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2017

UNIVERSITY OF ZAGREB
FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

March 2017 • ZAGREB, CROATIA

ABOUT
UNIVERSITY OF ZAGREB - UNIZG

Website:
www.unizg.hr

The **University of Zagreb - UNIZG** (1669) is the oldest and biggest university in South-Eastern Europe. As a comprehensive public Central European university, University of Zagreb offers education and research in all scientific fields (arts, biomedicine, biotechnology, engineering, humanities, natural sciences, and social sciences) and a broad spectrum of courses at all study levels, from undergraduate to postgraduate. With 29 Faculties, 3 Art Academies and the University Centre for Croatian Studies it is the flagship educational institution in the country, a place where more than 7900 teachers and 72480 students develop knowledge and acquire skills.

The University excels not only in teaching, but also in research, contributing with over 50 percent to the annual research output in Croatia and 80 percent of scientific productivity of all Croatian universities. The central strategic issue of the future development of the University of Zagreb is for it to be a research oriented institution with high quality teaching. Accordingly, the focus will be on master and doctoral programs, encompassing all fields of science and art, boosting transdisciplinarity and interdisciplinarity as well as transnational research, nurturing the culture of innovation and transfer of knowledge.

FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING - FER

Website:
www.fer.unizg.hr

The **Faculty of Electrical Engineering and Computing - FER** is part of the University of Zagreb - UNIZG. With 130 professors, 220 graduate teaching and research assistants, 4900 students enrolled in various programs, and operating in facilities of more than 35000 m2, FER is the largest technical high education institution and the leading educational and R&D institution in the fields of electrical and computer engineering and computer science in Croatia. It is the highest-quality member of the University of Zagreb, with a large and modern infrastructure devoted to research-based education. FER is organised in 12 Departments which represent the focal points of education and R&D. Currently FER participates in more than 20 projects financed by the EU through various grant schemes (FP7, H2020, IPA, COST, …).

DEPARTMENT OF CONTROL AND COMPUTER ENGINEERING

The **Department of Control and Computer Engineering** was founded in 1954 at the University of Zagreb, College of Engineering. The first head of the department was distinguished and renowned prof. Vladimir Muljević (1913-2007) who is also regarded as the Department founder. Since then, the Department has been the place of study and research for numerous undergraduate and doctoral students, researchers, industrial partners, and academics, growing to be one of the largest department at today's Faculty of Electrical Engineering and Computing. It has also been recognized worldwide as the partner to renowned and most prestigious education and research institutions.

At present, the Department consists of 14 professors and 50 researchers.

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Robotics research at UNIZG-FER is conducted within three laboratories: **Laboratory for Robotics and Intelligent Control Systems - LARICS** (larics.rasip.fer.hr), **Laboratory for Autonomous Systems and Mobile Robotics - LAMOR** (lamor.fer.hr) and **Laboratory for Underwater Systems and Technologies - LABUST** (labust.fer.hr). These laboratories are founders of **Centre of Research Excellence for Advanced Cooperative Systems - ACROSS** (across.fer.hr).

These groups are currently active in more than 20 scientific international and national projects with the topic of robotics in different areas. They are also tightly collaborating with companies from all around the world.

Special attention is devoted to knowledge transfer to students at the undergraduate, graduate and PhD level. Starting with elementary robotics, all the way to advanced control, navigation, and estimation, robotics students at UNIZG-FER have the opportunity to adopt state of the art robotics knowledge and apply it on a large number of robotic platforms that are available in the laboratories.

RESEARCH ROBOTICS LABORATORIES
LABORATORY FOR ROBOTICS AND INTELLIGENT CONTROL SYSTEMS - LARICS

LARICS
LABORATORY FOR ROBOTICS AND INTELLIGENT CONTROL SYSTEMS
Department of Control and Computer Engineering
Faculty of Electrical Engineering and Computing, The University of Zagreb

**Website:
larics.rasip.fer.hr**

**Contact:
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Head of LARICS**
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Prof. Stjepan Bogdan
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In the last 20 years, the **Laboratory for Robotics and Intelligent Control Systems - LARICS** research group has been involved in research on integrated robotics and process control. LARICS researchers (3 professors, 2 post docs, 11 PhD, over 15 MS and over 30 BS students) have mainly participated in research devoted to unmanned aerial systems, intelligent control systems, service robotics, control of multi agent systems, robot formations, planning, scheduling and decision making in autonomous systems, and application of new technologies in industrial control systems.

Particular emphasis has been given to collaboration with industry, which resulted in many successful implementations of novel control algorithms and human-machine-interfaces in industrial plants. LARICS members successfully completed the following selected industrial projects in collaboration with national and international companies: *Interactive simulator of the Ziegler fire-fighting vehicle control system; Control of a robot for hydrodynamic processing of concrete and metal surfaces; Control of the RCP manipulator for ultrasonic inspection of main pump welds in the VVER-1200 nuclear power plant; Advanced Control of Industrial Plants - Cold Rolling Mill Control (TLM Sibenik)*. Currently, the laboratory is involved in research on advanced evolutionary learning based methods for optimal characterisation of non-linear after treatment technologies funded by Ford Motor Company through the Ford Global University Research Program (URP).

Recently, together with partners, the Laboratory successfully brought to a close one EU FP7 project (Estimation and Control for Safe Wireless High Mobility Cooperative Industrial Systems - EC-SAFEMOBIL) and a project financed through the Air Force Office of Scientific Research (Human-in-the-loop Control of Multi-agent Aerial Systems Under Intermittent Communication) as well as two projects with scientists from the USA and PR China.

At this moment, LARICS researchers are involved in two EU FP7 projects: *European Robotics Challenge (EOLO: Wind generator remote inspection system)* - EuRoC and *Animal and robot Societies Self-organise and Integrate by Social Interaction (bees and fish)* - ASSISI_bf. The Laboratory is a partner on one Horizon 2020 project (*Submarine Cultures Perform Long-Term Robotic Exploration of Unconventional Environmental Niches* - subCULTron) and is currently coordinating a NATO Science for Peace project (*Unmanned system for maritime security and environmental monitoring* - MORUS). LARICS participates in several national projects financed by the government and industrial partners like for instance *Autism Diagnostic Observation with Robot Evaluator* - ADORE, two PoC6 (proof of concept) projects financed by the HAMAG-BICRO Agency, Automated Map Calibration for Autonomous Warehousing (AMACAL) and Confirmation of the Concept of an Electronic Differential for Electric Car with Independent Drives.

LABORATORY FOR AUTONOMOUS SYSTEMS AND MOBILE ROBOTICS - LAMOR
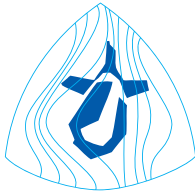
Website:
lamor.fer.hr

Contact:
Prof. Ivan Petrović,
Head of LAMOR
ivan.petrovic@fer.hr

The **Laboratory for Autonomous Systems and Mobile Robotics - LAMOR** has a long tradition in research of advanced control strategies and estimation techniques for a variety of applications with a strong emphasis on autonomous navigation of ground and aerial robots in unknown and dynamic environments. Our methodology relies on a strong coupling between theoretical research, algorithm development, experimental evaluations, and a healthy dose of serendipity. It is directed by Prof. Ivan Petrović of the UNIZG-FER and currently consists of 2 Assistant Professors, 8 doctoral students and 1 project manager. LAMOR's research activity is organized around three major axes: Motion Planning and Control (MPAC), Simultaneous Localization and Mapping (SLAM), and Detection and Tracking of Moving Objects (DATMO). The Laboratory is equipped with state-of-the-art ground and aerial robotic platforms, advanced perception sensors, and a motion capture covered arena.

LAMOR coordinated the major national robotic research program *Intelligent robotic systems and autonomous vehicles* (2007-2014), which involved 5 major robotic research groups in Croatia. LAMOR also has a long tradition of collaboration with research centres in the EU and worldwide. Prof. Petrović coordinated the EU project ACROSS - *Centre of Research Excellence for Cooperative Robotic Systems* (across.fer.unizg.hr), which involved 14 research groups from the University of Zagreb and 16 research institutions from 10 European countries, and is currently coordinating the ACROSS Centre of Excellence through the Phase I of H2020 WIDESPREAD Teaming. Furthermore, Prof. Petrović also coordinated the European Regional Development Fund project *Advanced technologies in power systems and rail vehicles* in partnership with the Končar Electrical Engineering Institute Inc. Currently, the group is involved in nine projects: ACROSS - *Centre of Excellence for Autonomous and Cooperative Robotic Systems* (H2020-WIDESPREAD Teaming project), L4MS - *Logistics for Manufacturing SMEs* (H2020 IA project), SafeTRAM - *System for Increased driving safety in public urban rail traffic* (ERDF project), CROBOHUB - *Feasibility study for Croatian robotics digital innovation hub* (H2020 project), RoboCom++ - *Rethinking Robotics for the Robot Companion of thefuture* (FLAG-ERA project), EOLO - *Wind generator remote inspection system* (Challenge competition 3 within FP7 project EuRoC), SafeLog - *Safe human-robot interaction in logistic applications for highly flexible warehouses* (H2020 RIA project), cloudSLAM - *Cooperative cloud based simultaneous localization and mapping in dynamic environments* (Unity Through Knowledge Fund project) and *Human localization and intention recognition based on wearable sensors* (German Academic Exchange Service and Croatian Ministry of Science and Education project).

LAMOR successfully organized two robotic conferences: the *4th European Conference on Mobile Robots* - ECMR'09 (www.ecmr09.fer.hr) and the *10th IFAC Symposium on Robot Control* - SYOROCO 2012 (www.syroco2012.org). Prof. Petrović is the Editor-In-Chief of the journal *Automatika - Journal for Control, Measurement, Electronics, Computing and Communications*.

LABORATORY FOR UNDERWATER SYSTEMS AND TECHNOLOGIES - LABUST

Website:
labust.fer.hr

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The **Laboratory for Underwater Systems and Technologies - LABUST** is a 12 member research group that serves as the focal point for applied research and development activities in unmanned marine systems and technology for end-users. We aim to create new knowledge, educate students, provide advice for end-users, innovate and implement solutions for our customers. We contribute to innovation in sustainable exploitation of ocean resources. LABUST sets itself apart from others in its values and mission to inspire and seek challenging tasks.

Our vision is to advance in a multidisciplinary engineering research that innovates, applies and teaches world class attainments in autonomous marine systems, sensor processing, and underwater acoustics for marine science, maritime archaeology, maritime security, the offshore energy sector, and other applications.

We are currently coordinating three Horizon 2020 projects **EXCELLABUST - *Excelling LABUST in marine robotics,* aPad *- smaller, lighter, smarter autonomous marine surface vehicle***, and **PlaDyFleet** - ***A fleet of unmanned surface marine vehicles PlaDyPos***. We are partners in 10 projects:

• ACROSS - *Centre of Excellence for Autonomous and Cooperative Robotic Systems* (Horizon 2020)

• BLUEMED - *plan/test/coordinate Underwater Museums, Diving Parks and Knowledge Awareness Centres in order to support sustainable and responsible tourism development and promote Blue growth in coastal areas and islands of the Mediterranean* (Interreg Mediterranean)

• CROBOHUB - *Feasibility study for Croatian robotics digital innovation hub* (Horizon 2020)

• CroMarX - *Cooperative robotics in marine monitoring and exploration (Croatian Science Foundation)*

• EUROFLEETS2 - *New operational steps towards an alliance of European research fleets* (EU FP7)

• e-URready4OS - *Expanded underwater robotics ready for oil spills* (ECHO-DG)

• MORUS - *Unmanned system for maritime security and environmental monitoring* (NATO Science for Peace project)

• RoboCom++ Rethinking Robotics for the Robot Companion of the future (FLAG-ERA)

• SPATEL - *Spatial Auditory Human-Machine Interface for UxV Teleoperation* (ONRG)

• subCULTron - *Submarine Cultures Perform Long-Term Robotic Exploration of Unconventional Environmental Niches* (Horizon 2020)

In the last 5 years, the group has also participated in 3 national projects related to marine robotics. We have experience in developing guidance and control software for industry (VideoRay, USA; LD TravOcean, France).

LABUST is a light member of the HYCON2 network of excellence. We have organized 9 annual field trainings Breaking the Surface - BtS with the purpose of conducting multidisciplinary research within marine biology, archaeology and security.

RESEARCH ROBOTICS CENTRE
CENTRE OF RESEARCH EXCELLENCE FOR DATA SCIENCE AND COOPERATIVE SYSTEMS

Website:
across-datascience.hr

Contact:
Prof. Ivan Petrović,
Centre Co-director
ivan.petrovic@fer.hr

The **Centre of Research Excellence for Data Science and Cooperative Systems** is the first national centre of research excellence in the area of technical sciences. It is a successor of the Centre of Research Excellence for Advanced Cooperative Systems - ACROSS which was an interdepartmental project at UNIZG-FER (across.fer.hr, see ACROSS description on page 17). Its establishment and operation was funded by the European FP-7 Capacities Research Potential program [285939, FP7-REGPOT-2011-1]. The Centre gathers 13 renowned partners including 11 higher education institutions from Zagreb, Split, Rijeka, Osijek and Dubrovnik, Ruđer Bošković Institute and the company Ericsson Nikola Tesla. The Centre's mission is to become a leading party in new technology research and development in the fields of data science and cooperative systems. The Centre will advance Croatian science and reinforce its inclusion in the European Research Area, i.e. foster participation in the EU and world research programmes and, additionally, act as a focal point of collaboration between the academia and the business and public sector. This will lead to a strong enhancement of the quality of life and economic growth of Croatia. The Centre consists of the Data Science (DS) and the Advanced Cooperative Systems (ACROSS) research units.

The DS research unit, headed by Prof. Sven Lončarić, studies the problem of extracting knowledge from data, including so called "big data". It is further divided into four Strategic Research Domains: i) multimodal data processing and information control, ii) machine learning and deep data analysis, iii) heterogeneous computing and advanced cloud services, and iv) multidisciplinary data intensive applications. Applications of data science are manifold and include particle and astroparticle physics, biological sciences and healthcare, business analytics and finance, complex networks and society, and analysis of data traffic.

The ACROSS research unit, headed by Prof. Ivan Petrović focuses on the following four Strategic Research Domains: i) autonomous and cooperative robotics systems, ii) cognitive computer vision systems, iii) ubiquitous sensors and networked human-oriented services and iv) advanced control and estimation strategies for cyber-physical systems. Fundamental methodological research within each Strategic Research Domain will be transferred to applications areas while establishing the compatibility of research between the domains. Applications of cooperative systems are truly numerous, and in the Centre we will focus on healthcare systems, security and protection, environment, advanced cities and factories of the future.

WORKSHOPS

ACROSS WORKSHOP

Contact:
Prof. Ivan Petrović
across@fer.hr

The **1st ACROSS Workshop on Cooperative Systems - WoCS 2014**, was held on September 10-12, 2014 in the Grand Hotel Park, Dubrovnik, Croatia. The workshop was organized by the Centre of Research Excellence for Advanced Cooperative systems - ACROSS of the UNIZG-FER, which was funded by the European Commission under FP7-REGPOT-2011-1 ACROSS project (grant No. 285939). The general Chair of the workshop was **Prof. Ivan Petrović**. The workshop will continue to be held annually under the auspices of the Centre of Research Excellence for Data Science and Cooperative Systems.

BREAKING THE SURFACE - INTERNATIONAL INTERDISCIPLINARY FIELD WORKSHOP OF MARITIME ROBOTICS AND APPLICATIONS

Website:
bts.fer.hr

Facebook:
www.facebook.com/
BtSCroatia

Contact:
Assoc. Prof. Nikola Mišković,
Programme Chair
bts@fer.hr

Breaking the Surface - BtS workshop is organized by LABUST laboratory for the 9th year in a row. BtS serves as a meeting place of experts and students of marine control engineering and signal processing and the marine robotics application areas in various types of ocean science. This is the world's first successful, multi-year field training program that combines academic topics in maritime robotics and robotics application areas and hands-on working experience in the sea, doing remote sensing and sampling for various ocean sciences. It is also unique in that strong emphasis is put on the participation of principal investigators and established research group leaders from across the globe, catering not only to the EU or USA research communities.

BtS 2017 will be held from **1st** until **8th October** in **Biograd na Moru (Croatia)**. In 2017 it will be organized in the scope of Horizon 2020 project EXCELLABUST - *Excelling LABUST in marine robotics* (GA No 691980) and in partnership with the Centre for autonomous marine operations and systems - AMOS from the Norwegian University of Science and Technology - NTNU.

The programme novelty is "Innovation day"- a whole-day workshop where you will learn how to commercialize robotics-related technologies.

The general chair of the workshop is **Prof. Zoran Vukić** and the Programme Chair is **Assoc. Prof. Nikola Mišković**.

SCIENTIFIC AND RESEARCH PROJECTS

Currently there are 23 ongoing research projects at the Department of Control and Computer Engineering, which makes more than 20% of all research projects at UNIZG-FER. The list of ongoing projects contains seven Horizon 2020 projects, two FP7 projects, one NATO project, one ERDF project, one Unity Through Knowledge Fund project, two projects by the Croatian Science Foundation, one COST project, one bilateral project, and four projects from other international funding programmes. There are also numerous R&D projects carried out with industry partners from Croatia and abroad.

Robotics projects leaders at FER are Prof. Stjepan Bogdan, Prof. Zdenko Kovačić, Asst. Prof. Ivan Marković, Dr. Sc. Damjan Miklić, Assoc. Prof. Nikola Miškovic, Prof. Ivan Petrović, Mr. Sc. Antonio Vasilijević and Prof. Zoran Vukić.

SELECTED ONGOING RESEARCH PROJECTS

ACROSS - CENTRE OF EXCELLENCE FOR AUTONOMOUS AND COOPERATIVE ROBOTIC SYSTEMS

Contact:
Prof. Ivan Petrović,
Project Coordinator

ACROSS is a H2020 WIDESPREAD Teaming Phase I project. The overall objective of the project is to create a Centre of Excellence for Autonomous and Cooperative Robotic Systems in Croatia (ACROSS CoE), which will be at the forefront of research and innovation of novel methodologies and advanced engineering approaches in the targeted domains. ACROSS CoE will be created and run as a long-term joint venture between the UNIZG-FER, the KTH - Royal Institute of Technology, and the ICENT - Innovation Centre Nikola Tesla. To achieve the overall objective, the proposal focuses on long-term objectives for Teaming Phase 2 and on one-year objective for Teaming Phase 1. Long-term objectives of the Phase 2 and beyond are: (i) Reinforcing scientific capacity and innovation performances in autonomous and cooperative robotic systems, (ii) Increasing scientific visibility and reputation at international level, and (iii) Improving responses to socioeconomic needs of Croatia. ACROSS CoE will achieve these objectives by striving for high quality research, in line with international standards of excellence, and by directing its research towards areas serving the technological needs identified by the Croatian Smart Specialisation Strategy. The ultimate objective of the Phase 1 is to produce an extensive, detailed, and robust Business Plan for ACROSS CoE; and to achieve this, the plan will be built upon (i) Assessment of the existing ACROSS ecosystem and (ii) Development of roadmaps for achieving ACROSS CoE excellence. The ACROSS project is relevant to the work programme since the main goal is to create a new Centre of Excellence in Croatia, a low R&I performing country, by building upon partnership with KTH, a world leading scientific and innovation institution. Creation of the ACROSS CoE will help Croatia in attaining a competitive position in the global value chains, thus also contributing to Europe's competitiveness and its ability to address future societal challenges.

ADORE - AUTISM DIAGNOSTIC OBSERVATION WITH ROBOT EVALUATOR

ADORE

Contact:
Prof. Zdenko Kovačić

ADORE is a project funded by Croatian Science Foundation whose main goal is to help clinicians from the Faculty of Education and Rehabilitation Sciences to diagnose autism spectrum disorders more quickly and efficiently by using NAO humanoid robots from Aldebaran Robotics.

Through this project LARICS laboratory is working on developing a new set of motoric and cognitive skills for NAO humanoid robots. Autism spectrum disorder (ASD) is a developmental disorder characterized by impairment in social interaction, verbal and nonverbal communication, and by repetitive behaviours and interests. The diagnosis, which is usually given during the preschool period, depends on the education and experience of human evaluators, which can be susceptible to personal bias. The goal of the project is the development of a robot-based diagnostic protocol and testing of its verification in clinical settings. The robots will be used as ASD co-evaluators to help a human evaluator to assess a child's behaviour objectively. Technically, this means developing specific robot skills and behaviours to be deployed within the standard clinical diagnostic procedure of ASD. The robots will have two functions: observation and quantitative measurement of a child's social responses; and performance of standardized social presses designed to provoke child response. This involves actions such as analyses of the audio signal and differentiation of vocalizations and speech, detection of eye-gaze direction, performance of different actions and gestures and utilization of human-robot and robot-robot interaction to attract child attention.

This involves work on cooperation, cognition and human-robot interaction, focusing on multimodal communication.

AMACAL - AUTOMATED MAP CALIBRATION FOR AUTONOMOUS WAREHOUSING

Website:
larics.rasip.fer.hr/amacal-project/

Contact:
Dr. sc. Damjan Miklić

AMACAL is a proof-of-concept project funded by the Croatian Agency for SMEs, Innovation and Investments HAMAG-BICRO within the PoC6 call. The project is supported by our industrial partners Euroimpianti s.r.l. and Konzum d.d.

The goal of the project is proof of concept evaluation and market potential analysis of an innovative method for improving autonomous forklift navigation in warehouses. If proven feasible, the proposed method would significantly reduce the commissioning costs and increase the flexibility of operations in warehouses equipped with autonomous forklifts. This would remove a significant barrier on the way towards wider adoption of fully autonomous vehicles in logistic operations.

aPAD - SMALLER, LIGHTER, SMARTER AUTONOMOUS MARINE SURFACE VEHICLE

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

The project proposes transformation of Autonomous Unmanned Marine Surface vehicle 'aPad', the specific research result of the ongoing FET project no. 640967 "subCULTron", into commercially attractive, sustainable and innovative product that both address societal challenges and is highly competitive in global markets.

Current stage of aPad development, according to EC Technology Readiness Level scale, is 6 (prototype demonstration in a relevant environment). The project foresees three main groups of activities. The first is development of a business plan to support future commercialization process, including strong brand development based on market analysis and development of strategies for three main pillars of innovation business: market, intellectual property and finances. The second is oriented towards linking and interacting with the identified potential customers, societal end-users and investors to collect their feedback, assess technological impact on the society, develop case studies and detect potential future partners. The third one is preparation for the actual spin-off oriented towards establishment of the manufacturing processes and building of spin-off organizational structure.

ASSISI_BF - ANIMAL AND ROBOT SOCIETIES SELF-ORGANISE AND INTEGRATE BY SOCIAL INTERACTION (BEES AND FISH)

Website:
assisi-project.eu

Contact:
Prof. Stjepan Bogdan

The main goal of ASSISI_bf project is to establish a robotic society that is able to develop communication channels to animal societies (honeybees & fish swarms) on its own.

These robots will adapt by evolutionary algorithms until they have learned to interact with animals in a desired way. This new technology is aimed to lay new foundations for the way in which humans can interfere with animal societies in order to manage the environment.

The researchers expect their work to have impact on agriculture, live stock management and environmental protection. In parallel, the mixed societies of animals and robots will represent a novel kind of bio-hybrid ICT system, as the animals will enrich the capabilities of the machines and vice versa. The research is conducted by six European institutions from Austria, Croatia, France, Germany, Portugal and Switzerland.

BLUEMED - PLAN/TEST/COORDINATE UNDERWATER MUSEUMS, DIVING PARKS AND KNOWLEDGE AWARENESS CENTRES IN ORDER TO SUPPORT SUSTAINABLE AND RESPONSIBLE TOURISM DEVELOPMENT AND PROMOTE BLUE GROWTH IN COASTAL AREAS AND ISLANDS OF THE MEDITERRANEAN

Interreg Mediterranean
BLUEMED

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

BLUEMED project, funded by Interreg Mediterranean Programme, aims to support competent government authorities develop strategies, plans and policies for local coastal and island economies of the Mediterranean region in adopting a sustainable and responsible model for tourism development. This will be achieved by planning, testing and coordinating Underwater Museums, Diving Parks and Knowledge Awareness Centres (KACs). Main objective is the valorisation and protection of underwater natural and cultural heritage in accordance with UNESCO 2001, the raising of public awareness and tourism attractiveness.

The main project focus is on:
• a process scheme for supplying local/regional authorities with a multi-disciplinary plan (management models, innovative technologies) for Underwater Museums, Diving Parks and Knowledge Awareness Centres to be developed in Capo Rizutto, Baia bay, Western Pagasitikos / Sporades and Cavtat sites (policy recommendations, management practices, networking and promotion)
• promoting innovation in the diving industry and improving divers experience through innovative diving services and technologies
• attracting an important part of the increasing number of people who choose diving tourism
• introducing the wider public to underwater cultural heritage by means of 3D immersive visualisation in museum exhibitions and KACs
• setting up 'Underwater Natural and Cultural Routes in the Mediterranean' web-based platform for a unified tourism promotion and networking of Med underwater natural and cultural heritage sites.

CROBOHUB - FEASIBILITY STUDY FOR CROATIAN ROBOTICS DIGITAL INNOVATION HUB

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

The overall objective of the CROBOHUB is to make a significant contribution to development of high-tech industry in Croatia in a short term and in the Western Balkans in a long term through strong existing research foundation and development of innovation.

The CROBOHUB's direct impact is seen in the creation of an arena for collaboration that would increase automation maturity and awareness through:

• improved communication between research institutions and the business sector and other stakeholders in the innovation ecosystem,
• enhanced technology transfer,
• created regional innovation robotic ecosystem.

To prove feasibility of such a hub there is a need to develop a CROBOHUB feasibility study and its business plan.

CroMarX - COOPERATIVE ROBOTICS IN MARINE MONITORING AND EXPLORATION

CroMarX
Cooperative robotics in marine monitoring and exploration

Website:
cromarx.fer.hr

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

CroMarX project is a project funded by the Croatian science foundation (HRZZ). It increses efficiency of maritime research and surveillance by using cooperative marine vehicles. The project focuses on cooperative control algorithms for surface and underwater unmanned vehicles.

The project is built around three scenarios:
• formation keeping and collision avoidance scenario with multiple unmanned surface vehicles (USV)
• cooperative control between USVs and an autonomous underwater vehicle (AUV) using low-bandwidth acoustic communication and localization
• environment-adaptive formation shaping for USV groups

While research work in previous related projects focused on navigation, guidance and control of unmanned vehicles, CroMarX allows for continued research and scaling towards cooperative heterogeneous systems. Intended CroMarX impacts are:
• increase research capabilities of LABUST, and
• increase efficiency of marine resources management via cooperative robotics.

cloudSLAM - COOPERATIVE CLOUD BASED SIMULTANEOUS LOCALIZATION AND MAPPING IN DYNAMIC ENVIRONMENTS

Website:
cloudslam.fer.hr

Contact:
Prof. Ivan Petrović

cloudSLAM is a Unity Through Knowledge Fund project coordinated by Prof. Ivan Petrović with partner principal investigator Prof. Dana Kulic from the University of Waterloo, Canada.

One of the main prerequisites for autonomous robot operation in unknown environments populated by humans or other robots is to perform simultaneous localization and mapping (SLAM) so that the robot can infer its position and relate it to other objects of interest. The main focus of the cloudSLAM project is to develop algorithms for solving the SLAM problem so that robots can operate reliably even in highly dynamic environments. This will be achieved through a mathematical framework accurately describing the non-Euclidean geometry of objects moving in space and through robot cooperation via a cloud based service.

The methodology of the proposed project will be grounded in a novel estimation approach based on the recently developed Kalman filter on Lie groups. We will estimate the state of the robot and the tracked objects in six degrees of freedom by representing the state with the special Euclidean group (SE3) and performing filtering directly on the introduced group. Finally, all information will be shared by multiple agents through a common cloud-based service, thus enabling robots which have just started operating to immediately exploit the experience of veteran team members.

DAAD - HUMAN LOCALIZATION AND INTENTION RECOGNITION BASED ON WEARABLE SENSORS

Website:
lamor.fer.hr/lamor/rese arch/running_projects

Contact:
Asst. Prof.
Ivan Marković

This is a bilateral German-Croatian research project with the Karlsruhe Institute of Technology. According to the recent report by the International Robotics Federation (IFR, www.ifr.org/industrial-robots/statistics) linking the real-life factory with virtual reality will play an increasingly important role in global manufacturing. Furthermore, it is also stated that global competition requires continued modernization of production facilities and that growing consumer markets require expansion of production capacities. For example, the European market for e-commerce is growing rapidly, with more than 18,6% just in the year 2015. With the growing markets, the need for larger warehouses and their automation will only increase. To advance the position of the European manufacturing and trade sector, a new automation paradigm should be implemented to ensure their efficient operation. According to the same IFR report, robots and human-robot collaboration will play an important role in the upcoming years. And indeed, robots are nowadays able to successfully solve complicated tasks like autonomous transport and autonomous manipulation. Yet, when it comes to human-robot collaboration, cooperation, or generally speaking coexistence, the main barrier is safety as it typically affects performance and costs of the robot system. Current automation solutions in manufacturing and logistics is based on strict separation of humans and robots. In order to enable coexistence of humans and robots in the same environment, one of the prerequisites is to know the location of the humans in the warehouse and predict their intentions. This project aims to overcome this issue by developing methods for human indoor localization and intention prediction based on wearable sensors. This approach also enables solving the project problem with minimal changes to the environment. Furthermore, wearable sensors can also be used to provide online information to workers, e.g., via an augmented reality (AR) device, thus even further increasing the working efficiency and link the real-life factory with virtual reality.

EUROC - EUROPEAN ROBOTICS CHALLENGE (EOLO: WIND GENERATOR REMOTE INSPECTION SYSTEM)

Website:
euroc-project.eu

Contact:
Prof. Ivan Petrović
Prof. Stjepan Bogdan

The European manufacturing industry needs competitive solutions to keep global leadership in products and services. Exploiting synergies across application experts, technology suppliers, system integrators and service providers will speed up the process of bringing innovative technologies from research labs to industrial end-users. As an enabler in this context, the EuRoC initiative, funded by EU through the FP7, proposes to launch three industry-relevant challenges. It aims at sharpening the focus of European manufacturing through a number of application experiments, while adopting an innovative approach which ensures comparative performance evaluation. Each challenge is launched via an open call and is structured in 3 stages.

The FER team participates in Challenge 3 which aims at targeting the open problems in existing MAV solutions (especially in multicopters) to enable their deployment in real life scenarios. MAVs are naturally unstable platforms exhibiting great agility and they thus require a trained pilot to operate them, while being restricted to line-of-sight range. The scenario is the demonstration of high-level teleoperation of a single MAV for an inspection task. The goal is to enable an inspection expert untrained in piloting MAVs (e.g. trained boiler inspector) to tele-operate a MAV as an aid to his/her mission, while being able to focus on the inspection task at hand.

EUROFLEETS2 - NEW OPERATIONAL STEPS TOWARDS AN ALLIANCE OF EUROPEAN RESEARCH FLEETS

Website:
eurofleets2.eu

Contact:
Prof. Zoran Vukić

EUROFLEETS2 is about developing a new pan-European distributed infrastructure with common strategic vision and coordinated access to Research Vessels and marine equipment, leading to more interoperable and cost effective European research fleets.

Our work package aims to develop key technologies and innovative functions for underwater systems such as new Hybrid ROVs (Hybrid Remotely Operated Vehicle). FER is involved in research and development of optical 3D based mapping in strong relief and control strategies for AUVs, ROVs and HROVs: dynamic positioning, target tracking and terrain following. This 4-years FP7 project started in 2013 and is coordinated by Institut Francais de Recherrche pour L'exploitation de la Mer (IFREMER). At UNIZG-FER, the project is led by **LABUST** and by **Prof. Zoran Vukić**.

e-URready4OS - EXPANDED UNDERWATER ROBOTICS READY FOR OIL SPILLS
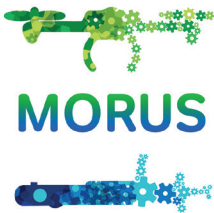

Website:
upct.es/urready4os

Contact:
Prof. Zoran Vukić

A fleet of autonomous vehicles will provide earlier detection and tracking of in-water oil plumes to feed numerical models and increase the preparedness to reduce the consequences of the oil spill on the coast. This Project is an extension of the URready4OS funded in the 2013 call to increase a fleet of training vehicles. It will expand the already existing URready4OS fleet (from 5 to 12 assets), provide training to new vehicles teams joining the fleet, improve the current URready4OS system and transfer the know-how to Maritime Safety Agencies.

MORUS - UNMANNED SYSTEM FOR MARITIME SECURITY AND ENVIRONMENTAL MONITORING

Website:
morus.fer.hr

Contact:
Prof. Stjepan Bogdan,
Project Coordinator

The main goal of NATO Science for Peace project MORUS is to design and develop a fully operational complex robotic system prototype comprised of an Unmanned Aerial Vehicle (UAV) and Unmanned Underwater Vehicle (UUV) capable of autonomous and cooperative mission execution related to environmental, border and port security. The proposed research thrives within internationally competitive field with the main objective to design and develop autonomous aerial and marine robotic system, capable of collective engagement in missions taking place in dynamic and nondeterministic environments. The design will focus mainly on payload enhancement and UAV autonomy which is mandatory for UUV transport.

Besides that, a docking system and cooperative control algorithms will be developed enabling autonomous deployment, re-deployment and data exchange at the open sea. The operating environment of the proposed prototype is unknown, uncertain and remote, i.e. far from a human operator. Therefore, a whole set of novel cooperative control algorithms, combined with an augmented human machine interface, will be designed and implemented in order to ensure safety and recoverability of the described system. The project is executed by two research groups, **LARCIS** and **LABUST**, coordinated by **Prof. Stjepan Bogdan**.

L4MS - LOGISTICS
FOR MANUFACTURING SMES

Contact:
Ivan Petrović

L4MS is a Horizon 2020 project. It will spark incremental (productivity increase of new users by a factor of 4 and system setup time reduction by a factor of 10) and disruptive innovation (batch size one & consumerization) for over 100,000 European Manufacturing SMEs & Mid-Caps, building on their intra-factory logistics challenge (50% of the production cost of an item) unleashing their digitalization potential by powering new robot systems that are more cost effective at lower lot sizes.

L4MS relies upon:

• An open industrial IoT platform with enablers for rapid and efficient deployment of customized logistics solutions.

• A suite of "Smartization services" including business modelling, technical support, mentoring, access to skills and to finance.

• The L4MS Marketplace, a one-stop-shop, where European Manufacturing SMEs & Mid-Caps will access the L4MS services.

• A portfolio of 23 cross-border Application Experiments by 50 SMEs selected through 2 competitive Open Calls, that will test more than 40 services & apps leveraging 10M€ of public funding across 12 established and emerging Digital Innovation Hubs.

• A growing ecosystem that will foster Smart Specialization in each single region linked to L4MS.

L4MS will transform a pan-European ecosystem into a self-sustainable start-up operating an Open Platform for Innovations in Logistics (OPIL) and L4MS marketplace consisting of 21 members. Comprising 6 Competence Centres, 5 technology providers, 4 industry associations, 3 end-users and 3 business developers -currently engaged in I4MS (XS2I4MS, HORSE and BEinCPPS) and FIWARE- plus 6 Satellites Nodes. L4MS covers 14 EU countries, 15 regions with 8 of them from East Europe.

L4MS will help demonstrate that public funded research with a "Smartization" approach (accelerating Industry 4.0) can help manufacturing SMEs & Mid-Caps achieve digital excellence and global competitiveness through logistics automation become "entrepreneurial states and digital industries".

PLADYFLEET - A FLEET OF UNMANNED SURFACE MARINE VEHICLES PLADYPOS

**Website:**
fer.unizg.hr/plady
fleet

Contact:
Mr. Sc. Antonio
Vasilijević

PlaDyFleet project relates to the topic "Direction of enhancement 2: USV additions and customization" of the RAWFIE project. RAWFIE (Road-, Air-, and Water- based Future Internet Experimentation) is a project funded by the European Commission (Horizon H2020 programme) under the Future Internet Research Experimentation (FIRE+) initiative that aims at providing research facilities for Internet of Things (IoT) devices. The project introduces a unique platform across the space and technology by integrating numerous test beds of unmanned vehicles for research experimentation in vehicular, aerial and maritime environments.

The PlaDyFleet project proposes:
• delivery of fleet of 10 USVs (PlaDyPos), capable to perform automated or remote operation in order to extend RAWFIE testing infrastructure;
• support to the RAWFIE consortium to ensure smooth operation and further development of the USV fleet throughout the project lifetime.
• increase RAWFIE and UNIZG-FER scientific excellence and innovation capacity by actively supporting further integration and development of the test platforms as well as participating in scientific dissemination of the project results related to the delivered USVs.

PlaDyPos is very suitable USV for RAWFIE needs: one-man portable, easy to transport, deploy/recover; overactuated and omnidirectional thus highly manoeuvrable with 3DOF; good communication capabilities; ROS based architecture convenient for integration into the RAWFIE platform; remote programming, control and data collection (over-the-air).
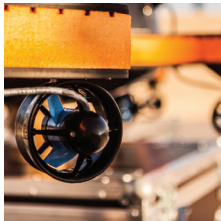
ROBOCOMM++ RETHINKING ROBOTICS FOR THE ROBOT COMPANION OF THE FUTURE

Webiste:
ec.europa.eu/futuriu
m/en/content/robot-
companions-citizens

Contact:
Prof. Ivan Petrović

RoboCom++ is an EU FLAG-ERA JTC project. Its main objective is to lay the foundation for a future global interdisciplinary research programme (e.g., a FET-Flagship project) on a new science-based transformative Robotics, to be launched by the end of the H2020 Programme. RoboCom++ will gather the community and organise the knowledge necessary to rethink the design principles and fabrication technologies of future robots. RoboCom++ will aim at developing the cooperative robots (or Companion Robots) of the year 2030, by fostering a deeply multidisciplinary, transnational and federated effort. The mechatronic paradigm adopted today, although successful, may prevent a wider use of robotic systems. For example, system complexity increases with functions, leading to more than linearly increasing costs and power usage and decreasing robustness. RoboCom++ will pursue a radically new design paradigm, grounded in the scientific studies of intelligence in nature. This approach will allow achieving complex functionalities in a new bodyware with limited use of computing resources, mass and energy, with the aim of exploiting compliance instead of fighting it. Simplification mechanisms will be based on the concepts of embodied intelligence, morphological computation, simplexity, and evolutionary and developmental approaches.

Exploring these concepts in order to develop new scientific knowledge and new robots that can effectively negotiate natural environments, better interact with human beings, and provide services and support in a variety of real-world, real-life activities, requires a coordinated and federated initiative. Ultimately, the Companion Robots conceived in RoboCom++ may foster a new wave of economic growth in Europe by boosting the deployment of ubiquitous robots and web-based robotic services.

The RoboCom++ community will pursue these ambitious objectives by cooperating along three main lines of action: 1) building the community and the tools for research reproducibility (benchmarks, metrics, data sharing protocols, test platforms, standards); 2) proof-of-concept research pilots; and 3) defining the long-term S&T roadmap, competitiveness strategy, governing and financing structure, and the ethical, legal, economic and social framework of a future FET Flagship -like initiative on Robotics .

RoboCom++ will actively pursue collaboration with industry, along with dissemination, community outreach and participation of EU citizens and stakeholders, with particular attention to the issue of robots and jobs, and to the analysis and proposition of viable policy options.

SAFELOG - SAFE HUMAN-ROBOT INTERACTION IN LOGISTIC APPLICATIONS FOR HIGHLY FLEXIBLE WAREHOUSES

Contact:
Prof. Ivan Petrović,
Principal Investigator

SafeLog is a Horizon 2020 ICT project coordinated by Prof. Björn Hein from the Karlsruhe Institute of Technology with UNIZG-FER being one of six partners (Principal Investigator: Prof. Ivan Petrović).

The European market for e-commerce is growing rapidly, with more than 16% just in the year 2014. With the internationalization of distribution chains, the key for success lies within efficient logistics. In such facilities, goods for the end-user or products in the B2B sector are stored, commissioned and shipped. To manage the supply chains, many new warehouses have been erected and more will follow. With the growing markets, the need for larger warehouses and their automation increases. To advance the position of the European trade sector, technical restrictions on the size of warehouses should be avoided and a new automation paradigm should be implemented to ensure their efficient operation. Therfore, European robotics and automation companies should be able to provide appropriate solutions, making scalable systems and scalable software mandatory. Current automation solutions based on strict separation of humans and robots cannot provide such efficient operation of large warehouses. SafeLog aims to overcome this issue by enabling much more efficient warehouse concepts joining human and robot workforce. Given that, the overall objective of SafeLog is the conception and implementation of a large-scale flexible warehouse system which enables safe and efficient collaboration of humans and robots in the same area and at the same time. On the way to reach this objective SafeLog will develop, integrate and test: (1) a holistic and certifiable safety concept based on the safety vest, which allows the collaboration of robots and humans in a flexible warehouse system, (2) planning and scheduling algorithms for a heterogeneous fleet manager, which allow the adhoc reactive planning and scheduling for human and robot workforce in a flexible warehouse system, and (3) augmented reality based interaction strategies to support workers in a robotized warehouse system with information about their current task and environment.

SAFETRAM - SYSTEM FOR INCREASED DRIVING SAFETY IN PUBLIC URBAN RAIL TRAFFIC

Contact:
Prof. Ivan Petrović

The goal of the SafeTRAM project is to develop an innovative system which would increase traffic safety by implementing safety functions for urban rail traffic, thus lowering the number of accidents causing great material damage and human casualties. Electric trams use up to five times less energy than an automobile, do not pollute the environment and have a number of ecological advantages with respect to road traffic, which is responsible for 95% of traffic gas emissions. In the near future, systems like SafeTRAM will be a key element of autonomous vehicles which is one of the final goals of the modern society.

SafeTRAM is a European Regional Development Fund (ERDF) project coordinated by Končar Electrical Engineering Institute with UNIZG-FER being the research partner.

SPATEL - SPATIAL AUDITORY HUMAN-MACHINE INTERFACE FOR UXV TELEOPERATION

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

SPATEL investigated innovative uses of auditory interfaces in remote control of marine vehicles. For teleoperated unmanned vehicles, mishaps tend to occur during the periods of high workload, in situations where the operator must perform complex and stressful tasks. In order to address these unique human-factors problems associated with unmanned vehicles we used auditory display as a means to reduce visual workload, to enhance situation awareness, and mitigate the visual and cognitive demands of contemporary marine teleoperations.

LABUST demonstrated that the use of an auditory display that presents spatial auditory cues can be successfully used for guidance of unmanned vehicles. The system addressed two significant hearing downsides: the spatial acuity of the visual channel is much better than that of the auditory channel, and humans use vision on a permanent basis for navigation, we are very well trained for visual, but not for audio navigation.

The existing LABUST fleet of unmanned vehicles was used to prove the exploitability of the basic research results related to the Spatial Auditory Interface and the quality of performance in real life conditions.

SUBCULTRON - SUBMARINE CULTURES PERFORM LONG-TERM ROBOTIC EXPLORATION OF UNCONVENTIONAL ENVIRONMENTAL NICHES

subCULTron

Website:
subcultron.eu

Contact:
Assoc. Prof.
Nikola Mišković

subCULTron is a Horizon FET project that aims to achieve long-term autonomy in a learning, self-regulating, self-sustaining underwater society/culture of robots in a high-impact application area: Venice, Italy. It is the first Croatian Horizon 2020 FET project.

The envisioned heterogeneous system consists of 3 different agent types:
1) on the seabed, **artificial mussels** are the collective long-term memory of the system that monitors the natural habitat
2) on the water surface, **artificial lily pads** interface with the human society, delivering energy and information influx from ship traffic or satellite data
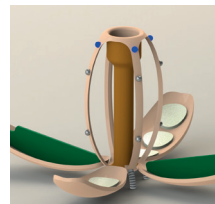3) between those two layers, **artificial fish** move/monitor/explore the environment and exchange info with the mussels and lily pads.
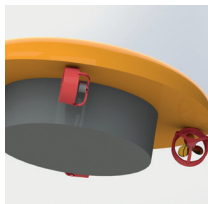
aPad
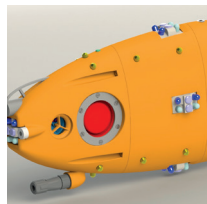
aFish

aMussel

The four year project started in April 2015 and it is executed by two research groups, **LABUST** and **LARICS**, coordinated at UNIZG-FER by **Assoc. Prof. Nikola Mišković**.

SELECTED FINISHED PROJECTS

ACROSS - CENTRE OF RESEARCH EXCELLENCE FOR ADVANCED COOPERATIVE SYSTEMS

Centre of Research Excellence
for Advanced Cooperative Systems

Website:
across.fer.unizg.hr

Contact:
Prof. Ivan Petrović,
Project Coordinator

ACROSS Research Centre was a European FP-7 Capacities Research Potential program project [285939, FP7-REGPOT-2011-1]. The project research activities focused on four major Strategic Research Domains: Cooperative Cognitive and Robotic Systems, Cooperative Networked Embedded Systems, Cooperative Renewable Energy Systems, and Cooperative Control Methods. ACROSS gathered fourteen research groups from seven UNIZG-FER departments and tightly collaborated with sixteen leading EU research centres and three Croatian partner companies. Close to 100 months were spent by ACROSS researchers at the partnering renowned EU institutions, the project employed 26 experienced researchers during three years, including 4 researchers returning from abroad after obtaining their PhD degree, and 15 renowned EU experts held seminars at the UNIZG-FER. The members of the Steering Committee were distinguished scientists in the ACROSS strategic research domains, senior managers from industry as well as representatives of public authorities and funding agencies. The project was coordinated by **Prof. Ivan Petrović**.

CADDY - COGNITIVE AUTONOMOUS DIVING BUDDY

Cognitive Autonomous Diving Buddy

Website:
caddy-fp7.eu

Facebook:
www.facebook.com/
caddyfp7

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

CADDY was the first FP7-ICT Cognitive Robotics project coordinated by UNIZG-FER. It started in January 2014, and together with 7 EU partners CADDY aimed to replace a human buddy diver with an autonomous underwater vehicle and a new autonomous surface vehicle to improve monitoring, assistance, and safety of the diver's mission.

The resulting system plays a threefold role similar to those that a human buddy diver should have:
• the **buddy "observer"** that continuously monitors the diver;
• the **buddy "slave"** that is the diver's "extended hand" during underwater operations performing tasks such as "do a mosaic of that area", "take a photo of that" or "illuminate that"; and
• the **buddy "guide"** that leads the diver through the underwater environment

The coordinator of this 3-year research project was **Assoc. Prof. Nikola Mišković** and the project was executed by **LABUST** research staff.

EC-SAFEMOBIL - ESTIMATION AND CONTROL FOR SAFE WIRELESS HIGH MOBILITY COOPERATIVE INDUSTRIAL SYSTEMS

Website:
ec-safemobil-project.eu

Contact:
Prof. Zdenko Kovačić

The European Commission, under the 7th Frame Program, provided funds to perform the project EC-SAFEMOBIL, recognizing the growing importance of the UAV market and applications. In the case of EC-SAFEMOBIL project, these were related to the utilization of autonomous systems in general and UAVs in particular, in many applications that cannot be accomplished with manned systems, including disaster management, monitoring and measurement of events, rescue missions (particularly in stormy conditions) and in general all missions where there are risks for human beings. The awarded EC-SAFEMOBIL Consortium included the most important organizations and companies within the European sector and represented an appropriate mixture of research organizations and key players at an industry level. FADA-CATEC acted as the project leader and the consortium team included DLR, Astrium, Indra, SELEX GALILEO, Euroimpianti, University of Seville, University Duisburg-Essen and UNIZG. The EC-SAFEMOBIL project was devoted to the development of sufficiently accurate motion estimation and control methods and technologies in order to reach levels of reliability and safety to facilitate unmanned vehicle deployment in a broad range of applications. It also included the development of a secure architecture and the middleware to support the implementation. The EC-SAFEMOBIL project developed world first technology demonstrators in several applications dealing with the landing of UAVs on mobile platforms in challenging conditions, launching of an UAV from a manned vehicle, surveillance, and warehousing involving a large number of autonomous vehicles.

FER-KIET - ADVANCED TECHNOLOGIES IN POWER PLANTS AND RAIL VEHICLES

Website:
fer-kiet.fer.hr

Contact:
Prof. Ivan Petrović

The project goal is to develop four advanced technologies focusing on applications in power plants and rail vehicles. Research conducted within the Advanced Sensors Technologies aims to establish a knowledge base and develop new sensing technologies with expected commercial applications in rotational machines monitoring systems. In a broader sense, research in the area of advanced sensing technologies constitutes a specific segment in the ICT domain with applications in the electrical power and transport sectors, as well as other areas such as environmental protection, health, smart infrastructure, etc. Research conducted within the Advanced Estimation and Control Algorithms in Microgrids aims to develop an advanced battery management system with state-of-charge and state-of-health estimation, and development of the algorithm for prediction of renewable energy systems availability using free weather forecast. Research of the Multilevel Converters Electric Energy Storage Systems element of the project aims to investigate the possibilities of using multilevel converters for connecting renewable energy sources to the power grid and to explore the possibilities of efficient storage of electricity in rolling stock. Research of the Driver Assistance System aims to develop new technologies in the area of detection and tracking of vehicles and pedestrians. The project was coordinated by **Prof. Ivan Petrović**.

HUMAN-IN-THE-LOOP CONTROL OF MULTI-AGENT AERIAL SYSTEMS UNDER INTERMITTENT COMMUNICATION

Contact:
Prof. Stjepan Bogdan

The objective of this research is decentralized control of heterogeneous multi-agent systems in degraded communication environments. We proposed a novel design of an HMI that allows a human to become a supervisor, when necessary, instead of a single unit operator. By deploying dexterous aerial robots as components of multi-agent systems, we allow the supervisor to interact with its surroundings. We aim to utilize our aerial platforms in a multi-agent system that has the ability to perform both reconnaissance missions and missions that require interaction with its surroundings. Of course, building such a system raises the need for a completely new HMI, that we have introduced earlier. Given our heterogeneous testbed and strong history in modeling and control of autonomous agents, optimal control, robotic control systems, and nonlinear systems, as well as our published work on aerial robots and real communication artifacts, the PI was uniquely positioned to bring these areas together to develop new scientific results. The funding agency of the project was the Air Force Office of Scientific Research (AFOSR).

URREADY4OS - AUTONOMOUS UNDERWATER VEHICLES READY FOR OIL SPILL

Website:
upct.es/urready4os

Contact:
Prof. Zoran Vukić

The URready4OS project was co-financed by the Directorate-General for Humanitarian Aid and Civil Protection of the the European Commission, and had the general aim to join forces to make available to the European Civil Protection a fleet of autonomous underwater vehicles (AUVs), unmanned aerial vehicles (UAVs), and unmanned surface vehicles (USVs) with operational capability to intervene against oil spills in European seas using new cooperative multi-vehicle robotic technologies.
This two year project was executed by **LABUST**.

DEVELOPING CROATIAN UNDERWATER ROBOTICS RESEARCH POTENTIAL - CURE

Contact:
Prof. Zoran Vukić,
Project Coordinator

CURE significantly improved Croatian research potential in underwater systems and technologies and enabled intensification of dissemination of UNIZG-FER-LABUST research results and capabilities that can accommodate the needs of Croatia and the whole West Balkan region related to the exploration of underwater systems and technologies.

The CURE project enabled intensified proliferation of underwater robotics knowledge in Croatia. The transfer of knowledge undertaken during the duration of the project showed intense activity within the scope of the project providing both LABUST researchers and a diverse user community with an opportunity to have deep insight into the corresponding technology. Besides revealing a huge potential for underwater robotics, the CURE project also provided a big momentum for scientific and commercial applications in the region.

The CURE project was put on the list of important EU projects that had a significant and real impact on Europe's economy and society. CURE was listed as Croatian choice in the booklet "Achivments of FP7 - examples that makes us proud".

The project was coordinated by UNIZG-FER and **Prof. Zoran Vukić (LABUST)**.

CART - COOPERATIVE AUTONOMOUS ROBOTIC TOWING SYSTEM

Website:
cart.posidonia.com

Contact:
Prof. Zoran Vukić

The project CART proposed a new concept for salvage operations of distressed ships at sea. The CART concept was based on the development of robotized unmanned marine platforms able to (semi-)automatically execute the high risk operation of linking the emergency towing system of distressed ships to towing vessels. This minimised the risk for human lives and increased the safeguard of the environment, helping, for instance, to prevent oil pollution at sea, during salvage operations.

COORDINATION CONTROL OF MULTI-AGENT SYSTEMS

Contact:
Prof. Stjepan Bogdan

Recent years have witnessed an increasing interest in decentralized control of multi-agent systems (MASs). Decentralized control is characterized by local interactions among agents where each agent exchanges information only with its neighbors. Based on these local interactions, a desired collective behavior of MASs is achieved. Examples are formation control, flocking, consensus control, etc. When compared with centralized control, decentralized control avoids a single point of failure which in turn increases the robustness of MASs, allows for inexpensive and simple agents, and lowers the implementation cost. In addition, decentralized control scales better as the number of agents increases and is sometimes an intrinsic property of MASs. For instance, in industrial applications, we are facing coordination and cooperation of a number of small, inexpensive autonomous systems which replace complex large-scale integration devices. In natural exploration, disaster prevention and handling (firefighting, earthquake, mine clearance etc.) as well as in the service sector (healthcare of senior citizens), autonomous robots, as parts of distributed networks, can help in many ways, and even replace a human in complicated, dangerous and repetitive tasks. Funding agency: Joint grant - PR China and Republic of Croatia.

DINARO - DIVER NAVIGATION USING RANGE-ONLY MEASUREMENTS FROM AN AUTONOMOUS SURFACE VEHICLE

Contact:
Assoc. Prof.
Nikola Mišković,
Project Coordinator

Divers operate in an extremely unfriendly environment where human activities depend on technical systems. The goal of this project was to improve the current methodology of tracking and navigating divers during their underwater activities. We exploited range measurements from a single autonomous surface vehicle manoeuvring in such a way to increase the quality of diver position measurement and the observability of the measurement system.

SEAJUMPER - BIO-INSPIRED SYNCHRONOUS JUMPING MARINE SENSOR NETWORKS

Contact:
Assoc. Prof.
Nikola Mišković

SeaJumper is a joint effort with Imperial College London, with the main goal to develop novel distributed, low-energy, marine sensors inspired by jumping aquatic animals such as the flying squid. The system will be capable of transmitting obtained underwater data by executing the sinking, rising and jumping cycle. The envisioned system will exploit jumping properties to enable autonomous recovery on-board a small-scale autonomous surface marine platform. This project will kick-start the SeaJumper development and will focus on delivering the key scientific contributions in advanced mobility across the air-water interface and robust sensor communication. Future developments will combine these concepts and integrate the SeaJumpers with Autonomous Surface Vehicles (ASV) for fully automated sensing and recovery of sensor nodes in marine environments.

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