 100



BHP parameter b as a function of the nanowire orientation distribution.



Normalized PDF for various distributions of the nanowire orientations under light conditions.



HIGHLIGHTS

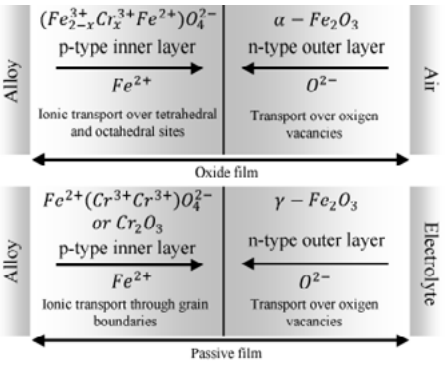
In last two years the Group was involved in one international project ("Low temperature controlled incorporation of Si quantum dots in amorphous matrices (Si, SiC and SiN) for application as active layers in single- and multi-junction solar cells", prof. Zulim active researcher). In the period from the beginning of 2012 to the end of 2013 there was one PhD Viva – Ivan Marasović (May 2012).

The advances achieved include improvements in modeling breakdown phenomena in dielectric films, electrical transport in ensembles of silicon quantum dots and electrical properties of complex nanostructure devices like nanowire grid light sensor. Models based on percolation theory and random resistor networks have been further improved and are applied in failure analysis of medical electrodes.

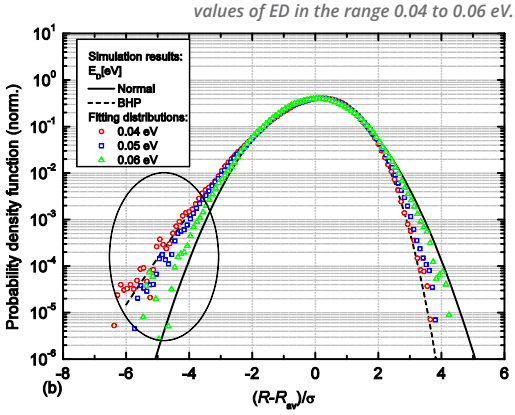
The study of solar radiation has included analysis of available sunshine models to Croatian climate as well as development of 3D solar radiation maps.

The activities in the area of photovoltaic systems have included computer modeling of small photovoltaic systems in the various mismatch conditions (shadowing, connection of different PV modules etc.), study of optimal land use for fixed and different tracking technologies and analysis of models for estimating electricity production from the grid-connected photovoltaic systems.

Schematic representation of the diffusion processes through the individual layers of thermally grown oxides and passive films.



Distribution of the resistance fluctuations for different values of ED in the range 0.04 to 0.06 eV.



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The results having come out of the 2 year research period are documented in various publications. The most important references are given:

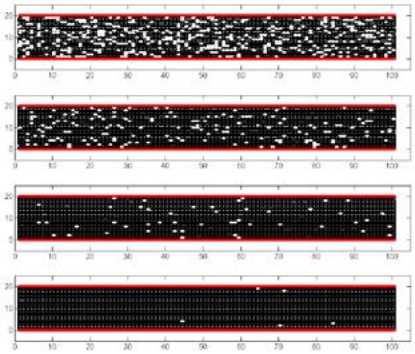
Journal/conference papers

1. Marasović, Ivan; Garma, Tonko; Betti, Tihomir. **Modelling a nanowire grid for light-sensing applications**. *// Journal of physics*. D, Applied physics. 45 (2012), 21; 215103-1-215103-11

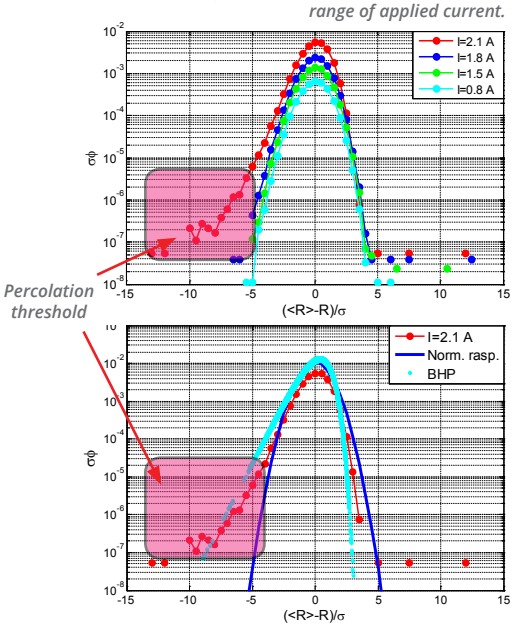
2. Garma, Tonko; Milanović, Željka; Marasović, Ivan. **Insulation verification using low voltage and high current sensitivity**. *// Engineering review*. 32 (2012), 2; 86-95

3. Milanović, Željka; Marasović, Ivan; Zanchi, Vlasta. **Analysis of PD response on different input voltages and incident light wavelengths**. *// Proceedings of International Conference on Innovative Technologies IN-TECH 2012*

Evolution of 20x100 RRN for different values of ED (from 0.04eV to 0.15eV top to bottom).



Distribution of the resistance fluctuations for wide range of applied current.



TECHNICAL SCIENCES

MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE

Cutting and Deformation Processes

GROUP LEADER
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Research Group for Cutting and Deformation Processes, at the Department of Mechanical Technology deals with conventional and nonconventional metal cutting processes, CAD/CAM technology, rapid prototyping, reverse engineering and deformation processes.

The group has established three research laboratories: Machine tools laboratory, CAD/CAM laboratory and Laboratory for deformation processes.

RESEARCH INTERESTS AND TOPICS

cutting processes

deformation processes

monitoring and control of cutting and deformation processes

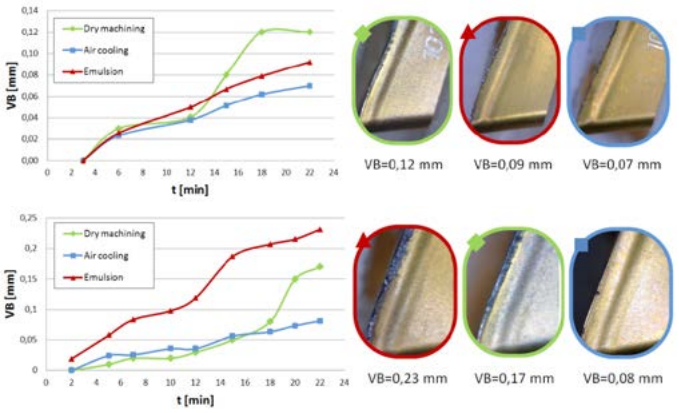
reverse engineering and rapid prototyping

THE GROUP AT A GLANCE

Activities of the Group for Cutting and Deformation Processes are divided in the following areas of research:

Sustainable production technologies

Sustainable production technologies have become an important area of research and the research team is working to develop mathematical models that describe machining processes using alternative types of cooling in form of the compressed cold air. The vision is to strive towards an environmental friendly machining processes and to investigate the capabilities and benefits of applying dry machining and alternative types of cooling in terms of reaching a better surface quality with longer tool life.



Variation of flank wear for different machining environment

Modeling of cutting processes for predictive simulation

Research of the cutting processes with various workpiece and tools materials has been carried out with a particular emphasize to predict problems on the early stages of manufacturing process. Therefore the group works constantly with the modeling of cutting processes using different mathematical methods. Our objective is to combine extremely close tolerances with reduced cycle times and high production volumes.

Real-time analysis of processing data and machine elements impact on the stability and machining performance

In last two year the research group has been concentrating on interference problems associated with the manufacturing processes. Such disturbances may be a lack of rigidity in the machine system, clamping or workpiece. The research team is developing an advanced prototype systems for processing control connected to a CNC machine center.

Rapid prototyping

In the field of rapid prototyping the group has developed the procedure for preparation and printing models which are used for planning purposes of the filling line in the actual plant. Rapid prototyping enables the quick production of physical models using three-dimensional computer aided design (CAD) data.

Micro milling

Mechanical micromachining is increasingly finding applications in production of components in various fields, such as, biomedical devices, optics, electronics, medicine, communications, etc. Our focus is to investigate the feasible machining by means of micro mills and to provide model-based estimation and the control of mechanical systems.

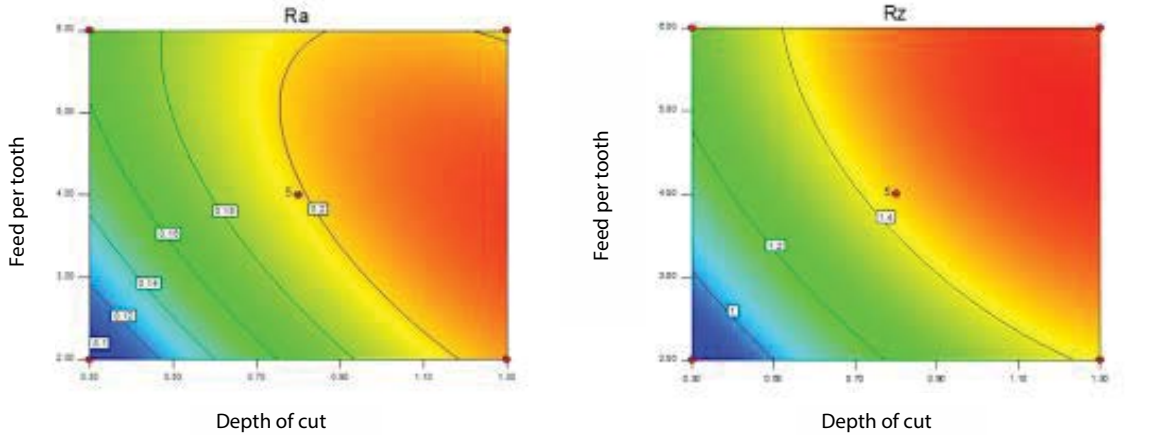
HIGHLIGHTS

The main research goals in the period 2012-2013 were as follows:

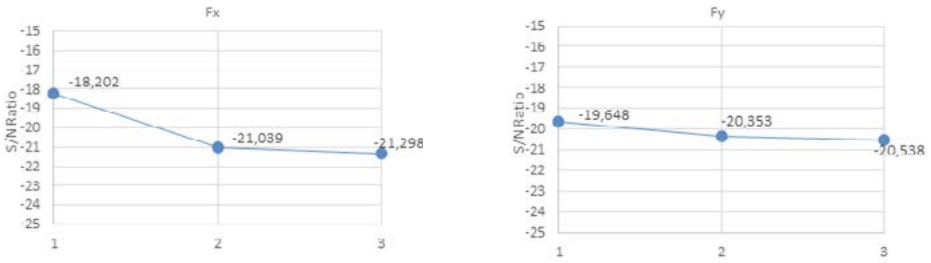
- Determination of the influence of cutting parameters on the output process variables for cutting processes applying cooling with compressed cold air using vortex tube.
- Obtaining mathematical models which describe surface roughness and cutting force in down and up micro milling.
- Using CAD/CAM system based on software package CATIA V6R19 it was enabled to machining complex geometry workpiece on the three-axis CNC machining center such as parts for Student Formula Project.

In last two years the Group was involved in two national projects.

The results having come out of the 2 year research period are presented in various publication.



Surface diagram of variation of surface roughness, micro milling



Main effects plot of S/N ratios for Fx and Fy, micro milling

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2. Bajić, Dražen; Celent, Luka; Jozić, Sonja. **Modeling of the influence of cutting parameters on the surface roughness, tool wear and the cutting force in face milling in off-line process control**. *// Strojniski vestnik - Journal of mechanical engineering*. 58 (2012), 11; 673-682
3. Celent, Luka; Bajić, Dražen; Jozić, Sonja. **Effect of cooling with cold compressed air using vortex tube on tool performance in milling process** *// CIM2013 Computer integrated manufacturing and high speed machining*. 2013. 87-92
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5. Celent, Luka; Prelas, Ivan. **Green manufacturing through sustainable machining process** *// Mechanical Technologies and Structural Materials conference* / Živković, Dražen (ur.). Split: HDST, 2013. 79-86
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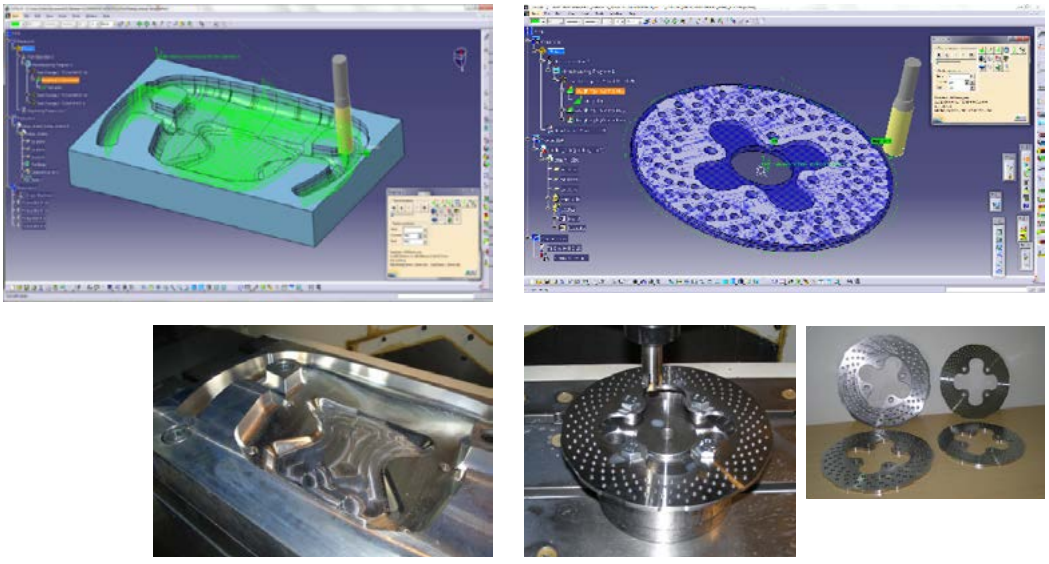
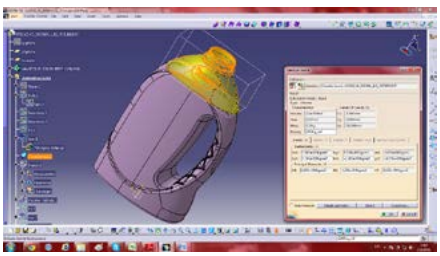
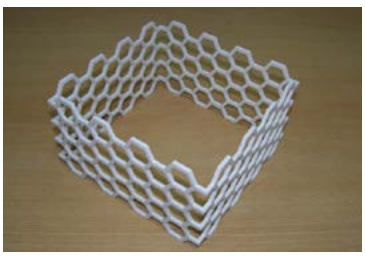
9. Duplancic, Igor; Lela, Branimir; Musa, Ante; Zovko, Oliver. **Functional Data Analyses in Control of Extrusion Process** *// Proceedings of the Tenth International Aluminum Extrusion Technology Seminar*. Wauconda, Illinois, USA: ET Foundation, 2012. 655-663



CAD/CAM – Parts for Student Project Formula



Constructing models according to a size of 3D printer workspace in CATIA V5 R19



Printed model of hexagonal cell, 200 mm × 200 mm × 110 mm, wall thickness 3 mm

Applied Thermodynamics

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DESCRIPTION OF LABORATORIES

Laboratory for new thermo-energy technologies at FESB is equipped with state of the art stations for testing of fuel cells (Teledyne Medusa), with built-in electrochemical impedance spectroscopy (Scribner & Assoc.), and data acquisition (software: Scribner & Assoc.; hardware: National Instruments), potentiostat/galvanostat for electrochemical measurements (BioLogic), several sets of fuel cell hardware (Fuelcell Technologies Inc.), in-house made segmented fuel cell with individual segment temperature control with Peltier elements and relative humidity sensors between the segments, two generations of complete 1 kW fuel cell system (Nexa) and equipment for their testing (Heliocentris).

Laboratory for thermodynamics currently has two in-house built test beds: one for experimental simulation of convective vortices and the other one for studying of a hybrid energy system consisting of a standard air-conditioning split system unit, with integrated boiler for the preparation of the hot water, and powered by a photovoltaic panel.

Laboratory for heat engines is yet to be equipped with research equipment and instrumentation. Current research is performed using Lotus and Ricardo software packages for simulation and optimization of internal combustion engines.

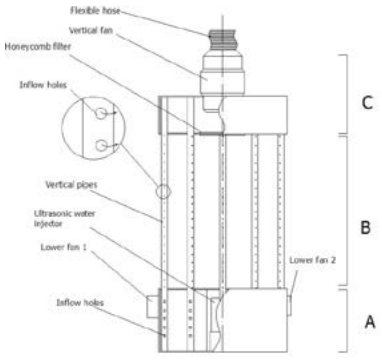
RESEARCH INTERESTS AND TOPICS

fuel cells and hydrogen technologies

renewable energy sources and technologies for their utilization

energy efficiency in buildings

heat engines and their diagnostics



Experimental simulation of convective vortices

THE GROUP AT A GLANCE

The group leader, prof. Frano Barbir is a world renowned expert on Proton Exchange Membrane (PEM) fuel cells. He has published more than 200 papers in journals, books, encyclopedias and proceedings. His work has over 1000 citations which makes him one of the most cited Croatian scientists in technical sciences. For his scientific contribution in the area of hydrogen technologies and fuel cells he was awarded a National Science Award in 2012. He is the author of the book PEM Fuel Cells Theory and Practice (Elsevier/Academic Press, 2nd edition 2013) which has been translated in several languages. He is a member of the Board of Directors of the International Association for Hydrogen Energy, and Editor Emeritus of the International Journal of Hydrogen Energy. His research interests include heat and mass transfer in PEM fuel cells, effects of operational conditions on fuel cell performance and durability, design of fuel cells and fuel cell stacks, fuel cell applications, and hydrogen energy concept and its role in energy future.

Prof. Radica's research is on the processes inside an internal combustion engine using numerical simulations for optimization of engine performance. He is developing expert diagnostic systems and new technologies for remote wireless control systems, with a common goal of increasing engine efficiency and reducing emissions.

Prof. Nižetić's field of research includes renewable energy sources, energy efficiency in buildings and energy management. Fundamental research on renewable energy is focused on development of an alternative solar chimney power plant with short diffuser. In the area of energy efficiency in buildings he conducts analyses of energy performance of public buildings as well as households identifying possibilities for energy savings, and optimizations of existing efficient energy technologies and products. His current research is on combination of PV, solar thermal panels and heat pump for integrated cogeneration and trigeneration systems.

COLLABORATIONS

The Group has established contacts and developed active cooperation with many international research groups, such as:

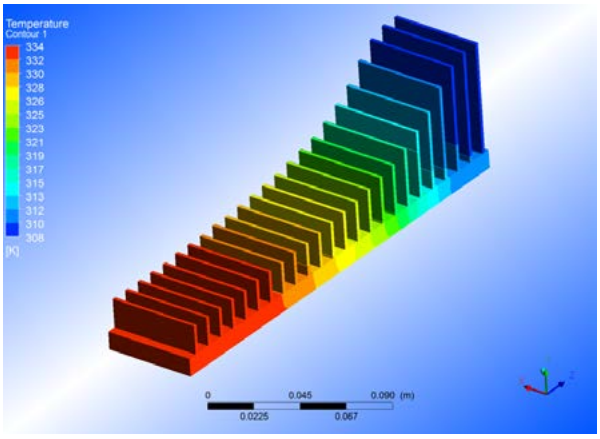
- HySA Systems, University of Western Cape, Bellville, South Africa (exchange of researchers)
- Insitute for Idustrial Robotics, Polytechnic University of Catalunya, Barcelona, Spain (exchange of researchers)
- Institute for Electrochemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria (visits; joint proposals)
- Parthenope University, Naples, Italy (visits, exchange of researchers, joint projects and conferences)
- SINTEF,Trondheim, Norway (working on a joint project)
- Center for Solar Hydrogen Research (ZSW) Ulm, Germany (working on a joint project)
- European Institute for Energy Research (EIFER)Karlsruhe, Germany (working on a joint project)
- FC Lab, Universite of Franche Comte, Belfort, France (working on a joint project)

RESEARCH HIGHLIGHTS

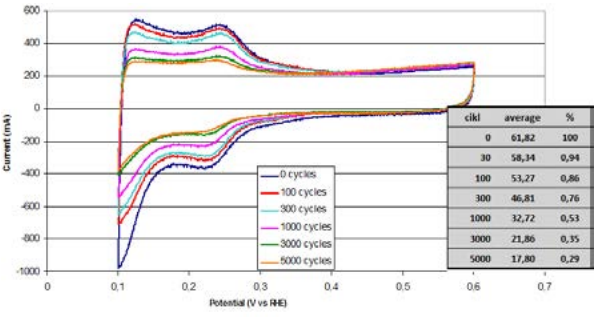
A novel concept of spatially variable heat removal rate from a PEM fuel cell has been developed, which establishes a temperature profile along the cathode channel allowing the product water to humidify the air flowing through the cathode up to 100% relative humidity. This concept allows PEM fuel cell operation without external humidification of the reactant gases.

Fuel cell application for powering remote telecommunication base stations in conjunction with renewable energy sources has been studied. A tehno-economic analysis of various options and configurations has been performed. Including hydrogen delivery and on-site generation by elec-

Temperature distribution along the cathode channel on a fuel cell passive heat exchanger



Cyclic voltammetry results of a fuel cell exposed to potential cycling degradation



trolysis. Although economics of such solutions may not be favorable at the moment, the fuel cells add increased reliability and prolonged autonomy of the power supply system, which may be more important for such applications.

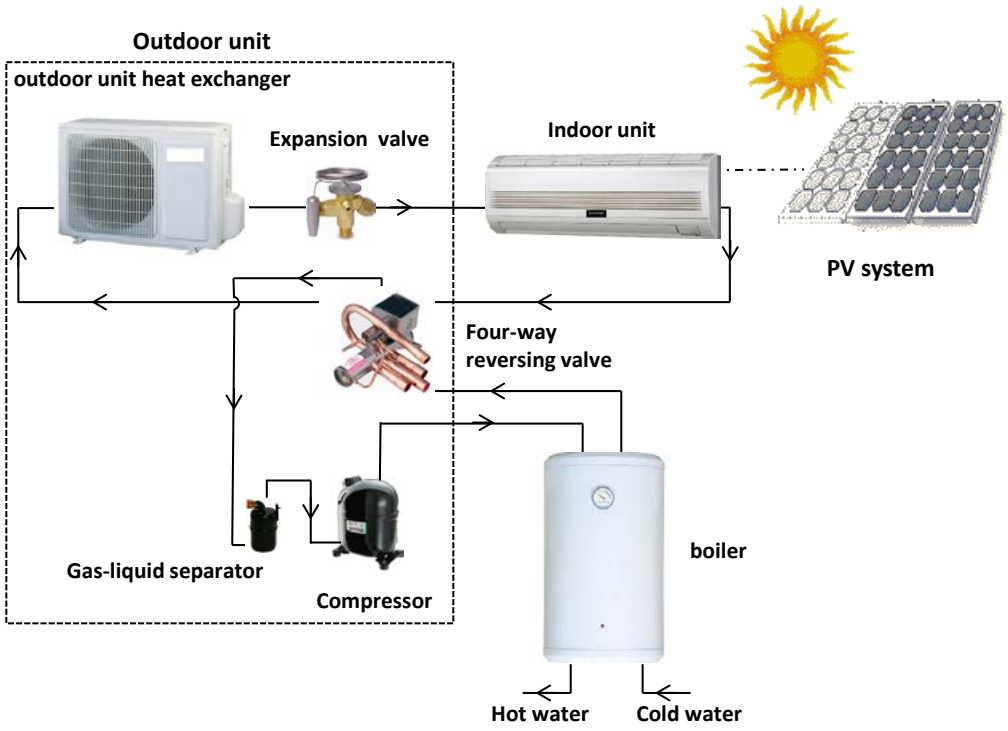
Since May 2013 the Group participates in an FP7 project System Automation of PEMFCs with Prognostics and health management for Improved Reliability and Economy (SAPPHIRE). The goal of the project is to develop an integrated control system for diagnostics of health and prognostics of the remaining life time of a low temperature PEM fuel cells in a cogeneration system. Such a control mechanism should result in improved life time and reliability of PEM Fuel Cells. Our group is in charge of one of the Work Packages – Analysis of degradation mechanisms.

Alternative energy concepts where convective vortices are used as heat engines are being studied. An experimental chamber has been developed for simulation of the convective vortices. Gained experimental findings are important for the further development of the energy concepts that utilise convective vortices. A novel analytical approach has been developed that estimates pressured drop potential in convective vortices. Developed analytical approach was validated by available meteorological data and found to be useful for the meteorological purposes.

A hybrid energy system has been developed and studied, consisting of a standard air-conditioning split system unit, with integrated boiler for the preparation of the hot water. The whole system is powered by a small off-grid photovoltaic plant. The system was assembled and tested in the cooling mode and preliminary results show that its COP value reaches an average value of 6.0. Further research will be oriented on the hybrid energy system performance test under different working regimes and to the possible increase of the PV cell efficiency by implementation of the different cooling technics of the PV cells.

Integral characteristics of an engine system have been studied, including an analysis of the thermodynamic process and the combustion process in engine cylinder, as well as numerical simulations based on mathematical model of physical and chemical processes. The research includes various parameters of the combustion process in an engine and resulting NOx emissions. Several novel engine concepts have been studied namely:

- Analysis and development of “Active Modular Internal Combustion Engine System” (AMICES) hybrid concept;
- Analysis and optimization of combustion process to increase cycle efficiency of cogeneration system for marine diesel two-stroke engines;
- Patent application on Turbine-Engine Regenerative System



Schematic of a PV/heat pump/boiler hybrid system

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Barbir, Frano. **PEM Fuel Cells: Theory and Practice, 2nd Edition.** Elsevier/Academic Press, Waltham, MA, 2013

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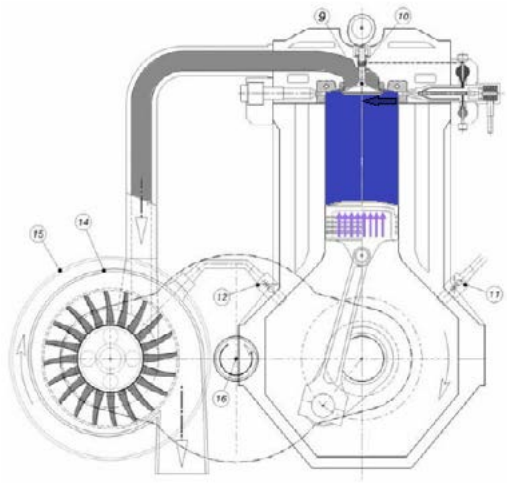
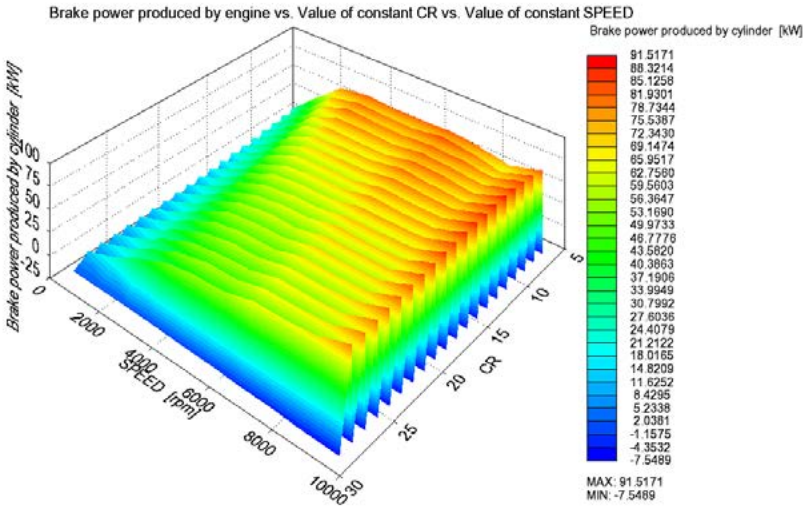
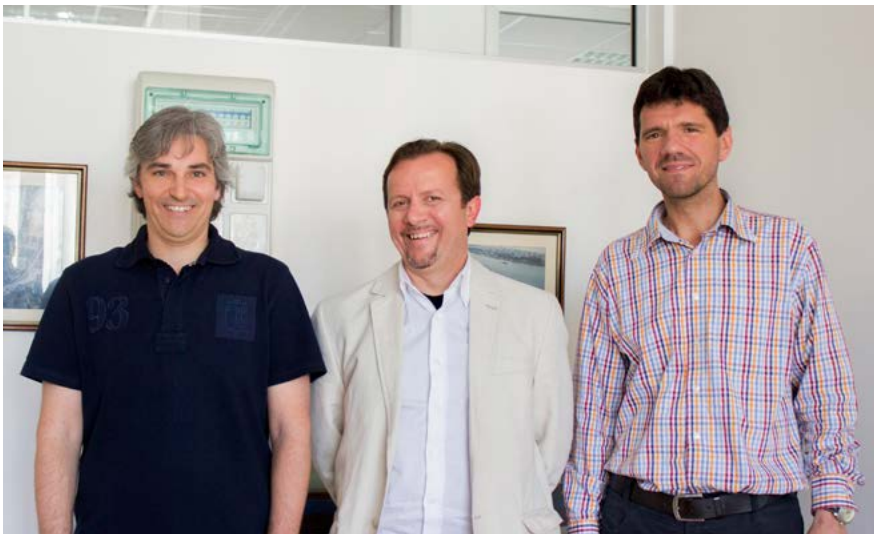


Advanced modular internal combustion engine system (AMICES)



Results of internal combustion engine optimization with Ricardo software

Naval Architecture



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RESEARCH INTERESTS AND TOPICS

design and propulsion of advanced marine vehicles (AMV)

computational geometry of ships

ship structural safety and reliability

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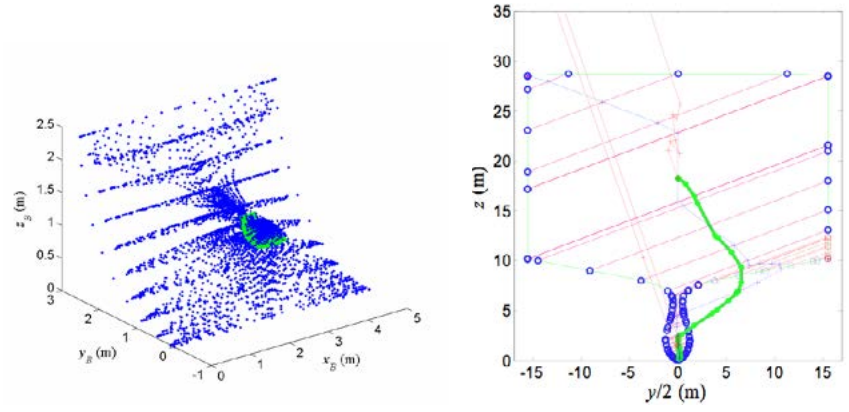
THE GROUP AT A GLANCE

In 2014. the group has founded a new lab for building small marine vehicles, like autonomous underwater vehicles, etc - up to 7m in length. We are now capable of making all kind of models, parts or vehicles out of composite materials in vacuum infusion. The lab also serves for student projects - in 2014. the first waterbike is built in the lab.

ACTIVITIES OF THE GROUP

Computational Geometry of Ships

The research of our group in this field is directed toward analytical computational geometry methods based on meshless RBF theory, containing the solutions of very accurate analytical, explicit, bijective geometry representations, the analytical solutions of the intersection between arbitrary waterline surfaces and ship geometry, and the solutions of the integrals in ship hydrostatics, for chosen degrees of freedom of the ship. Multivariate characteristics of RBFs can be used in unique hydrostatic properties description of the outer shell of the ship as well as inner compartments description, thus enabling direct hydrostatic properties determination, i.e. stability calculation.



The construction of the Hydrostatic Hyperspace of the test ship

Ship Structural Safety and Reliability

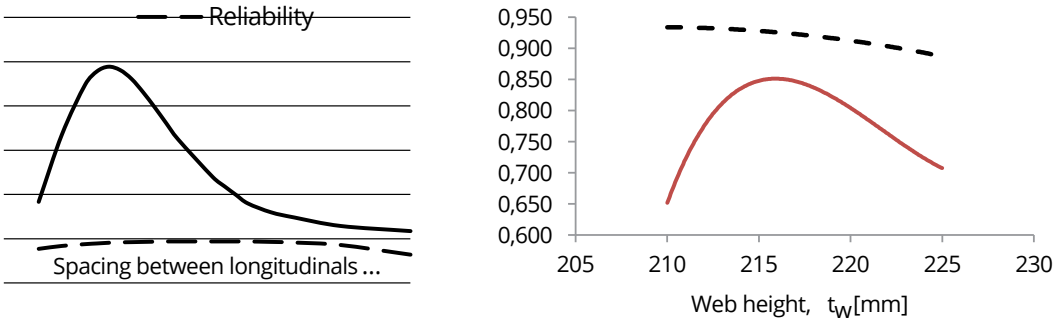
Research work on ship structural design is focused on reliability and safety of ship structures. The work was initially related only to steel ship structures, built in Croatian shipyard, but the group has recently started to consider composite structures of high-speed craft as well. The group has participated in the development of new measures of robustness and redundancy of ship structures. The robustness and redundancy have been formulated as conditional entropies, developed within the Event Oriented System Analysis (EOSA) in a joint project with a team of researchers from Faculty of Mechanical Engineering and Naval Architecture (FAMENA) at University of Zagreb. These new measures have been successfully incorporated in the existing reliability assessment procedures and have shown a great benefit in designing more reliable and safe ship structures.

In last two years the group's research work was mainly focused on design and propulsion of AMV's and as materials and manufacturing technologies in shipbuilding.

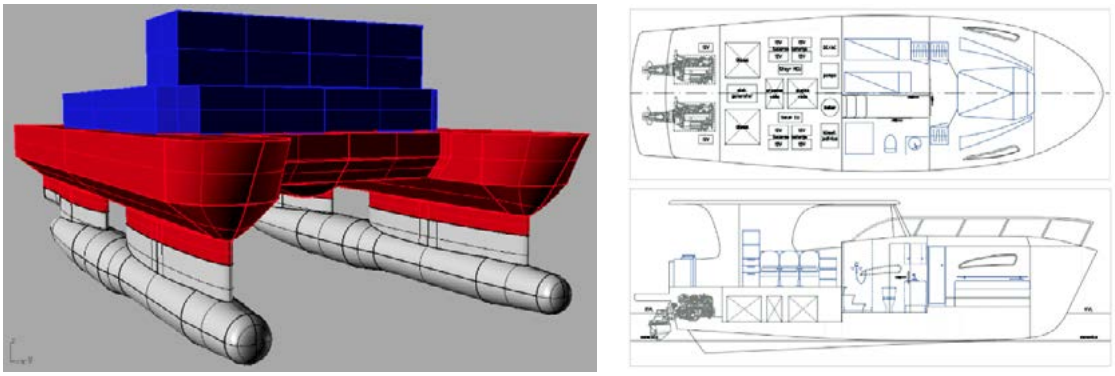
Design and propulsion of AMV's

The group has been developing/upgrading software:

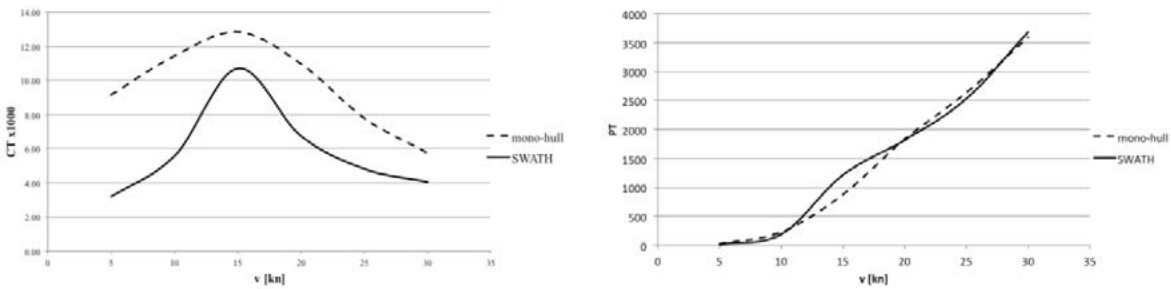
- SCGM – Ship Computational Geometry Modeling (code in MATLAB)
- RELI - for relibility, robustness and redundacy assessment of ship structures. The code was developed in cooperation with FAMENA Zagreb.



Comparison of reliability and redundancy based on EOSA for a segment of a deck plating of a tanker (left); Maximum robustness based on EOSA of a deck stiffener (right)



SWATH design, L_{pp} = 25m; v = 30kn (left); General plan of the fast ship with hybrid propulsion (right)



Comparison of total resistance coefficients (left); Total delivered power (right)

SELECTED REFERENCES

The results having come out of the 2 year research period are presented in:

1. Medaković, Josip; Ban, Dario; Blagojević, Branko. **Comparison of Hull Resistances of a Mono-Hull and A SWATH Craft**. *// International Journal of Engineering, Science and Innovative Technology*, 2 (2013) 4; 155-162.

2. Blagojević, Branko; Bašić, Josip. **A Concept Design of a Fast Craft with Hybrid Propulsion**. *// Journal of Marine Sciences*, 60 (2013), 5-6; 91-96.

3. Šestan, Ante; Vladimir, Nikola; Vulić, Nenad; Ljubenkov, Boris. **A study into resonant phenomena in the catamaran ferry propulsion system**. *// Transactions of FAMENA*, 36 (2012), 1; 35-44.

4. Rudan, Smiljko; Ljubenkov, Boris; Senegović, Hrvoje. **Structural Analysis in Shipbuilding Production Process.** *// Brodogradnja: časopis brodogradnje i brodograđevne industrije*, 63 (2012), 4; 336-341.

5. Žiha, Kalman; Ljubenkov, Boris; Dupor, Nikola; Kodvanj, Janoš; Bakić, Ante. **Strength and reliability of ships 'as-built'**. *// Proceedings of the 31st International Conference on Offshore Mechanics and Arctic Engineering OMAE2012, Rio de Janeiro, Brazil, ASME*, 2012. 1-6.

6. Barle, Jani; Đukić, Predrag; Ban, Dario. **Verification of Number of Cycles for Fatigue Life Estimation of Wind-Sensitive Structures**. *// 7th ICCSM / Zagreb, STUDIO HRG for Croatian Society of Mechanics*, 2012. 233-234.

7. Barle, Jani; Grubišić, Vatroslav; Đukić, Predrag; Ban, Dario. **Aspects of a reliable determination of wind-generated loading spectra**. *// 13th International Conference on Wind Engineering / Amsterdam ICWE13*, 2011.

8. Ban Dario, Branko Blagojević, Bruno Čalić. **On the direct analytical solution of 2D computational geometry problems with RBFs**. *// under review in Computer Aided Geometric Design (CAGD).*

9. Ban Dario. **Global, analytical, explicit solution of the description of 2D curve with discontinuities using composition of polynomial RBFs**. *// under review in Computer Aided Geometric Design (CAGD).*

10. Markovina Roko. **Analysis and comparison of gajeta wooden boats. XXth Symposium 'Theory and Practice in Shipbuilding'**, SORTA 2012, Zagreb, Croatia, september 2012.

11. Markovina Roko. **Reconstruction of the last Koručula's wooden leuta-trajta boat**. International Scientific Conference 'Maritime Heritage and Sustainable Development', Komiža, Island Vis, Croatia, 21.06.2013.

Structural Mechanics and Design

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RESEARCH INTERESTS AND TOPICS

structure design

thermoelastic stress analysis

IR thermography

certification of buildings

The research Group for Structural Mechanics and Design has its primary focus on: design, evaluation and repair of mechanical structures, infrared thermography (pulse thermography, Thermoelastic stress analysis, fatigue estimation base on thermal imaging, non-destructive testing), dynamical evaluation of open cell cellular structures, fatigue evaluation and life time predictions, numerical modelling, experimental mechanics, ultrasound measurements, energetic performance evaluation and certification of buildings (certified), design and study of the geometry of the bearing aluminum profiles and structures that are used in construction, shipbuilding, transport, etc.

The research laboratory for Structural Mechanics and Design has:

- 50 kN INSTRON sevro-hydraulic dynamic load frame
- Hottinger MGC plus multichannel amplifier for SG acquisition
- MW infrared cooled FLIR SC5000 camera with TSA software and Lock-in
- Krautkrammer ultrasound equipment
- NextEngine 3D scanner
- 3 workstations (for CAD and FEM applications)

THE GROUP AT A GLANCE

FUNDAMENTAL RESEARCH

- Investigation and estimation of fatigue service lives, fatigue cracks and their propagation.
- Repair of fatigue damaged components and structures.
- Experimental and computational testing of Advanced Pore Morphology spheres
- Development and evaluation of interactive double skin aluminium glass envelope
- Energetic performance evaluation
- Development of predictive method for determination of material fatigue life

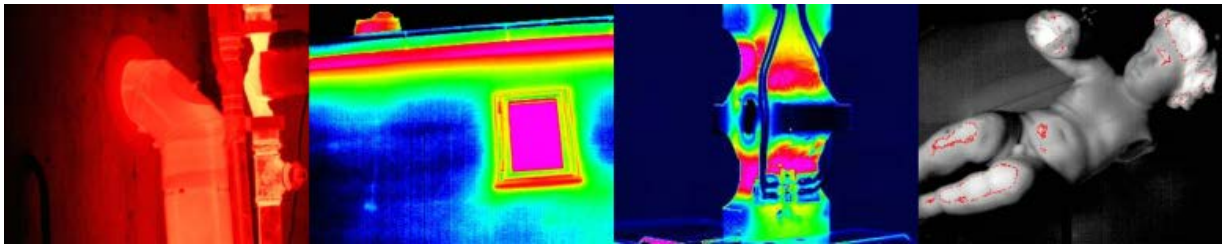
APPLIED RESEARCH

- Design, evaluation and repair of different mechanical structures

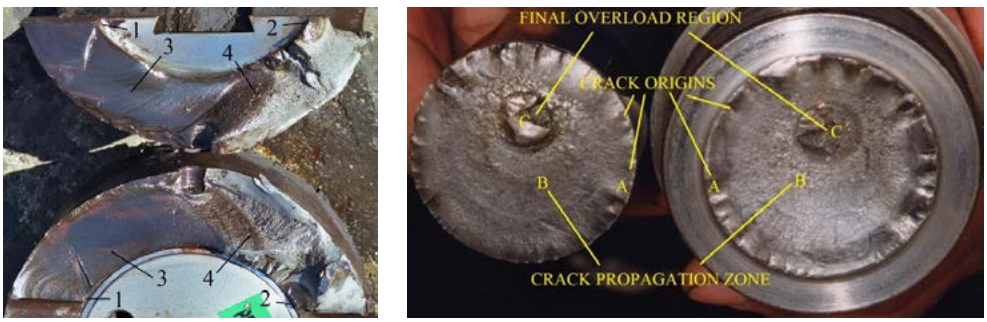
INTERNATIONAL COLLABORATION

- 2010-2012.-FP7-People-2010 (Marie Curie) Project: SPRINT (Smart Panels for the Reduction of Noise Transmission)
- 2 bilateral projects Croatia- Slovenia,
- 1 bilateral project Croatia-Germany,
- 1 bilateral project Croatia-Serbia,
- 2007. -2013. MZOS - (Croatian Ministry of Science) Project 023-0231744-1745,
- 2012. Domazet-visiting professor at MCAST – University of Malta

Design, evaluation and repair of different mechanical structures



Infrared thermography



Industrial failure investigation and repair

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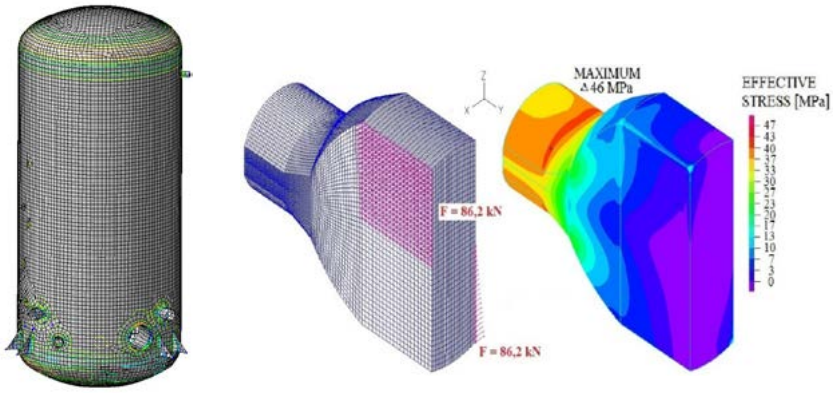
Published papers (CC, SCI)

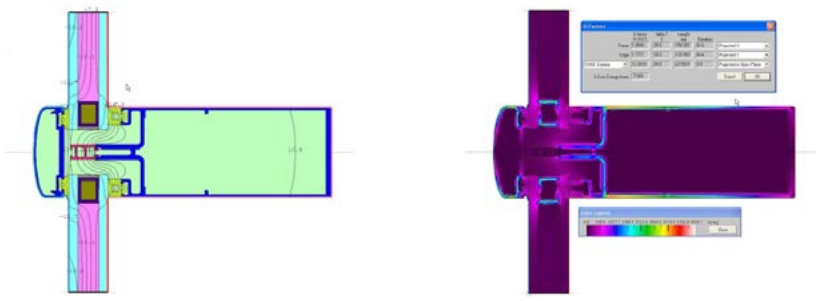
1. Domazet, Željko; Lukša, Francisko; Stanivuk, Tatjana. **An optimal design approach for calibrated rolls with respect to fatigue life**. *// International journal of fatigue*. 59 (2014); 50-63
2. Krstulović-Opara, Lovre; Domazet, Željko; Garafulić, Endri. **Detection of osmotic damages in GRP boat hulls**. *// Infrared physics & technology*. 60 (2013.); 359-364
3. Domazet, Željko; Lukša, Francisko; Stanivuk, Tatjana. **The influence of rolling speed on the fatigue life of rolls with grooves**. *// International journal of damage mechanics*. (2014)
4. Domazet, Željko; Lukša, Francisko; Bugarin, Miro. **Fatigue Strength of the Rolls with Grooves**. *// Applied Mechanics and Materials*. 459 (2014); 330-334
5. Domazet, Željko; Lukša, Francisko. **Influence of Rolling Temperature on Fatigue Life of Calibrated Rolls**. *// Advanced materials research*. 742 (2013); 482-487
6. Krstulović-Opara, Lovre; Domazet, Željko; Klarin, Branko; Garafulić, Endri. **The Application of IR Thermography to the NDT and Thermal Stress Analysis**. *// HDKBR info. 1* (2012.), 6/7; 17-22
7. Krstulović-Opara, Lovre; Garafulić, Endri; Klarin, Branko; Domazet, Željko. **Application of gradient based IR thermography to the GRP structures inspection**. *// Key Engineering Materials*. 488-489 (2012); 682-685

Ph.D Thesis

1. Lukša, Francisko. **Methodology for optimal design of calibrated rolls according to fatigue life** FESB-Split, 25.02. 2013, 123 p. mentor: Domazet, Željko.
2. Bugarin, Miro. **Development and evaluation of Al structure for interactive glass façade according to energy efficiency** FESB-Split, 07. 2012., 176 p., mentor: Domazet, Željko.
3. Šušnjar, Marko. **Development of predictive method for fatigue life estimation** FESB- Split, 10.07. 2012, 138 p., mentor: Domazet, Željko.
4. Garafulić, Endri. **Detection and evaluation of composite structures based on active infrared themography** FESB-Split, 12.12.2013., 246p., mentor: Krstulović-Opara, Lovre



Numerical modelling



Analysis of the thermal efficiency of the geometry of the bearing structure of aluminum glazed facades

Advanced Mechanical Power Transmissions and Integrity of Gears

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Nenad Vulić
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Srdjan Podrug
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Milan Perkušić
PhD student

RESEARCH INTERESTS AND TOPICS

power transmissions with independently controllable output speed

vehicle transmissions and control systems

wind turbine transmissions and control systems

numerical models for damage tolerant design of power transmission components

fracture mechanics

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THE GROUP AT A GLANCE

Activities of the Group

The group is trying to model the power transmissions with variable transmission ratio with lower production cost and higher efficiency. Among the globaly first, the group investigates the power transmissions with independently controllable output speed, without a complex control system – with only mechanical components. The advaced investigations of integrity of mechanical power transmissions components remains important task of the group.

SELECTED REFERENCES

1. Jelaska, Damir. **Gears and Gear Drives**. Chichester: John Wiley & Sons, Ltd., 2012 (monography).

2. Perkušić, Milan; Jelaska, Damir; Podrug, Srđan. **Procjena zamornog vijeka evolventnih zupčanih parova**. // *Strojarstvo 54* (2012) , 5; 381-391

3. Jelaska, Damir. **On the Goodman's Fatigue Safety Factor**. // *International Journal of Advanced Engineering*. 5 (2011), 1; 27-34

4. Podrug, Srdjan; Glodež, Srečko; Jelaska, Damir. **Numerical modelling of crack growth in a gear tooth root**. // *Strojniški vestnik - Journal of Mechanical Engineering*. 57 (2011) , 7-8; 579-586

5. Jelaska, Damir; Podrug, Srđan; Milan Perkušić. **On the feasibility of the power split type transmissions having independently controllable output speed** // *Proceedings CADAM 2013* / Obsieger, Boris (ur.). Rijeka : Revelin, 2013. 19-22

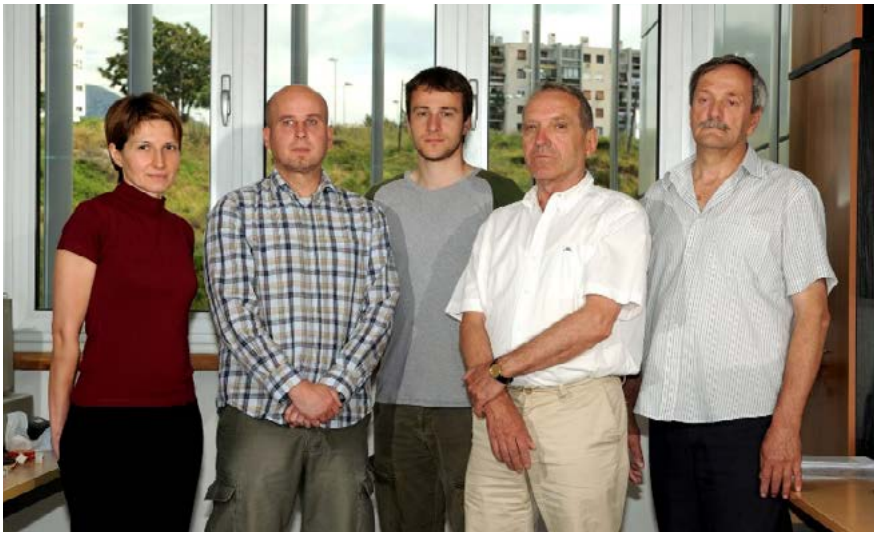
6. Jelaska, Damir. **Hibridni prijenosnik s neovisno upravljanom izlaznom brzinom vrtnje**. *Hrvatski patentni glasnik* 1 (2014).

7. Jelaska, Damir. **Power-split prijenosnik s neovisno upravljanom izlaznom brzinom vrtnje**. *Hrvatski patentni glasnik* 4 (2014).

8. Jelaska, Damir. **Prijenosnik s neovisno upravljanom brzinom vrtnje**. *Hrvatski patentni glasnik* 15 (2013).

Innovative wind turbine hybrid transmission

Linear and Nonlinear Analysis of Thin-Walled Structures



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Vedrana Cvitanić
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Frane Vlak
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Branka Bužančić Primorac
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Research group for Linear and Nonlinear Analysis of Thin-Walled Structures at the Department of Mechanical Engineering and Naval Architecture, University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture deals with advanced theories of bending and torsion of thin-walled beams with applications in analyses of thin-walled structures, modelling of thin-walled structures subjected to enviromental loads (wind, waves and other operational loads) and development of phenomenological elasto-plastic constitutive models for orthotropic metal sheets.

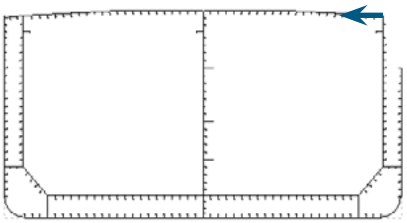
The group has established 2 research laboratories: Lab for Mechanics and Lab for Fluid Power.

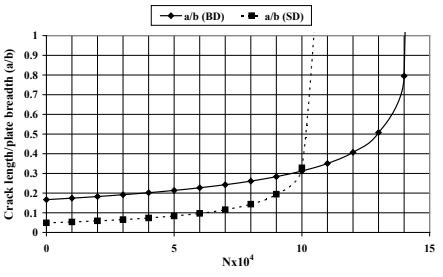
RESEARCH INTERESTS AND TOPICS

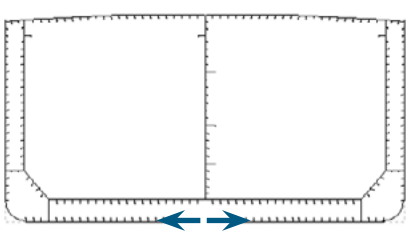
influence of shear warping and cross-section distortion on bending and torsion of thin-walled beams

design and modelling of thin walled-structures

constitutive elasto-plastic formulations for orthotropic sheet materials







Definition of location and extent of collision and grounding damage (ABS 1995) with crack propagation direction and results

THE GROUP AT A GLANCE

Activities of the Group for Linear and Nonlinear Analysis of Thin-Walled Structures can be divided in following areas of fundamental and applied research areas.

FUNDAMENTAL RESEARCH

Influence of shear warping and cross-section distortion on bending and torsion of thin-walled beams

The expressions for stresses and displacements for bending and torsion of thin-walled beams with influence of shear as well as the cross-section distortion in the analytic form are developed. The expressions are especially applicable in the analyses of thin-walled beams without adequate transverse stiffening (by diaphragms, transverse bulkheads). The expressions are verified by the finite element method on examples of modern thin-walled structures, as ship structures. The cross-section distortion of beam assembled of three plates subjected to torsion is considered.

Phenomenological elasto-plastic constitutive formulations for orthotropic sheet materials

One of the group activities is development of the phenomenological elasto-plastic constitutive formulations for the orthotropic materials with a special application to the sheet materials. The most important research achievements are related to the theoretical and algorithmic aspects of the constitutive formulations based on the non-associated flow rule. Several algorithmic formulations based on non-associated flow rule and well-known orthotropic stress functions as yield function/plastic potential are developed. For the description of the yielding asymmetry the asymmetric orthotropic yield functions are proposed. The current special scope of interest is a phenomenological description of the evolution of the yield function and plastic potential function with ongoing plastic deformation process for the materials with pronounced asymmetry in yielding.

APPLIED RESEARCH

Design and modelling of thin walled structures

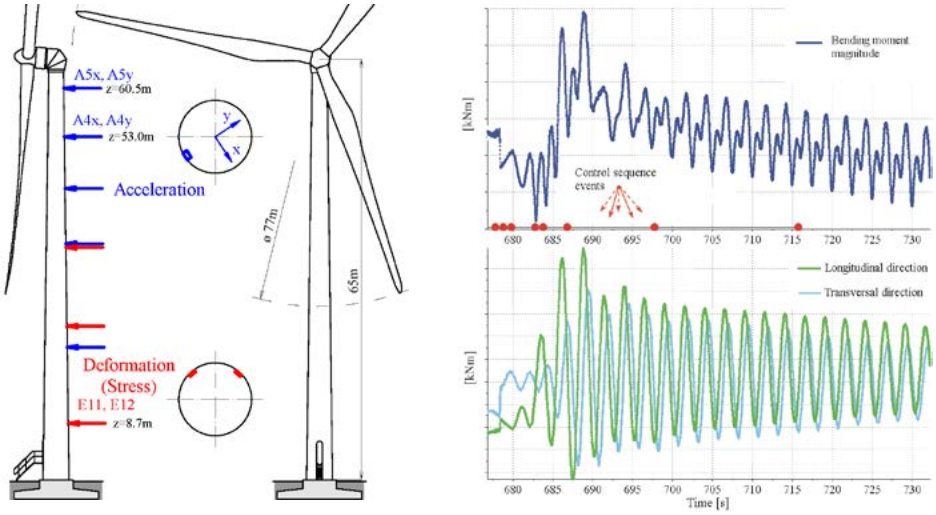
The expressions for stresses and displacements for bending and torsion of thin-walled beams with influence of shear as well as the cross-section distortion are used in the analyses of modern thin-walled structures, as ship structures. Lattice antena towers and wind turbine structures subjected to enviromental loads are analysed in order to reduce the model complexity with more realistic (validated) and more reliable load data.

Finite element simulations of sheet metal forming processes

The developed elasto-plastic orthotropic constitutive formulations are applied in predicting various sheet metal forming processes. The finite element program ADINA is upgraded with the updated Lagrangian formulation of the CBR shell element coupled with the algorithmic formulations of the analyzed material descriptions. By testing obtained formulations, influence of the description of the plastic flow anisotropy and yielding anisotropy/asymmetry on the process predictions is assessed.

The ultimate strength calculation and crack propagation in damaged ship structure

The ultimate strength calculation of damaged tanker hull subject to vertical bending moment is performed taking into account degradating effect of crack propagation on ultimate bending capacity. Damage growth assessment is performed by the fracture mechanics approach.



Wind turbine monitoring setup (left) and Bending moment and control events during an emergency shutdown (right).

HIGHLIGHTS

The theory of bending and torsion with influence of shear is presented in PhD achieved in the period 2012-2013: Matoković, Ado. Bending and torsion of thin walled beams of open section with influence of shear, PhD. Thesis (mentor R. Pavazza, FESB, 2012.). The theory is expanded to the orthotropic elastic materials in ongoing PhD thesis: Vukasović, Marko. Bending and torsion of thin-walled composite beams (mentor R. Pavazza, FESB).

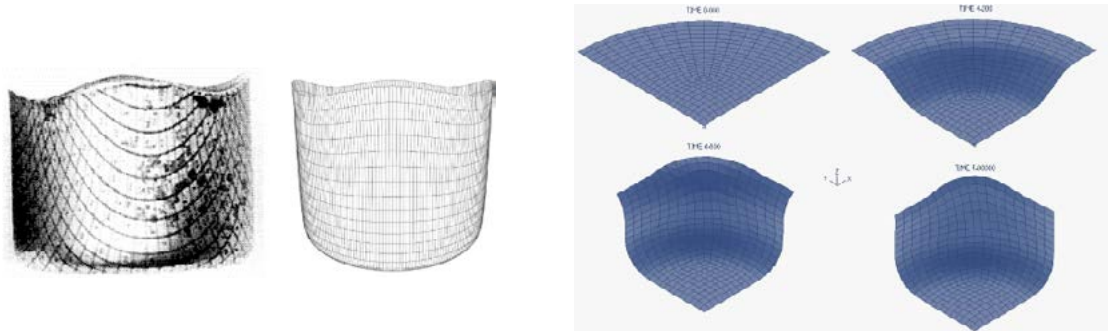
The research on the subject of the shear influence and the cross-section distortion of thin-walled beams is published in eminent scientific journals.

Several advances were reached in developing plasticity constitutive formulations for the orthotropic materials: the algorithmic formulations based on the quadratic and non-quadratic asymmetric yield function are developed, implemented into the finite element code and tested in predicting various complex sheet metal forming processes. The results proved that the developed formulations present efficient numerical tools and present basis for the further improvements of the constitutive descriptions.

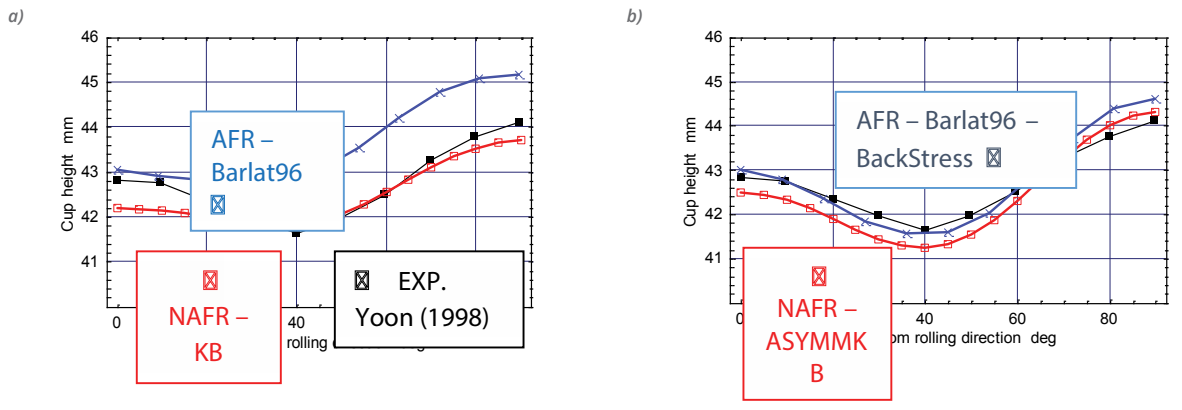
Extensive monitoring campaign of loads and responses on wind turbine supporting structure is carried out. The first phase of data analysis and related findings are included in PhD achieved in the period 2012-2013: Đukić, Predrag. Development of a reduced testing method for wind loaded line-like structures, PhD thesis (mentor J. Barle, FESB, 2012.).

The Group has developed and upgraded some research codes:

- SPAOS (software for the calibration and analysis of the orthotropic stress functions)
- upgrades of the finite element program ADINA (upgrade with the updated Lagrangian formulation of the CBR shell element coupled with the developed elasto-plastic orthotropic material descriptions)



Cylindrical cup drawing problem. Predicitons of the cup drawing steps for AA2090-T3 sheet obtained by the formulation based on non-associated flow rule and asymmetric yield function.



The influence of the yielding asymmetry description on the cylindrical cup drawing predictions for AA2008-T4 sheet. Predictions of the cup heights obtained by the developed formulations based on: a) symmetric yield functions; b) asymmetric yield functions.

SELECTED REFERENCES

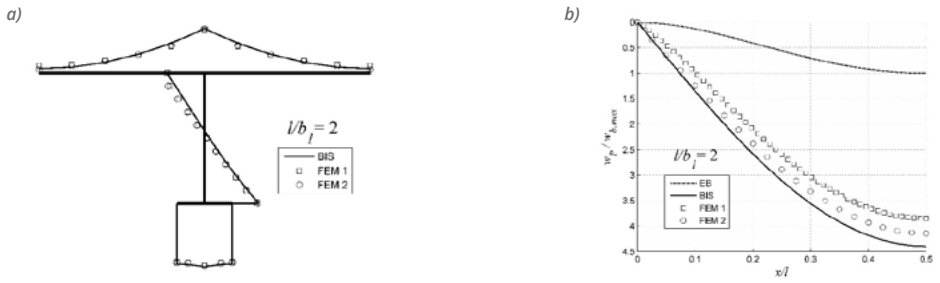
The results having come out of the 2 year research period are presented in:

Journal papers (CC, SCI, SCI Expanded) (3)

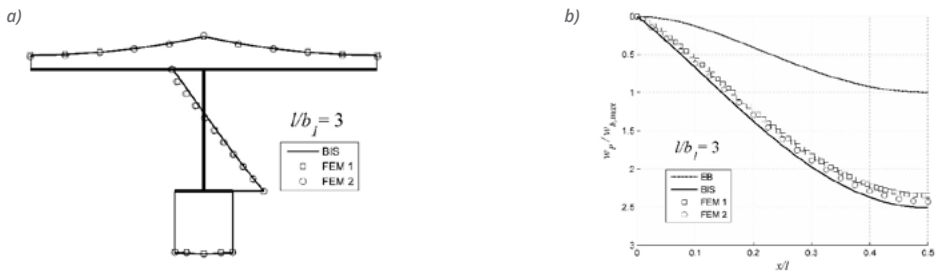
1. Pavazza, Radoslav; Plazibat, Bože. **Distortion of thin-walled beams of open section assembled of three plates.** *// Engineering Structures*. 57 (2013); 189-198.
2. Pavazza, Radoslav; Matoković, Ado; Plazibat, Bože. **Torsion of thin-walled beams of symmetrical open cross-sections with influence of shear**. *// Transactions of FAMENA*. 37 (2013), 2; 1-14.
3. Pavazza, Radoslav; Matoković, Ado; Plazibat, Bože. **Bending of thin-walled beams of symmetrical open cross-sections with influence of shear**. *// Transactions of FAMENA*. 37 (2013), 3; 17-30.

International conference proceedings (9)

1. Pavazza, Radoslav; Plazibat, Bože; Vukasović, Marko. **On the displacements of container ship hull girder under torsion.** *// Knjiga sažetaka XX. simpozija Teorija i praksa brodogradnje, Fakultet strojarstva i brodogradnje*, Zagreb. (2012), 75-75.
2. Pavazza, Radoslav; Matoković, Ado; Vlak, Frane. **An analytical solution for displacements and stresses for mono symmetrical stiffened plate structures under transverse loads.** *// Knjiga sažetaka XX. simpozija Teorija i praksa brodogradnje, Fakultet strojarstva i brodogradnje*, Zagreb. (2012), 76-76.
3. Bužančić Primorac, Branka; Parunov, Joško. **Reduction of the ultimate strength due to crack propagation in damaged ship structure**. *// 15th International Congress of the International Maritime Association of the Mediterranean*, La Coruna (2013), 365-371.
4. Burić, Zrinka; Bužančić Primorac, Branka; Parunov, Joško. **Residual Strength of Damaged Oil Tanker in the Adriatic Sea**. *// 17th International Conference on Ships and Shipping Research*, Naples (2012), 127-128.
5. Cvitanić, Vedrana; Ivandić, Daniel; Krstulović-Opara, Lovre. **Influence of constitutive and process parameters on the cylindrical cup deep drawing predictions for AA2090-T3 sheet**. *// Mechanical Technologies and Structural Materials Conference Proceeding, Croatian Society for Mechanical Technologies*, Split. (2013), 117-126.
6. Cvitanić, Vedrana; Salečić, Milena; Vukasović, Marko. **Numerical simulations of S-rail forming for 6111-T4 sheet based on Hill stress function**. *// 7th International Congress of Croatian Society of Mechanics*, Croatian Society of Mechanics, Zagreb. (2012), 181-182.
7. Barle, Jani; Wolf, Hinko; Đukić, Predrag. **Experimental verification of the dynamic model for a wind turbine tower** *// 30th Danubia-Adria: Symposium on Advances in Experimental Mechanics*, Primošten (2013), 219-220.
8. Đukić, Predrag; Barle, Jani; Grubišić, Vatroslav; Ban, Dario. **Reliable model of maximum wind load amplitude** *// 30th Danubia-Adria: Symposium on Advances in Experimental Mechanics*, Primošten (2013), 246-247.
9. Barle, Jani; Đukić, Predrag; Ban, Dario. **Verification of number of cycles for fatigue life estimation of wind-sensitive structures** *// 7th ICCSM Croatian Society of Mechanics*, Zadar (2012), 233-234.

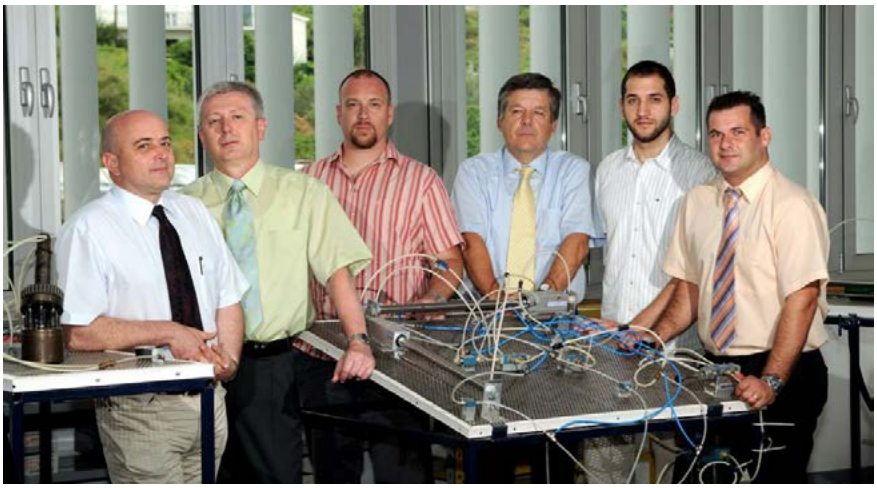


Stresses and displacements for mono symmetrical stiffened plate structures under transverse loads for ratio l/b1 = 2: a) normal stress distribution along the cross section contour (BIS - bending with influence of shear; FEM1 - shell finite element; FEM2 - membrane finite element); b) deflection line normalized to EB solution (Euler-Bernoulli beam theory).



Stresses and displacements for mono symmetrical stiffened plate structures under transverse loads for ratio l/b1 = 3: a) normal stress distribution along the cross section contour; b) deflection line normalized to EB solution.

Industrial Engineering



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Marko Mladineo
PhD student

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The group has established two research laboratories: **Laboratory for industrial engineering** (head: Ivica Veža, Full Professor) and **Laboratory for shape and dimension measuring** (head: Boženko Bilic, Full Professor).

THE GROUP AT A GLANCE

Activities of the Research Group for Industrial Engineering is in following applied research areas and international collaboration:

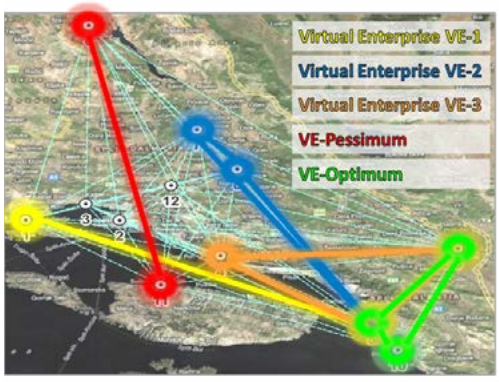
RESEARCH INTERESTS AND TOPICS

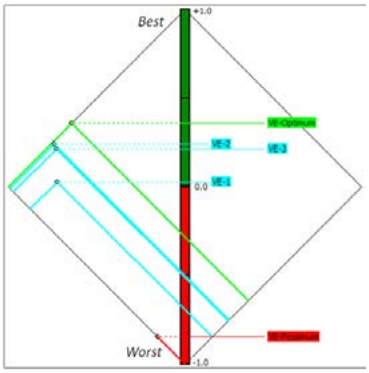
production management
lean management
six sigma
learning factory
production networks

APPLIED RESEARCH

Production Networks

Global economic crisis has brought into question sustainability of many industrial enterprises, especially Large-sized Enterprises (LEs). However, the strength of the European economy are not Large-sized Enterprises, but Small and Medium-sized industrial Enterprises (SMEs). As an alternative to LEs there is networking of SMEs into flexible production networks. Inside production network SMEs can collaborate on new product development forming Virtual Enterprise. However, to achieve sustainability through production networks, i.e. Virtual Enterprises, it is essential to choose an optimal com-





Evaluation, ranking and sorting of Virtual Enterprises

bination of SMEs in Virtual Enterprise formation process. It is a complex process that requires the use of multi-criteria decision-making methods (PROMETHEE method) and meta-heuristic optimization methods for solving NP-hard Partner Selection Problem (Ant Colony Optimization).

Learning Factory

The establishment of Learning Factory is in process. It will be a learning environment where processes and technologies are based on a real industrial site which allows a direct approach to product creation process. Learning Factories are based on a didactical concept emphasizing experimental and problem-based learning. The continuous improvement philosophy is facilitated by own actions and interactive involvement of the participants. It will be a "living lab" for demonstration and implementation of various production models.

Life-Long Learning

The main activity is involvement in project LOPEC. It is a project for vocational training organizations, aiming at people enhancement as entry ticket to Lifelong Continuous Learning by increasing the maturity level of personal logistic excellence.

INTERNATIONAL COLLABORATION

The Research Group for Industrial Engineering has established contacts and developed a long-term active cooperation with many international research groups. The most intensive on-going collaboration is achieved with the following institutions:

- The Fraunhofer – Institut for Systems and Innovation Research ISI, Karlsruhe, Germany (Key Enabling Technologies)
- The Reutlingen University, Germany (Life-Long Learning)
- The Technical University of Chemnitz, Germany (Production Networks)
- The Technical University of Vienna, Austria (Life-Long Learning, Learning Factory)
- The Technical University of Darmstadt, Darmstadt, Germany, (Learning Factory)
- KTH Royal Institute of Technology, Stockholm, Sweden (Learning Factory)

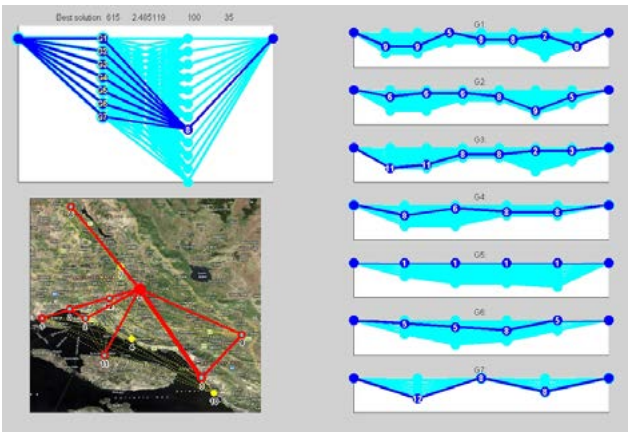
In last two years the Research Group for Industrial Engineering has been involved in three international projects:

Initiative On European Learning Factories

The „Initiative on EUROPEAN LEARNING FACTORIES", consisting of many internationally renowned scientists, has set the strategic goal to set up a thematic network, which is based on the standardization concept "System - Learning Factory". It is also aimed on establishing an internationally accepted standard and to contribute considerably to the quality management of learning factories, worldwide. Based on this objective, the "Initiative of EUROPEAN LEARNING FACTORIES" has applied for funding via the DAAD program type B – Thematic Networks.

LOPEC

LOPEC is a project for vocational training organizations, aiming at people enhancement as entry ticket to Lifelong Continuous Learning by increasing the maturity level of personal logistic excellence. A common European view is needed for "Logistics personal excellence" for skilled workers, to ensure that the final product is an open product, using international, pan European validated standards. To support this, the project will pilot the new solution in four regions of AT, CZ, DE and LV with at least 12 pilot implementations.



Solving NP-hard Partner Selection Problem

Aspect of standardisation of the System Learning Factory (EU Project „Initiative on EUROPEAN LEARNING FACTORIES")

Project DanKETwork

Leader The Fraunhofer - Institut for Systems and Innovation Research ISI, Karlsruhe, Know-how Exchange on Consequences and Challenges of the Integration of Key Enabling Technologies in European Manufacturing for the Danube Region. The main objectives are: to establish an Excellence-Network of the leading experts on manufacturing technologies and systems; and to exchange and develop the know-how regarding to the different consequences of the integration of KETs in European manufacturing industries for the countries of the Danube region.

SELECTED REFERENCES

The results having come out of the 2 year research period are presented in various scientific papers, conference papers and book chapters. Some selected references (2 book chapters, scientific papers: 1 CC, 1 SCI, 2 others and 3 conference papers) are given:

1. Veza, Ivica; Mladineo, Marko; Gjeldum, Nikola. **Production Networks and Partner Selection Problem, Industrial Engineering – Challenges for the Future**, D. Zelenovic & B. Katalinic (ed.). Novi Sad, Vienna, Stuttgart: Faculty of Technical Sciences, DAAAM International and Fraunhofer IAO (2013); p. 89-118

2. Gecevska, Valentina; Cus, Franc; Chiabert, Paolo; Veza, Ivica. **Linking Lean Production with Product Lifecycle Management for Sustainable Business Environment, Development of Intelligent and Innovative Tools for Production Process Engineering and Sustainable Management**, Cus, Franc; Gecevska, Valentina (ed.), Maribor, Slovenia: Faculty of Mechanical Engineering, Maribor (2013); p. 19-39

3. Peric, Tunjo; Babic, Zoran; Veza, Ivica. **Vendor selection and supply quantities determination in a bakery by AHP and fuzzy multi-criteria programming**. *International Journal of Computer Integrated Manufacturing*. 26 (2013), 9; p. 816-829

4. Anisic, Zoran; Veza, Ivica; Suzic, Nikola; Sremcev, Nemanja; Orcik, Anja. **Improving Product Design with IPS-DFX methodology Incorporated in PLM Software**. *Technical Gazette*. 20 (2013), 1; p. 183-192

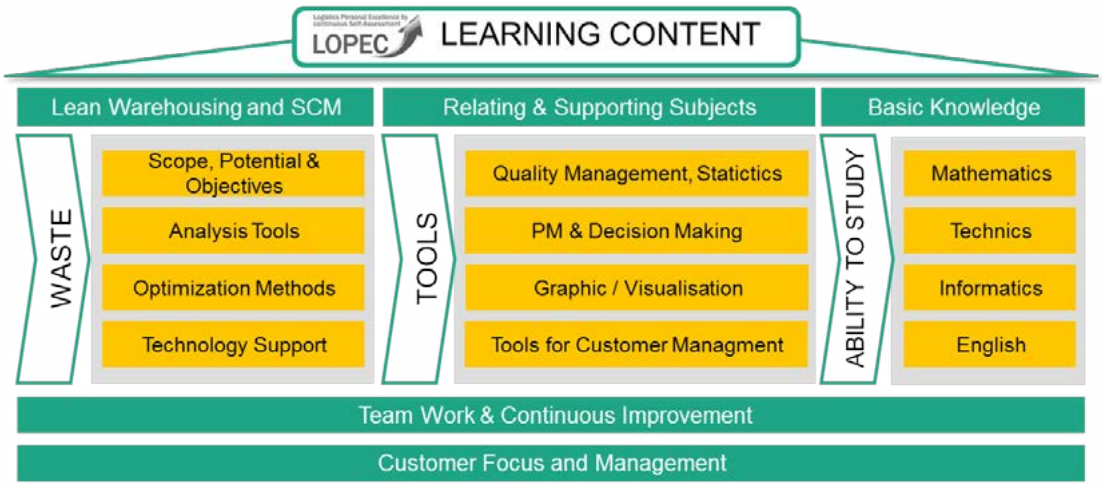
5. Mladineo, Marko; Veza, Ivica. **Ranking Enterprises in Terms of Competences inside Regional Production Network**. *Croatian Operational Research Review (CRORR)*. 4 (2013); p. 65-75

6. Veza, Ivica; Mladineo, Marko. **Sustainability through Production Networks**. *Management and Production Engineering Review*. 4 (2013), 4; p. 33-39

7. Gjeldum, Nikola; Bilić, Boženko; Kujundžić, Fabris. **Application of modified value stream mapping tool for restructuring of make-to-order production system** *// CIM 2013 - Computer Integrated Manufacturing and High Speed Machining* / Abele, Eberhard; Udiljak, Toma; Ciglar, Damir (ed.). Zagreb: Hrvatska udruga proizvodnog strojarstva, (2013); p. 113-118

8. Gecevska, Valentina; Stefanic, Nedeljko; Veza, Ivica; Cus, Franc. **Sustainable Business Solutions through Lean Product Lifecycle Management**. *Acta technica corviniensis*. 5 (2012), 1; p. 135-142

9. Gecevska, Valentina; Veza, Ivica; Cus, Franc; Anisic, Zoran; Stefanic, Nedeljko. **Lean PLM - Information Technology Strategy for Innovative and Sustainable Business Environment**. *International journal of engineering and management*. 3 (2012), 1; p. 15-23



LOPEC Learning Content (EU project „LOPEC - Logistics Personal Excellence through continuous Self-Assessment")

Modeling and Application of Computational Methods in Mechanical Engineering

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Gojko Magazinović
Full Professor

Zoran Milas
Associate Professor

Igor Pehnec
Postdoc

Milan Ćurković
PhD student

Ivo Marinić-Kragić
PhD student

RESEARCH INTERESTS AND TOPICS

the application of numerical methods and optimization in mechanics of deformable bodies and fluid mechanics

3D scanning

parameterization

FEM / CFD analysis

optimization

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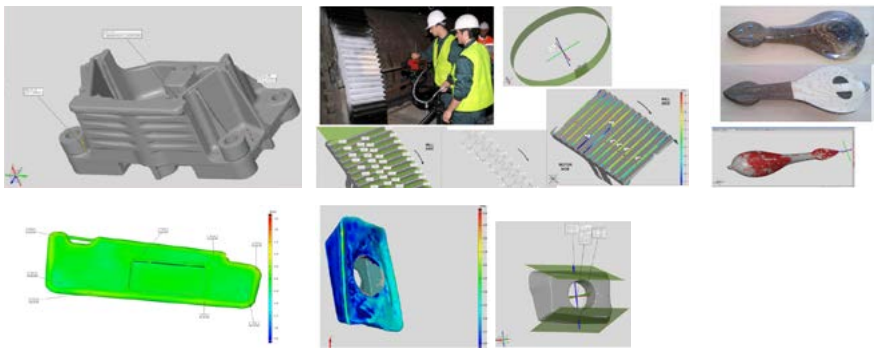
DESCRIPTION OF LABORATORIES

The research Group for Modeling and Application of Computational Methods in Mechanical Engineering has its primary focus in modeling of engineering problems for computational analysis and synthesis as well as development of advanced computational procedures.

The group has established two research laboratories: Lab for Optimum Design and Rapid Prototyping, and Lab for Numerical Modeling.

The Lab for Optimum Design and Rapid Prototyping includes the GOM ATOS high resolution and accuracy 3D scanning system. It is an optical system based on triangulation and stereo-photogrammetry which applies structured light patterns projection and uses time-based coding for addressing the positions of individual points. It uses reference points to align and combine multiple scans into single overall point clouds. The Lab also includes a 3D printing system that builds 3D models from layered rigid plastic materials and requires no post-build curing.

The Lab for Numerical Modeling is in development and includes custom-made and workflow-integrated applications for numerical analysis, synthesis and numerical optimization.



THE GROUP AT A GLANCE

The research group has its main focus in the following:

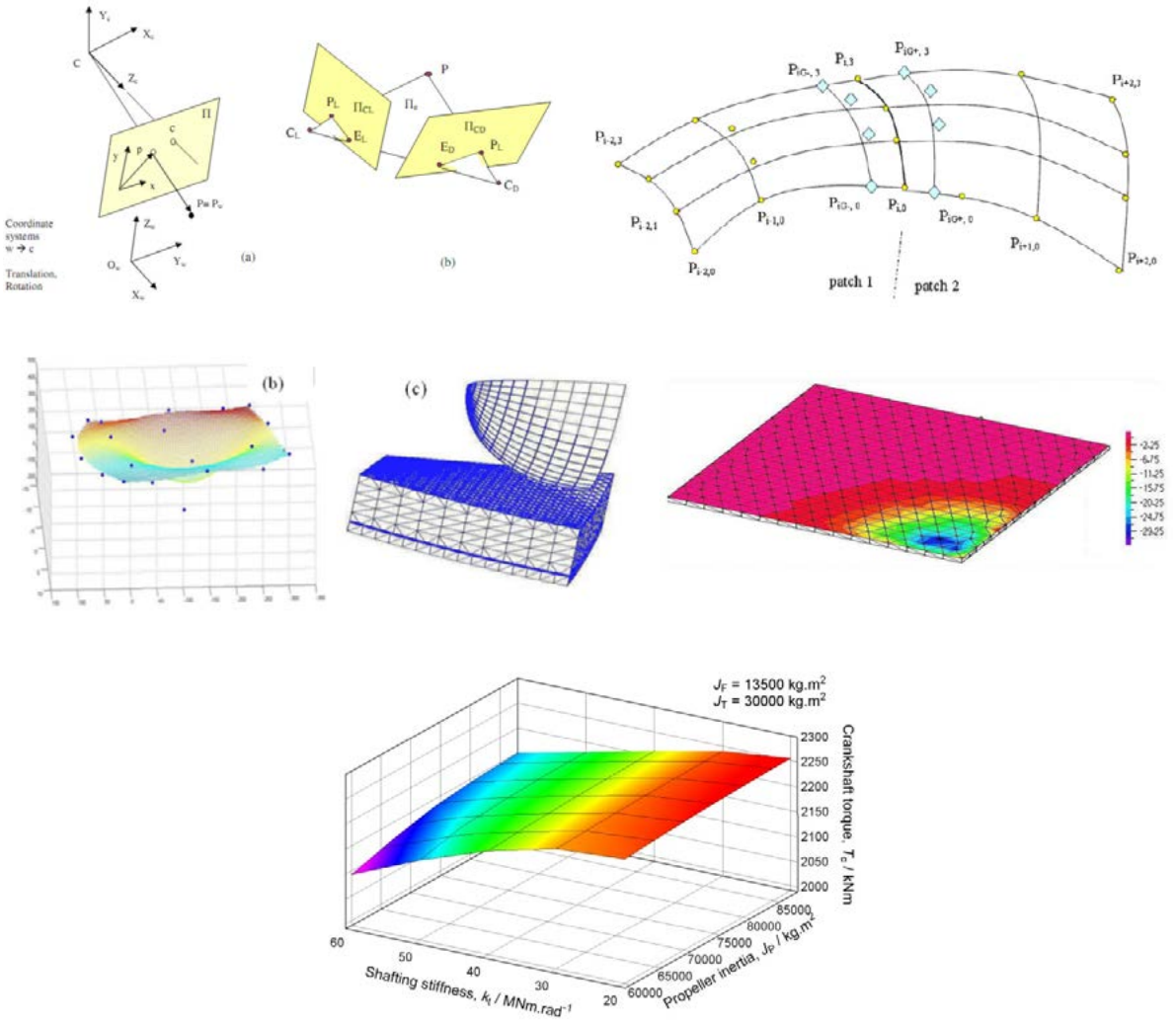
- Development of procedures and operators in classical and evolutionary numerical optimization,
- Setting up dedicated heterogeneous numerical workflows for distributed computational optimization,
- Development of advanced parameterizations of 3D shape for numerical optimization,
- Enhanced reverse re-engineering by coupling 3D shape acquisition, parameterization, simulation and shape optimization,
- Development of numerical procedures for engineering systems design, analysis and optimization.

The research group has long-term cooperation with the University in Trieste, Italy and University of Maribor, Slovenia.

In last two years the research group has implemented the national scientific project 'Intelligent and evolutionary algorithms for optimization of materials and structures', and participated in the national scientific project 'Fatigue strength of materials and structures'. The research group has developed several computer codes and implementations in the fields of computer-aided analysis and synthesis, numerical optimization, and feasibility evaluation.

The research group has developed original algorithms for the parameterization of 3D point clouds and feature detection (edges, peaks) which can are used for the adaptive parameterizations, dynamic feature-based partitioning of complex surfaces, compact representation of shape, and dynamic detection of surface deterioration and damage (gaps, impact cavities, etc.).

The group has also developed procedures for Level-set based shape based optimization using evolutionary algorithms. The group is also intensively involved in 3D scanning of engineering objects and subsequent processing including parametric surface representation, dynamic partitioning and parametric shape re-engineering and optimization.



SELECTED REFERENCES

Some of the 2012 / 2013 publications (or currently in publication) by the group include:

Journal papers (CC, SCI, SCI Expanded)

1. **Reverse Shape Synthesis of the Hydropump Volute using Stereo-Photogrammetry, Parameterization and Geometric Modeling**. *// ASME Journal of Computing and Information Science in Engineering*

2. **Computational procedure for optimum shape design based on chained Bezier surfaces parameterization**. *// Engineering applications of artificial intelligence*

3. **Ad-Hoc Cluster and Workflow for Parallel Implementation of Initial-Stage Evolutionary Optimum Design**. *// Structural and multidisciplinary optimization.*

4. **An approach for reduction of the volume loss in the rigid-plastic FEM using two-step updating procedure**. *// International journal of mechanical sciences*

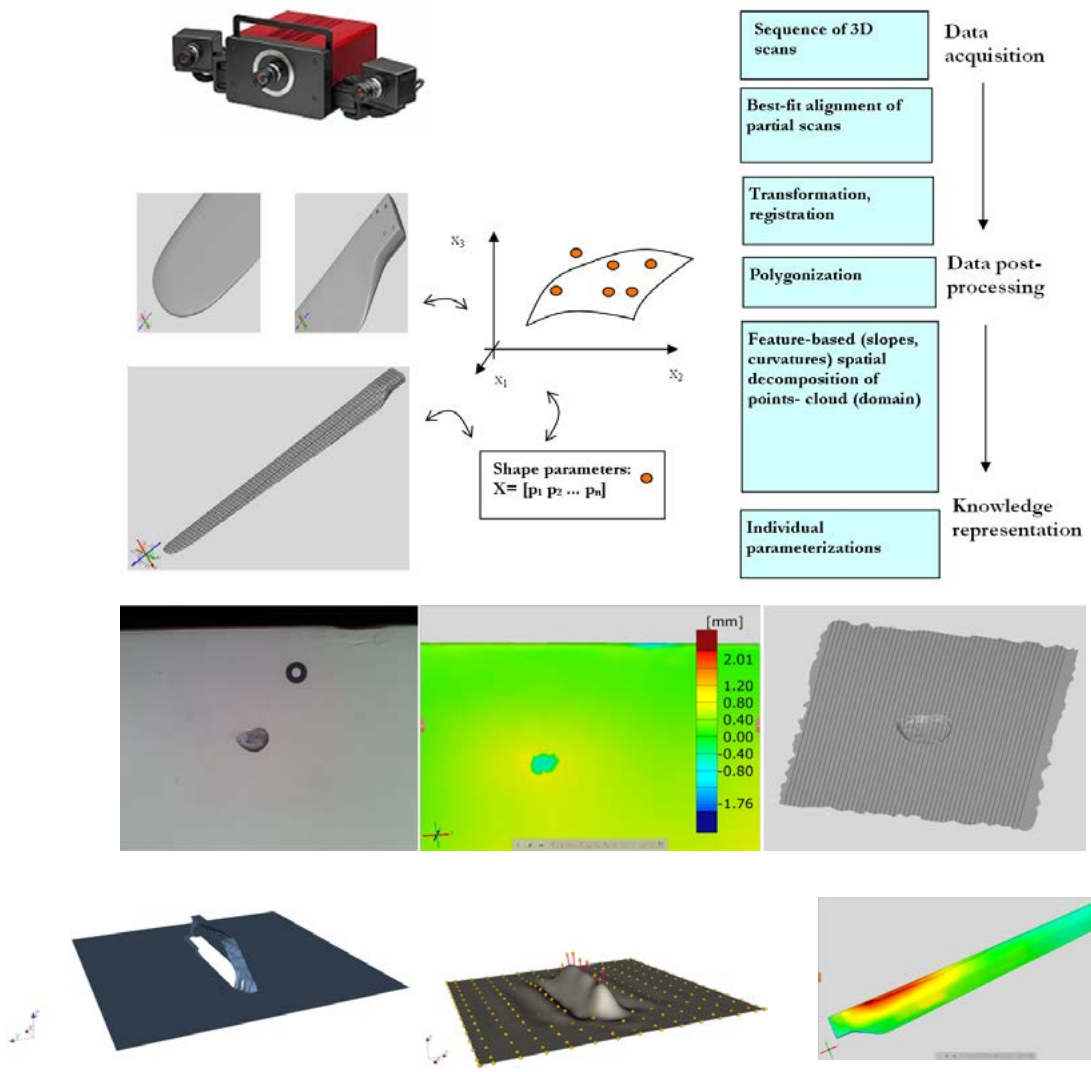
5. **NPV-based decision support in multi-objective design using evolutionary algorithms**. *// Engineering applications of artificial intelligence*

6. **3D Shape acquisition and integral compact representation using optical scanning and enhanced shape parameterization**. *// Advanced engineering informatics*

Monographs (2005, 2007)

1. Damir Vučina, **Application of Computers in Engineering Analysis: with examples in program languages C and MATLAB**

2. Damir Vučina, **Methods of Numerical Optimization in Engineering**



Materials and Tribology

GROUP LEADER
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Nedjeljko Mišina
Full professor

Zvonimir Dadić
PhD student

Nikša Čatipović
PhD student

Petar Ljumović
Laboratory Technician

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RESEARCH INTERESTS AND TOPICS

metal materials – selection

heat treatment and metal surface protection

nondestructive testing

metallographic analysis

mechanical properties testing

tribology

The group has established four research laboratories:

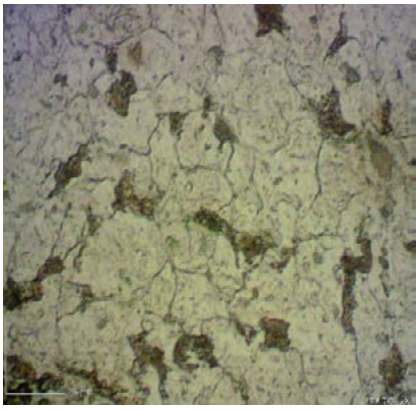
- Laboratory for mechanical property testing
- Laboratory for nondestructive testing
- Laboratory for metallographic analysis
- Laboratory for tribology

THE GROUP AT A GLANCE

Activities of the Group "Materials and Tribology"

The main activity is tribological research in the field of die-casting molds. Parallel the heat treatment of steels, as possible mold material was also considered.

During period from 2012 to 2013 the group was focused on determination of main tribological wear processes on molds for die-casting technology. In the same research period a laboratory device that simulates the main parameters of injection molding was developed. Heat treatment of of low carbon steels was investigated.



Metallographic photo of annealed sample (magnification x500)

SELECTED REFERENCES

The results having come out of the 2 year research period are presented in various publications. Some selected references are given below:

1. Branimir, Lela; Dražen Živković; Ivona Šapina. **Annealing influence on grain size and mechanical properties in low carbon steel** *// Conference proceedings "3rd Internationam Conference Mechanical Technology and Structural Materials 2013"*. pp 127-132,

2. Dražen, Živković; Igor, Gabrić; Slaven Šitić. **Utjecaj niskog i visokog popuštanja na tvrdoću čelika EN 42CrMo4** *// Tehnički glasnika 6* (2012), 2, pp 171-177,

3. Dražen, Živković; Igor, Gabrić; Slaven, Šitić. **Analiza utjecaja parematara toplinske obrade na tvrdoću čelika EN 42CrMo4** *// MATRIB 2012 materilas/tribology/recycling, Hrvatsko društvo za materijale i tribologiju*, pp 379 - 386

4. Dražen, Živković; Igor, Gabrić; Slaven, Šitić. **Utjecaj toplinske obrade na dinamičku izdržljivost čelika EN 42CrMo4** *// Heat Treatment and Surface Engineering – European Opportunities for Croatian Economy, Hrvatsko društvo za toplinsku obadu i inženjerstvo površina*, 2012, pp 67 – 74,

5. Zvonimir, Dadić. **Tribological principles and steps to reduce cutting tool wear** *// Conference proceedings "3rd Internationam Conference Mechanical Technology and Structural Materials 2013"*. pp 133 – 140,

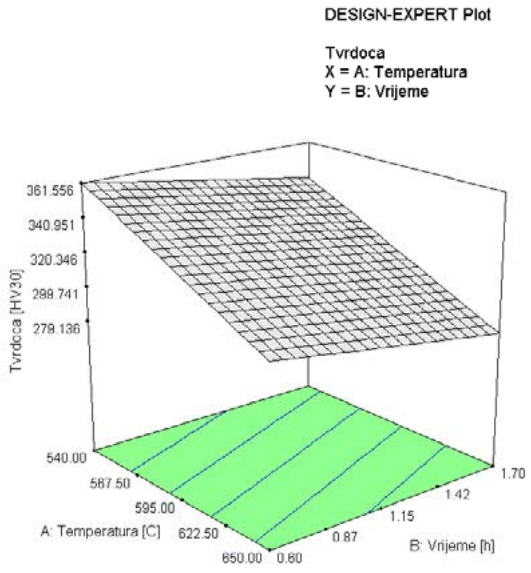
INTERNATIONAL COLLABORATION

The Group "Materials and Tribology" has established contacts and developed cooperation with several international research institutions.

- Dublin Institute of Technology, Ireland
- Slovak Academy of Science, Institute of Materials and Machine Mechanic, Slovakia
- Faculty of Mechanical Engineering, University of Maribor, Slovenia

The group Materials and Tribology took active participation in the organization of 3rd International conference "Mechanical Technologies and Structural Materials 2013".

Metallographic photo of annealed sample (magnification x500)



Hardness –temperature – time diagram for EN 42CrMo4 steel

NATURAL SCIENCES

MATHEMATICS

Mathematical Inequalities on Time Scale Calculus and Applications

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RESEARCH INTERESTS AND TOPICS

mathematical inequalities

time scale calculus

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THE GROUP AT A GLANCE

Activities of the Group can be described as fundamental and applied research in the area of mathematical inequalities. The main interests are mathematical inequalities on time scale calculus and the Jensen-Mercer inequality.

The theory of time scales was intruduced by Stefan Hilger in his PhD thesis, in 1988 as a unification of the theory of difference equations with that of differential equations, unifying integral and differential calculus with the calculus of finite differences, offering a formalism for studying hybrid discrete-continuous dynamic systems. It has applications in any field that requires simultaneous modelling of discrete and continuous data. After the publication of two textbooks in this area: Martin Bohner, Allan Peterson, „Dynamic equations on time scales“, Birkhauser Boston Inc., Boston, MA, 2001; and Martin Bohner, Allan Peterson, „Advances in Dynamic Equations on Time Scales“, Birkhauser, Boston, 2003, more and more researchers were getting involved in this fast-growing field of mathematics. Currently, there are about 400 researchers worldwide who have published about 600 research articles and 3 books in the area of time scales. Several workshops and special sessions on time scales were organized in USA, like is http://www.timescales.org/ (the Baylor University Group, Texas). In July 2003 calculus on time scales was topic of a cover story in the popular American journal “The New Scientist”. The number of these researchers is steadily growing and this research area is wide open.

Jensen-Mercer and related inequalities have been investigated since 2005. in papers by members of our group and several members of the *Research Group in Mathematical Inequalities and Applications* (RGMIA). Recently, one chapter in monographic: M. Fujii, J. Mićić Hot, J. Pečarić, Y. Seo, „Recent Developments of Mond-Pečarić Method in Operator Inequalities“, Element, Zagreb, 2012. has been dedicated to it.

HIGHLIGHTS

In last two years the Group expanded the investigation on time scale calculus trying to obtain new generalizations and refinements of the known inequalities in the terms of time scales and to find new applications of proved results. Some refinements of the time scale integral inequalities can be deduced from the known integral inequalities on time scales for convex functions using the properties of the superquadratic functions and first results of that kind have recently been published in paper [1], and more similar results can be proved in the next two or three years. Also, some new results on converse Jessen's inequality on time scales and new converse inequalities for generalized means, power means and the Holder inequality in the time scale setting are currently the main subject of our research work. Those results are derived from few recently published articles on converse Jessen's inequality for positive linear functionals.

The results on time scale integral inequalites, obtained in articles [2] and [3], are included in the book „Jensen's type inequalities and their applications on time scales" by J. Baric, R. Bibi, M. Bohner, A. Hafiza and J. Pecaric and in next two years we will continue our work on that book.

Also, we will continue investigation on Jensen-Mercer and related inequalities. In paper [4] a refinement of the Jessen-Mercer inequality is obtained and it is shown to be an improvement of the upper bound for the Jessen's difference. Also a generalization of the Jessen-Mercer inequality for convex functions on convex hulls in R^{k} is given and demonstrated to be an improvement of the inequalities obtained in some recent papers. An elegant method of producing n-exponentially convex and exponentially convex functions is applied using the Jessen-Mercer differences. Cauchy mean value type theorems are proved and shown to be useful in studying Stolarsky type means defined by using the Jessen-Mercer differences.

The two members of the Group were also researchers on the project "Convex functions and applications" (177-1170889-1207) supported by the Ministry of Science, Education and Sports of Republic Croatia (MSES).

SELECTED REFERENCES

The results having come out of the 2 year research period are presented in:

1. J. Barić, R. Bibi, M. Bohner, and J. Pečarić, **Time Scales Integral Inequalities for Superquadratic Functions**, *J. Korean Math*. Soc.50 (2013), No. 3.

2. J. Barić, M. Bohner, R. Jakšić, and J. Pečarić, **Converses of Jessen's inequality on time scales**, submitted for publication.

3. H. Ammara, J. Barić and J. Pečarić, **'Time scale Hardy-type inequalities with general kernel for superquadratic functions**, submitted for publication.

4. A. Matković, J. Pečarić, and J. Perić, **A refinement of the Jessen-Mercer inequality and a generalization on convex hulls in R^{k}**, submitted for publication.

Numerical Mathematics and Applications

GROUP LEADER
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RESEARCH INTERESTS AND TOPICS

numerical linear algebra (fast and accurate matrix algorithms, solving eigenvalue and singular value problems, perturbation theory)

operator theory

image segmentation

data mining

A research *Group for Numerical Mathematics and Applications* at the Department of Mathematics and Physics at the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split, deals with numerical methods for eigenvalue and singular value computations, operator theory, and applications to engineering problems such as image segmentation and knowledge extraction / data mining.

DESCRIPTION OF LABORATORIES

The group has established Lab for Multiprocessor Computing which uses and aids maintenance of part of the European cluster EGEE and national computer grid CRO-NGI (160 processor cores and 5 Tb of storage).

THE GROUP AT A GLANCE

FUNDAMENTAL RESEARCH

Numerical linear algebra

The principal activity is development of fast and accurate matrix algorithms and their applications. In particular, a new O(n2) algorithm for computing eigenvalues of arrowhead matrices and diagonal plus rank-one matrices was developed. Algorithm computes all eigenvalues and all components of corresponding eigenvectors to high relative accuracy.

Operator theory

The spectrum of generalized Fibonacci (bounded) and Fibonacci-like (unbounded) operators was analyzed in detail. The results have application in mathematical biology.

APPLIED RESEARCH

Web search engine

The group has been working on developing web search engine since 2004. The engine uses Croatian grammar, works in multiprocessor environment, and has several data mining capabilities. The research so far resulted in five final and three master theses. During the last two years the software was improved and will be used for searching Croatian government web sites.

HIGHLIGHTS

In last two years the members of the Group were involved in one national project and one professional project. In 2012, the group member Nevena Jakovčević Stor presented part of the results at the IX International Workshop on Accurate Solutions of Eigenvalue Problems organized by UC Berkeley, 5th Croatian Mathematical Congress held in Rijeka, and 8th Conference on Applied Mathematics and Scientific Computing held in Šibenik. In 2013, the group leader presented results at International Conference on Numerical Linear Algebra and its Applications held at IIT Guwahati, and at The Third Najman Conference on Spectral Problems for Operators and Matrices held in Biograd.

The most notable advances are the results obtained in fast and highly accurate eigenvalue algorithms for arrowhead matrices and rank-one modification of diagonal matrices, both in real symmetric and Hermitian case, and the extension of these results to computation of zeros of polynomials with all zeros simple and real.

SELECTED REFERENCES

The results having come out of the 2 year research period are presented in:

1. Slapničar, Ivan. **Symmetric matrix eigenvalue techniques** // *Handbook of Linear Algebra / Hogben, Leslie (ed.)*. Boca Raton; London; New York: Chapman & Hall / CRC (2013) 55:1-25

2. Slapničar, Ivan. **On the spectra of generalized Fibonacci and Fibonacci-like operators** // *Operators and Matrices* 6 (2012) 49-62

3. Jakovčević Stor, Nevena; Slapničar, Ivan; Barlow, Jesse L. **Accurate eigenvalue decomposition of arrowhead matrices and applications** // *Linear Algebra and Its Applications* (2013) http://dx.doi.org/10.1016/j.laa.2013.10.007

NATURAL SCIENCES

PHYSICS

Physics

The Chair of Physics at the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture is doing research in experimental particle and astroparticle physics through two international collaboration (CMS - http://cms.web.cern.ch/ and MAGIC - http://magic.mppmu.mpg.de/). There is also a theoretical research activity in a close collaboration with colleagues form the Faculty of Science in Zagreb.

Experimental Research (CMS Group)

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The CMS research group is a member of the Compact Muon Solenoid (CMS) collaboration at CERN (European Organization for Nuclear Research) in Geneva since 1994. The CMS collaboration has built and is now using the CMS detector to study physics of proton-proton collisions at Large Hadron Collider (LHC). The main goal of the collaboration is to search for a mechanism of electroweak symmetry breaking (or search for Standard Model Higgs boson), as well as search for new physics beyond the Standard Model of particle physics.

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Damir Lelas
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Ivica Sorić
Senior Lecturer

Marko Kovač
PhD Student

Dunja Polić
Lecturer

Bojan Lončar
Laboratory Technician

Stipe Mađor-Božinović
Laboratory Technician

RESEARCH INTERESTS AND TOPICS

Large Hadron Collider

Compact Muon Solenoid

electromagnetic calorimeter

electron reconstruction

Higgs boson

THE GROUP AT A GLANCE

Main research activities of the group can be divided as follows:

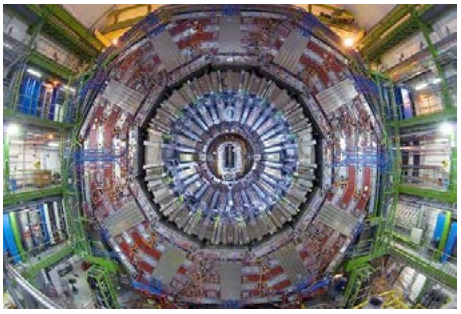
Construction, commissioning and operation of the CMS electromagnetic calorimeter

Since 1994, the group has been active in construction of the CMS electromagnetic (EM) calorimeter, mainly in the area of prototype testing using particle beams at CERN and in photodetectors testing in the laboratory in Split. After many years of development and production, the electromagnetic calorimeter has been successfully constructed and commissioned and is now fully operating as a part of the CMS detector.

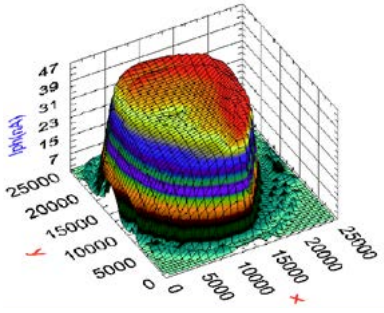
The group has been established the laboratory for photodetectors, which was used to study properties of CMS avalanche photodiodes and vacuum phototriodes, Recent focus of the lab moved to a single photon detection and development of novel photodetection technologies

Electron reconstruction in CMS

Electron reconstruction in CMS consists mainly of combining information from tracker detector and electromagnetic calorimeter. Many algorithms have been developed to find the best reconstruction and identification efficiencies for real and isolated electrons, while reducing contributions from fake and non-isolated electrons. Our group participated in a development of basic and more advanced algorithms that became a standard for the electron reconstruction in CMS and is used for many physical analyses. We are currently working on improvements of algorithms and their preparation for new LHC run on higher energies.



Transversal view of the CMS detector. EM calorimeter is the blue circular area in the middle

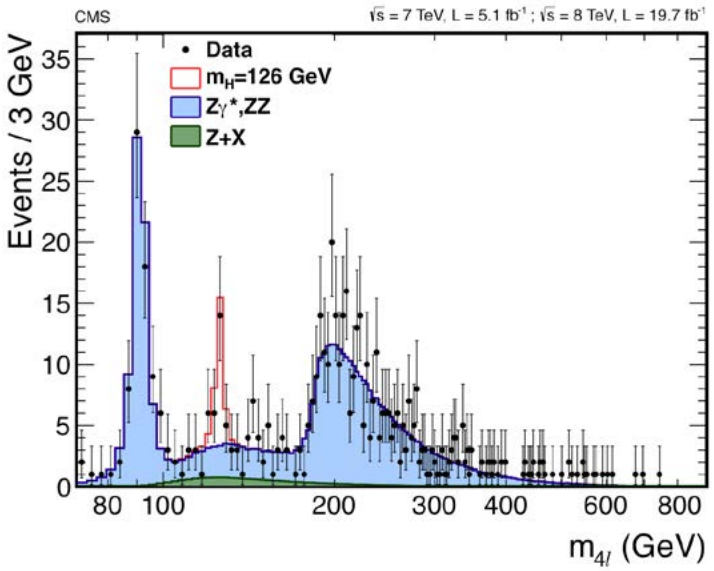


Vacuum phototriode for CMS electromagnetic calorimeter: uniformity of response

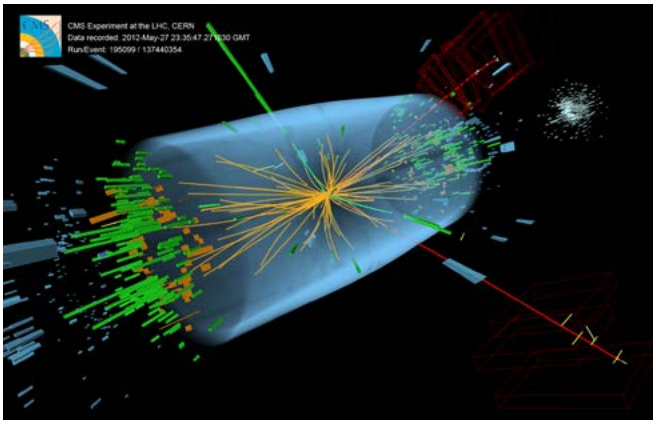
Discovery of the Higgs boson

Main activity of our group in CMS is search for the Higgs boson through decay channel to two Z bosons, which themselves decay to electron-positron or muon-antimuon pair: H→ZZ→4*l* (where *l* represents electrons or muons and their antiparticles). Due to excellent energy resolution for electron and muon measurements in the CMS detector, this channel was very important in search and discovery of the Higgs boson exclusion as well as on measurement of its properties. In 2012 CMS collaboration announced the discovery of new particle with the mass around 125 GeV and during 2013 by measuring its basic properties it was established that this particle correposponds to the Higgs boson of the Standard model. In the left figures below, one typical event for Higgs boson candidate decaying in four leptons in the final state is shown. In the right figure distribution of the four-lepton reconstruction mass is shown, comparing data with expectation from the Standard model background and signal. Excess of data, when compared with background expectation is visible around 125 GeV, and is in agreement with the expectation for the Higgs boson signal. One member of our group was convener of the CMS group searching and measuring the Higgs boson through its decay to two Z bosons. We have completed one PhD thesis on this subject in 2013 and one more is expected to be completed by the end of 2014. Both theses are done at Ecole Polytechnique, Palaiseau, France, in cotutelle with colleagues from Laboratorie Leprince Ringuet.

Besides research activity, the group is very active in popularization and promotion of science. We are organizing biannual conference "LHC Days in Split", since 1996, which is designed to reinforce and further develop High Energy Physics in Croatia, especially in connection with the LHC project. The conference attracts about 100 scientists from all over the world and is held in the old town in Split. In addition we have organized several summer schools, in 2013 "Thematic CERN School of Computing". We have also established "Sarajevo School of High Energy Physics", in collaboration with colleagues from Ecole Polytechnique and Saclay in France and University of Sarajevo. The school started in 2009 and is held annually in spring every year. We have also continued involvement in organization of the "CERN School of Computing", where the member of the group is currently chairman of the Advisory Committee, lecturer and the exam coordinator. During last 20 year members of the group performed more than 200 activities on popularization and promotion of science.



Distribution of the four-lepton reconstructed mass in full mass range for the sum of the 4e, 4μ, and 2e2μ channels. Points with error bars represent the data, shaded histograms represent the backgrounds, and the unshaded histogram the signal expectation for a mass hy- pothesis of mH = 126 GeV. Signal and ZZ background are normalized to the SM expectation, Z + X background to the estimation from data. The expected distributions are presented as stacked histograms. No events are observed with m4l > 800 GeV.



Event recorded with the CMS detector in 2012 at a proton-proton centre of mass energy of 8 TeV. The event shows characteristics expected from the decay of the SM Higgs boson to a pair of Z bosons, one of which subsequently decays to a pair of electrons (green lines and green towers) and the other Z decays to a pair of muons (red lines). The event could also be due to known standard model physics processes.

HIGHLIGHTS

In the last two years the group has been active in the discovery of the Higgs boson and measurements of its properties. From March 2011 to March 2013, one member of the group has been the co-convener of the group searching for Higgs boson through its decay to two Z bosons. Then, through the rest of 2013 he acted as the co-editor of the extensive paper describing all the results for the Higgs boson discovery and properties measurements with the four lepton final state. We have also been active in the calculation of Higgs boson decay branching ratios, as a part of the "Higgs boson cross section working group", a common group consisting of experimental physicists from the ATLAS and CMS collaborations together with theoretical physicists. The goal of the group is to bring together experimental and theoretical physicists with an idea to better exchange, synchronize and use most recent results of Higgs boson searches and measurements. One member of the Split CMS group has been co-convener of the Branching ratio working group.

One member of the group has taken his sabbatical year from 1st October 2011 to 30th September 2012 and obtained research associate position at CERN for one year.

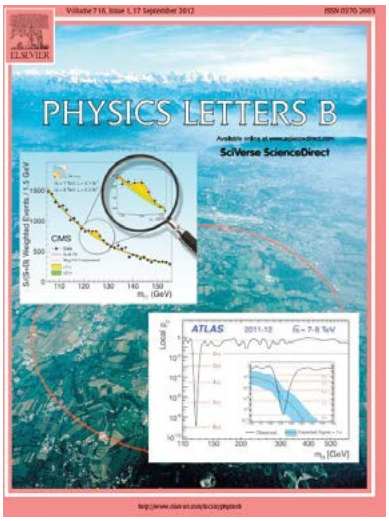
Two PhD students enrolled for their thesis at Ecole Polytechnique, Palaiseau, France, had spent a part of the year there, financed by the scholarship from the French Embassy in Croatia. One student completed the thesis in 2013, while the other is expected for completion by the end of 2014.

One member of the group has been awarded with the annual award for popularisation of science from the local newspaper "Slobodna Dalmacija" for 2011. One member of the group received the Croatian Nacional Order of "Danica Hrvatska", with Ruđer Bošković, for his scientific contribution. Our group received, as the member of the CMS collaboration, "The 2013 High Energy and Particly Physics Prize", awarded by the Euroopen Physical Society Prize.

SELECTED REFERENCES

Results of last two years research period have been presented in many international meetings. The group has published 195 papers in peer-reviewed scientific journals with very high impact factors. Statistics on the published paper from the database INSPIRE, as well as the cover page of the Higgs boson discover paper is given in the figure below.

Citation summary results	Citeable papers
Total number of papers analyzed:	195
Total number of citations:	9,694
Average citations per paper:	49.7
Breakdown of papers by citations:	
Renowned papers (500+)	2
Famous papers (250-499)	0
Very well-known papers (100-249)	12
Well-known papers (50-99)	36
Known papers (10-49)	114
Less known papers (1-9)	31
Unknown papers (0)	0
h_{HEP} index [?]	50



Statistics on the paper published by the CMS collaboration in 2012 and 2013, from the database INSPIRE (left). Cover page of The Physics Letters B, featuring the papers announcing discovery of the Higgs boson like particle (right).

Announcement of the first Thematic CERN School of Computing, held in Split in 2013 (left). Poster for the LHC Days in Split, October 2012 (right)

Very High Gamma-ray astronomy

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RESEARCH INTERESTS AND TOPICS

Gamma-ray Astronomy

MAGIC telescopes

pulsars

data quality

photodetectors

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A research Group for Very High Energy (VHE) Gamma-ray Astronomy at Department of Physics of the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split is a full member of the international MAGIC (Major Atmospheric Gamma-ray Imaging Cherenkov) collaboration since 2009. The MAGIC collaboration manages the two largest and most sensitive VHE gamma-ray telescopes, located at the Observatory Roque de los Muchachos (ORM) observatory on the Canary island of La Palma.

DESCRIPTION OF LABORATORIES

Laboratory for photodetector characterization has been established with an aim to measure all relevant characteristics and performance of photodetectors, particularly a new type of semiconductor photodetector with single photon sensitivity. The laboratory is equipped with computer controlled temperature chamber, 6485 Keithley picoammeter, Keithley 6487 voltage source/ picometer. 2000 Keithley multimeter, CAEN N478 programmable power supply and CAEN Silicon Photomultiplier Kit.

MAGIC telescopes at the ORM observatory

THE GROUP AT A GLANCE

Activates of the group can be divide in two categories:

Service and operation works

Our MAGIC group is responsible for data quality check. Every day, the group has to perform a basic analysis of the data collected during the previous night to check performances of both telescopes and the quality of measured data. Main goals are to inform the collaboration and to possibly alarm other groups who are responsible for different subsystems to take appropriate action if a subsystem is malfunctioning and to make telescopes ready for new observation, following night. Recently we have developed a new web interactive software tool, which allows studying the long-term performances and correlations among different parameters. Experience with MAGIC data quality check allowed us to start to actively participate in the design and development of the similar software for the future CTA (Cherenkov Telescope Array) observatory. CTA project is a worldwide scientific collaboration aiming to build the next generation ground-based very high-energy gamma-ray instrument. About 100 Cherenkov telescopes on two sites in the northern and the southern hemisphere will allow for an improvement in sensitivity of a factor 5-10 when compared with current installations like H.E.S.S., MAGIC or VERITAS. CTA will also extend the energy range and will grant access to photon energies above 100 TeV. The design of the software for CTA data quality check is performed in collaboration with the colleagues Humboldt University Berlin.

Research activities

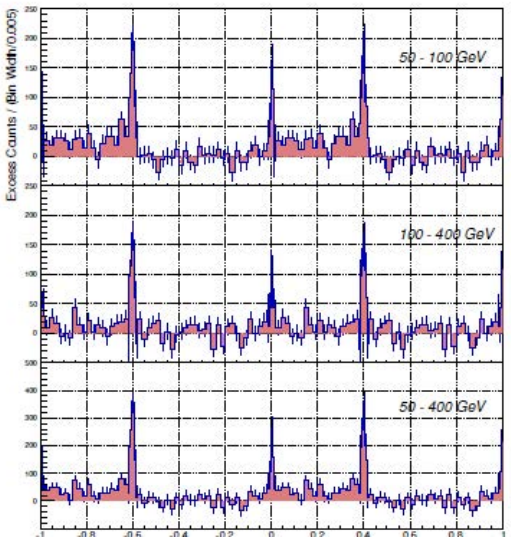
Our group in Split mainly studies pulsed emission of VHE gamma-rays from pulsars (fast rotating neutron stars – a remnant of a supernova explosion. The Crab pulsar, remnant of the supernova explosion that occurred in 1054, is one of a very few pulsars whose pulsed emission has been detected in the all parts of the electromagnetic spectrum, from radio waves up to VHE gamma-rays. Actually, the MAGIC telescope was first to observe gamma-ray emission above 25 GeV from Crab pulsar. MAGIC detected gamma-ray pulsations up to 400 GeV in contradiction to all existing models of pulsar emission. Our group has actively participated in this important discovery, doing special data quality checks and data analysis. Particularly in analysis of optical pulsation, which are in phase with VHE gamma-ray pulsations, to a crosscheck the MAGIC timing systems. Detailed analysis of the Crab pulsar data also showed that besides two clearly visible peaks there is a significant emission between these two peaks (bridge emission). To sum up, experimental results of the MAGIC telescopes, which shows that Crab pulsar besides a pulsed emission up to 400 GeV also has a significant bridge, emission should be accounted by any theoretical model.

HIGHLIGHTS

The group have actively participated in the upgrade of the MAGIC trigger system with the new stereo sum-trigger which ensure the lowest low energy threshold (30 GeV) for the ground based VHE gamma-ray telescopes. The software for daily check has been adapted to perform the performance check of the data taken by sum-trigger during its commissioning. We have applied together with the University of Geneva to the SCOPE Joint Research Project of the Swiss National Science Foundation to establish at FESB the laboratory for the characterization of different types of photodetectors which are going to be used to build the cameras for the CTA telescopes. U

SELECTED REFERENCES

In the last two years our group has published 24 scientific papers and discovered several new very high energy gamma-ray sources, 2 students completed their diploma thesis.



Light Curve of the Crab pulsar for 50 -100 GeV (top), 100 - 400 GeV (middle) and 50 - 400 GeV (bottom).

Theoretical Research Group

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RESEARCH INTERESTS AND TOPICS

optics

ultracold quantum gases

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Theoretical research is performed by postdoc Karlo Lelas, in collaboration with professor Hrvoje Buljan from the Faculy of Science at the University of Zagreb.

THE GROUP AT A GLANCE

Optics and ultracold quantum gases

A research involving theoretical physics of ultracold quantum gases at the Department of Physics, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture is a part of the reasearch activities of the Group for optics and ultracold quantum gases at the Physics Department, Faculty of Science of Zagreb University. This report focuses on activities in Split, which were a part of the PhD thesis of Karlo Lelas.

HIGHLIGHTS

In quantum many-body systems, interactions between particles create correlations and particles cannot be described independently. As a consequence, the wave function of the system is a complicated object holding a large amount of information and in most cases it is not possible to obtain it exactly or analytically. Studying correlations in the context of strongly interacting one-dimensional (1D) systems is interesting because in this regime we can exactly determine many-particle wave function through Fermi-Bose (FB) mapping. FB mapping is in the essence of a Tonks-Girardeau (TG) gas proposed in 1960, a theoretical model of 1D Bose gas with strongly repulsive contact interactions between particles. TG gas is experimentally realized in 2004 with Rubidium atoms confined in a tight atomic waveguides and it is still a topic of experimental studies.

In 2012 we focused on the Tonks-Girardeau gas in a particularly interesting configuration which admits critical point. If a weak periodic potential (optical lattice) is applied along the axial direction of a one-dimensional ultracold quantum gas, it is possible to generate an atomic simulation of the sine-Gordon model. When the interactions between the particles in the gas are sufficiently repulsive and the lattice is commensurate with the particle density (one particle per lattice site), this model has a quantum phase transition where atoms become ‘pinned’ to the Mott insulator state. We investigated this pinning quantum phase transition in the Tonks-Girardeau limit using ground state fidelity and Loschmidt echo as diagnostic tolls [1].

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1. K. Lelas, T. Ševa, H. Buljan and J. Goold , Phys. Rev. A 86,033620 (2012).

HUMANITIES

FOREIGN LANGUAGES AND COMMUNICATION SKILLS

Improvement of Students' Spoken and Written Communication Skills in English

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RESEARCH INTERESTS AND TOPICS

research interests and topics

presentation skills

improved writing skills

peer assessment

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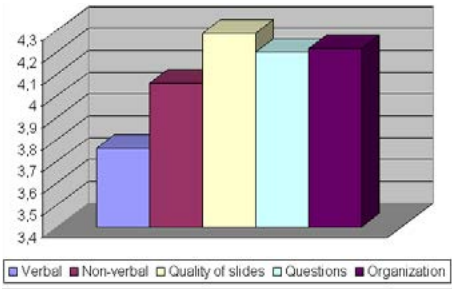
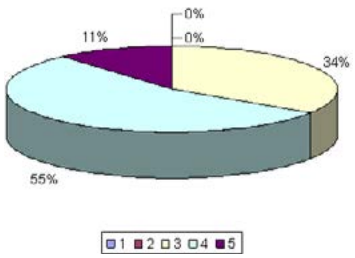
The Research Group for Improvement of Students' Spoken and Written Communication Skills in English is a part of the Department of General Courses at the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture. The group deals with various aspects of theoretical and applied forms of technical English, with the focus on improving the learning process in order to increase students' overall communication skills in technical English.

The present situation in scientific research requires a broad knowledge of one's own theoretical and professional skills, but the tendency towards an interdisciplinary approach among scientific fields also creates a demand for highly acquired spoken and written communication skills in the successful exchange of knowledge. The main aim of the group is to help students acquire the required knowledge and skills, as well as build self-confidence in open communication.



Average grade for different presentation aspects



Peer evaluation: Grades for the verbal aspect of L2 communication

THE GROUP AT A GLANCE

Activities of the Group for Improvement of Students' Spoken and Written Communication Skills in English can be divided into the following areas of fundamental and applied research areas:

FUNDAMENTAL RESEARCH

Improving students' presentation skills

Renowned accreditation agencies for higher education in the scientific field of technical sciences propose that the students, besides the engineering skills necessary for the engineering practice, also attain the ability to communicate effectively, that is, to deliver an effective oral presentation. Therefore, the group investigated how students give specific feedback by evaluating oral presentations in English (L2) against established and relevant criteria. The engineering students display most difficulties at the level of speech production, that is the frequent occurrence of filled and silent pauses, repetitions, false starts, grammatical errors, which negatively affect the overall oral performance. However, the technical level of performance is a less difficult part of presenting. The obtained results point to the conclusion that the students are aware that speech disfluencies negatively affect the overall oral performance and that efforts should be made in order to reduce them.

APPLIED RESEARCH

Peer review as a means for developing the skills in giving and receiving feedback

The issue of peer evaluation has received great attention in recent years. The promotion of peer assessment activities positively affects student learning. It has been confirmed that if the students are reminded to pay attention and monitor the grammatical accuracy of their peers, they more frequently notice incorrect grammatical usage of tenses, inappropriate pronunciation of words, etc. Consequently, the students gradually become aware of the necessity of delivering fluent speech through different task types.

Peer evaluation is a useful part of assessment for learning, as it enables learners to recognize how to improve their work. Moreover, it has been regarded as an important part of the professional practice in IT. It develops skills in giving and receiving feedback, it builds learners' confidence to present their ideas, it helps learners value interpersonal skills and it also increases learners' motivation and persistence. In addition, peer review helps learners see different ways of understanding, including how others sometimes arrive at misconceptions, which in turn greatly strengthens learning.

Information on the monitoring skills and repair behaviour

The working group investigated the repair distribution, the error correction rates and the repair successfulness in the speech of L2 learners, with the goal to find out more information on the monitoring skills and repair behaviour. A detailed subcategory analysis within syntactic, lexical and morphological categories which have not been investigated so far was included in the research. The lowest correction rates were observed in the case of morphological subcategories, showing that the speakers' attention was not oriented towards grammatical accuracy. The findings of this study may find practical application in foreign language teaching, suggesting possible reviews of formal teaching methods, aiming at more efficient linking of grammatical development to the ability to communicate.

HIGHLIGHTS

The course entitled Communication skills is oriented towards acquiring professional competence in the field of communication skills, that is, according to the requirements of the renowned accreditation agencies, good presentation skills. In the last two years the group tried to successfully integrate the acquired contents from this course into the existing English course. Besides concentrating on the specific needs of scientific language, students are expected to develop spoken and written communication skills as well. Another important aspect is raising awareness about the necessity of fluent speech in the English language which also includes the reduction of the excessive use of fillers. Besides the verbal and vocal level, other levels of presenting were also taken into consideration such as the non-verbal communication, quality of slides, and the level of information feedback. The group worked on encouraging active participation of all students. By actively participating as evaluators, students gradually became more receptive and co-operative, which in turn makes the lessens more creative.

SELECTED REFERENCES

The research results presented in journals are referred in CC data base and in a Canadian journal paper. The references are as follows:

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2. Kovač, Mirjana Matea, Milatović, Biljana, **Analysis of Repair Distribution, Error Correction Rates, and Repair Successfulness In L2**, *Studia Linguistica: A Journal of General Linguistics*, John Wiley and Sons Ltd., No. 67, 2013. 225-255

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