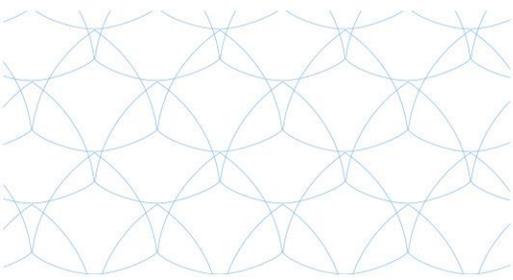


EXCELLABUST
EXCELLING LABUST IN MARINE ROBOTICS

EXPERT VISIT 3

18 - 20 January 2017

University of Limerick



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691980.



1. VENUE

Grey Hall, University of Zagreb Faculty of Electrical Engineering (UNIZG-FER)
Address: Unska 3, Zagreb, Croatia

2. PREREQUISITES FROM PARTICIPANTS

It is required to have a computer with MATLAB and LabVIEW.

MATLAB version: 2007B or higher.

LabVIEW version: 2014 SP1 or higher.

3. SCHEDULE

Day 1: 18 January 2017 (Wednesday)

08:30 – 09:00	Meet and greet coffee
09:00 – 10:00	Invited Talk
10:00 – 10:15	BREAK
10:15 – 11:00	Introduction & Overview of Lectures by Edin Omerdic
11:00 – 11:15	BREAK
11:15 – 12:00	Modelling & Simulation of Marine Crafts: Part 1 by Edin Omerdic
12:00 – 13:30	LUNCH BREAK
13:30 – 14:15	Modelling & Simulation of Marine Crafts: Part 2 by Edin Omerdic
14:15 – 14:30	BREAK
14:30 – 15:15	Modelling & Simulation of Marine Crafts: Part 3 by Edin Omerdic
15:15 – 15:30	BREAK
15:30 – 17:00	Hands-on: Modelling & Simulation of ROV (MATLAB/Simulink) by Edin Omerdic

Day 2: 19 January 2017 (Thursday)

08:30 – 09:00	Meet and greet coffee
09:00 – 10:00	Control of Marine Crafts: Part 1 by Edin Omerdic
10:00 – 10:15	BREAK
10:15 – 11:00	Control of Marine Crafts: Part 2 by Edin Omerdic
11:00 – 11:15	BREAK
11:15 – 12:00	Control of Marine Crafts: Part 3 by Edin Omerdic
12:00 – 13:30	LUNCH BREAK
13:30 – 14:15	Hands-on: Modelling & Simulation of ROV (MATLAB-LabVIEW) by Edin Omerdic
14:15 – 14:30	BREAK
14:30 – 15:15	Hands-on: Control of ROV/USV (LabVIEW) Part 1 by Edin Omerdic
15:15 – 15:30	BREAK
15:30 – 16:00	Hands-on: Control of ROV/USV (LabVIEW) Part 2 by Edin Omerdic

Day 3: 20 January 2017 (Friday)

08:30 – 09:00	Meet and greet coffee
09:00 – 10:00	Brushless DC Motor Control using FPGA by Edin Omerdic
10:00 – 10:15	BREAK
10:15 – 11:00	Hands-on: Thruster Control using FPGA (LabVIEW) Part 1 by Edin Omerdic
11:00 – 11:15	BREAK
11:15 – 12:00	Hands-on: Thruster Control using FPGA (LabVIEW) Part 2 by Edin Omerdic

4. EXPERT VISIT PLANNED OUTCOMES:

- Learn basic principles of modelling, simulation and control of marine crafts, including transformation of reference frames, kinematics and dynamics equations of motion, disturbances, control allocation, and low-level motor control.
 - Explore tools for simulation, control design, and real-time control using MATLAB, LabVIEW, myRIO and ROV thrusters.
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5. LECTURE DESCRIPTION:

Modelling & Simulation of Marine Crafts (Day 1)

This lecture will begin with introduction to kinematics of marine crafts, including definition and transformation between reference frames. Special attention will be devoted to quaternions and their role in vector rotations. Simulation models of open-frame ROVs, based on attitude representation with Euler Angles and Unit Quaternions, will be gradually developed throughout the lecture. Full nonlinear 6 DoF dynamics model will be described, including nonlinear model of propulsion system dynamics. Models of waves and ocean currents will be described. Procedure to introduce disturbance model to ROV simulation models will be explained.

Hands-on: Modelling & Simulation of ROV (MATLAB/Simulink) (Day 1)

This session will provide opportunity to implement and validate simulation models, introduced previously in theoretical sessions, in MATLAB/Simulink environment. Simulation model of generic open-frame ROV, based on attitude representation with Euler Angles, will be introduced first, highlighting singularity issues. Simulation model based on attitude representation with unit quaternions will be introduced next, including transformation blocks to present attitude to users using conventional HMI. Finally, simulation model will be linked to Virtual Reality underwater scene to visualise ROV motion.

Control of Marine Crafts (Day 2)

This lecture is focused on control aspects of a marine craft, including design and implementation of low-level controllers and fault-tolerant control system. Autotuning method for finding optimal gains will be described. The hybrid algorithm for control allocation, capable to find a feasible solution over the entire attainable input control space, will be explained in detail. 3D visualisation of input and true control spaces will be demonstrated, providing deep insight into geometry of underlying control allocation optimisation problem. Real-world applications of proposed algorithm will be presented.

Hands-on: Modelling & Simulation of ROV (MATLAB-LabVIEW) (Day 2)

In this session, it will be shown how to build LabVIEW simulation model from existing MATLAB model. Interface of LabVIEW with other languages will be demonstrated, including C/C++ and MATLAB script.

Hands-on: Control of ROV/USV (LabVIEW) (Day 2)

This session will provide more insight into control system for ROV/USV using demonstration platform - subsystem of OceanRINGS (smart technologies for subsea operations, developed by MMRRC, UL). Features include full 6 DoF motion of ROV/USV in presence of waves and ocean currents, range of control modes (from pure manual, over semi-manual to fully automated), autotuning, and dynamic positioning in absolute frame or relative to reference frame.

Brushless DC Motor Control using FPGA (Day 3)

This lecture is focused on development of interface between control software and physical actuators (thrusters) using NI myRIO. Two approaches will be explained: (i) approach based on Express VI (RT only, without need to develop FPGA code), and (ii) approach based on RT & FPGA code development. Methods to overcome friction/dead zones for low speed rotations will be demonstrated for both approaches.

Hands-on: Thruster Control using FPGA (LabVIEW) (Day 3)

This practical session will demonstrate how to use FPGA to generate PWM signals for high precision speed and direction control of Blue Robotics T200 thrusters.

6. DESCRIPTION OF THE PARTNER INSTITUTION:

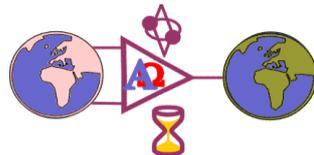


University of Limerick

Address: **University of Limerick**
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Website: <http://www.ul.ie>

The University of Limerick (UL) with over 13,000 students and 1,300 staff is an energetic and enterprising institution with a proud record of innovation and excellence in education, research and scholarship. The dynamic, entrepreneurial values which drive UL's mission and strategy ensure that we capitalise on local, national and international engagement and connectivity. Research at UL is renowned for its close alignment to real world problems and the university has an enviable reputation in fundamental research, which can have real impact on society and the economy alike. This strong focus allowed UL to gain a five-star rating for innovation and excellence from QS, the international ranking body. UL has a strong international reach and Involvement in the European Framework actions from FP2 to FP7, and current involvement in Horizon 2020 has grown UL's international network of collaborators.



Mobile & Marine Robotics
Research Centre

Address: **Mobile & Marine Robotics
Research Centre**
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Established in 2000 by Director Dr. Daniel Toal, the Mobile & Marine Robotics Research Centre (MMRRC) in the University of Limerick is the only research centre focused on the application and development of marine robotics within the island of Ireland. This research centre consists of a mix of academics, postdoctoral researchers, research engineers and PhD students from various disciplines including electronic, computer, mechanical and aeronautical engineering backgrounds. The research centre brings together a highly capable engineering group focused on developing innovated, practical and industrial relevant marine technologies and field robotics. From marine robotics to navigation, sensor development, emergency response planning, remote operated vehicle (ROV) and unmanned aerial (UAS) technologies, they are actively involved in developing a diverse range of practical technologies in national funded, European funded and industry collaborative projects. The core research activities of the research centre are listed below:

- Remotely operated vehicle smart systems- fault tolerant control, auto tuning, one-click auto survey, augmented reality visualisations (transparent ocean).
- Remote & auto flight control of tethered parafoil kites for airborne wind energy & aerial sensor/comms platforms.
- Sensored telemetry streaming from fixed wing aircraft, system identification, controller design.
- Emergency response exercise planning & coordination. UAVs deployed in segregated airspace over three-day exercise. Key partners: Irish Aviation Authority, Irish Naval Service, Irish Coast Guard, Commissioner of Irish Lights.

- Long Range High Bandwidth comms- remote presence, live interaction with distant robotic vehicles independent of existing infrastructure.
- Ocean sensing platforms with daughter mini ROVs- for persistent remote presence offshore with global satellite comms (controlled & monitored anywhere in world).

Over the last ten years the MMRRRC research centre has developed OceanRINGS – a suite of smart technologies for subsea operations, designed to be integrated with any ROV – support vessel combination. It includes advanced control solutions for full range of ROVs – from mini ROVs used for remote monitoring & inspection to full-size work-class ROVs. Remotely Operated Vehicle (ROV) LATIS is a 1000 m depth-rated underwater robot developed at MMRRRC and has been used to test and validate OceanRINGS. System validation and technology demonstration has been performed over the last six years through a series of test trials with different support vessels off the north, south and west coast of Ireland and in the Mediteranean sea.

7. BIOGRAPHIES OF LECTURERS



Dr. Edin Omerdic
Senior Research Fellow

Website: <http://www.mmrrc.ul.ie/dotnetnuke/mmrrc/People/PostdoctoralResearchers/EdinOmerdic.aspx>
Email: edin.omerdic@ul.ie

Edin Omerdic received the Dipl. Eng. and M.S. degree in Electrical Engineering from the University of Zagreb, Croatia, in 1997 and 2001, respectively. In 2001 he joined the Mechatronics Research Centre, University of Wales, Newport, UK and took part in the EPSRC funded IMPROVES project. He received his PhD in Electrical Engineering from the University of Wales in 2004, with the thesis titled "Thruster Fault diagnosis and Accommodation for Overactuated Open-frame Underwater Vehicles".

Edin is currently employed by the University of Limerick as a Senior Research Fellow at the Department of Electronic and Computer Engineering. He is engaged in numerous research projects funded by the Higher Education Authority and the Marine Institute in the area of submersible robotics, he is also the main developer & designer of OceanRINGS concept & software suite, including design of state-of-the-art control architecture for ROV LATIS. Edin's research interests include modelling & simulation of dynamic systems (marine platforms, ocean dynamics & disturbances), renewable energy, real-time simulators, virtual reality, development and design of guidance, navigation and control system for marine vessels, nonlinear control systems, implementation of soft-computing techniques in intelligent systems, underwater robotics, fault-tolerant systems.

Up to date he has 18 journals, 5 book chapters, 2 books, 50 papers in conference/workshop proceedings, 7 invited lectures, 4 keynote/plenary talks, 4 tutorials, 22 presentations & technology demonstrations, 2 articles in business magazines, 2 online articles and 1 desk study. Dr. Omerdic received five awards for his work, including First Prize Winner in National Competition in Mathematics (Bosnia, 1985), Society of Underwater Technology (SUT) Prize for Best Multimedia Presentation (GCUV 2003) 'Thruster Fault Accommodation for Underwater Vehicles', IFAC prize for best on-line demonstration (MCMC 2003) 'Fault Detection and Accommodation for ROVs', IMarEST SMI Donald Maxwell Award Prize for Best Journal Paper (2004) 'A Fuzzy Track-Keeping Autopilot for Ship Steering' and Curriculum Paper Contest National Instruments International Competition LabVIEW in the Curriculum 2006 (First Prize Winner) 'Virtual Underwater Lab: Efficient Tool for System Integration & UUV Control Development'.