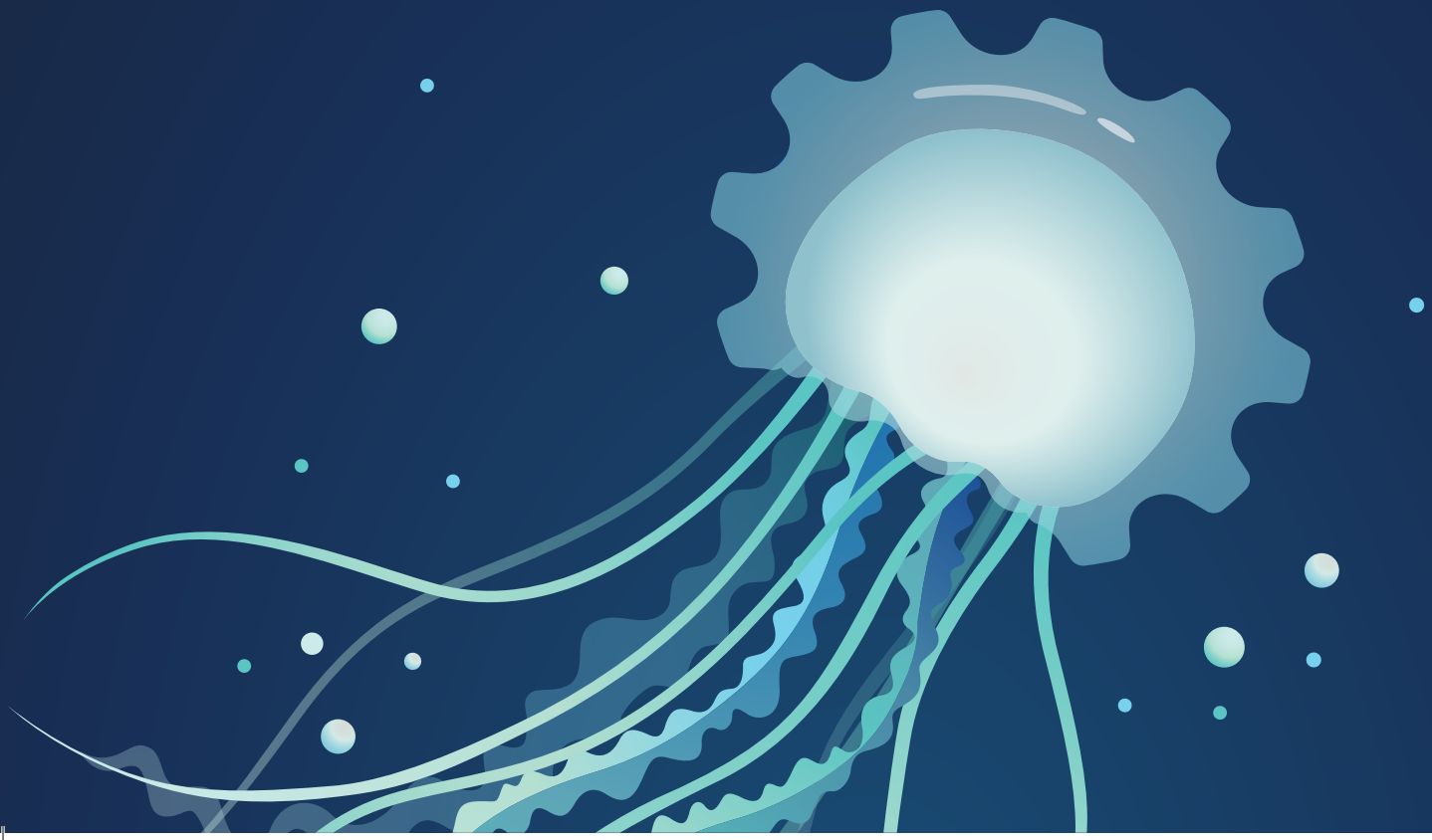
2022 25.09. - 2.10.

Biograd na Moru, Croatia

BREAKING THE SURFACE

14th INTERNATIONAL INTERDISCIPLINARY FIELD WORKSHOP OF MARITIME ROBOTICS AND APPLICATIONS



BTS MAP

HOTEL ADRIATIC

- **1 / ACCOMMODATION**
- **2 / LECTURE ROOM**
- **3 / TUTORIAL ROOM**
- **4 / REGISTRATION ROOM OFFICE**
- **5 / COFFEE BREAK**
- **6 / LAVENDER BAR**
  Social events
- **7 / DEMO SITE**
- **8 / DEMO POOL**
- **9 / HOTEL ILIRIJA RESTAURANT** (in hotel)
  Conference restaurant and accommodation for participants
- **10 / HOTEL KORNATI**
  Accommodation for participants
- **11 / PARKING**

ORGANIZED BY

University of Zagreb

Faculty of Electrical Engineering and Computing

Laboratory for Underwater Systems and Technologies

Center for Underwater Systems and Technologies

ABOUT BTS

The Breaking the Surface – BTS is an international interdisciplinary field workshop of maritime robotics and applications. Ever since 2009, it has served as a meeting place for international experts, university professors, scientists, industry representatives and students from various fields.

BTS 2021 IN NUMBERS

15 COUNTRIES

140 ATTENDEES

20 LECTURES

7 TUTORIALS

5 DEMOS

1 WORKSHOP

COMMITTEES

COMMITTEES CHAIRS

Prof. Zoran Vukić, PhD
General Chair

Prof. Nikola Mišković, PhD
Programme Committee Chair

Ana Golec
Organizing Committee Chair

Igor Kvasić
Technical Committee Chair

PROGRAMME COMMITTEE

Bridget Buxton; Massimo Caccia; Fausto Ferreira; Mateo Ivanac; Bill Kirkwood; Jeff Neasham; Irena Radić Rossi; Igor Radusinović

ORGANIZING COMMITTEE

Ana Golec

TECHNICAL COMMITTEE

Anja Babić; Nadir Kapetanović; Nikica Kokir; Ivan Lončar; Igor Kvasić; Đula Nađ, PhD

LEGEND

SESSION COLOURS

- Lectures
- Tutorials
- Demonstrations
- Company programme

CATEGORIES

- Marine Robotics (MAROB)
- Maritime Archaeology (MARCH)
- Marine Biology (MARBIO)
- Marine Oceanography (MAROCEAN)
- Tutorials
- Company Presentation
- Workshops
- Demonstrations

LOCATIONS

LECTURE HALL – HOTEL ADRIATIC
All lectures and presentations

DEMO POOL AND OPEN WATERS NEARBY
Equipment demonstrations

ILIRIJA ROOM
Tutorials

LAVENDER BAR – HOTEL ADRIATIC
Social events

SEA
Demonstrations and Tutorials

	SUNDAY, 25.09.	**MONDAY,** 26.09.			**TUESDAY,** 27.09.		
09:00 - 09:15		The Chagos Remote Ocean Voyager Expedition (C-Rove) *Bridget Buxton*			Motion capture for underwater communication and diver health monitoring *Iain Anderson*		
09:15 - 09:30							
09:30 - 09:45							
09:45 - 10:00		The role of acoustics in underwater robotics *Nuno Cruz*			Monitoring biodiversity with a wired underwater camera *Neven Cukrov*		
10:00 - 10:15							
10:15 - 10:30							
10:30 - 11:00		COFFEE BREAK			COFFEE BREAK		
11:00 - 11:15		Autonomous platforms for oceanographic data collection *Riccardo Gerin*			Control of Autonomous Underwater Vehicles for Hydrobatics *Ivan Stenius, Sriharsha Bhat*		
11:15 - 11:30							
11:30 - 11:45							
11:45 - 12:00		Longterm deployment – does AUV really need to surface *Antonio Vasilijevic*			Data Policy and Challenges for Marine Robotics *Roberta Ferretti, Simona Aracri*		
12:00 - 12:15							
12:15 - 12:30							
12:30 - 13:00		LUNCH			LUNCH		
13:00 - 13:45							
13:45 - 14:00		T1 Intro - Meet the Expectations: Accuracy Aspects in Underwater Photogrammetry *Fabio Menna*			T3 Intro - Getting started with Reeds, the world's largest dataset for perception algorithms *Reeds*		
14:00 - 14:15							
14:15 - 14:30							
14:30 - 14:45		T2 Intro - Underwater localization of acoustic sources – principles and approaches *challange, INESC-TEC*			T4 Intro - Multibeam echosounder (MBES) *GEOMAR*		
14:45 - 15:00							
15:00 - 15:15							
15:15 - 15:30		BREAK			BREAK		
15:30 - 16:00		T2 *Fabio Menna*	T2 *INESC-TEC*	DEMO *H2O*	T3 *Reeds*	T4 *GEOMAR*	DEMO *KTH*
16:00 - 16:30							
16:30 - 17:00							
17:00 - 17:30	REGISTRATION						
17:30 - 18:00							
18:00 - 18:30	WELCOME DRINK						
18:30 - 19:00							
19:30 - 20:30	DINNER	DINNER			DINNER		
From 20:30		IEEE OES UNIZG PARTY			WOMEN IN BLUE		

WEDNESDAY, 28.09.	THURSDAY, 29.9.	FRIDAY, 30. 9.	SATURDAY, 1.10.
Deep learning computer vision-based obstacle detection for autonomous boats *Matej Kristan*	**Developing imaging technologies to search for, discover, and understand life in the deep sea** *Kakani Katija*	**Welcome**	
Development of a secure, interoperable and highly scalable standard for underwater acoustic communications *Jeff Neasham*	**Fantastic cold – water corals and where to find them** *Johanna Järnegren*	**Clean Ocean Mission** *Mr. Iain Shepherd* **Ocean Technology Funding 1/2**	
COFFEE BREAK	COFFEE BREAK	COFFEE BREAK	
Integrated observations and monitoring solutions for exploration and sustainable exploitation of marine abiotic resources *Marzia Rovere*	**AUVROVA-autonomous low-cost resident inspection underwater drone concept** *Kjetil Eik*	**Ocean Technology Funding 2/2**	
Company Presentation *MDM Team*	**Autonomous catamaran and tethered ROV as part of a heterogeneous marine robotic system on a monitoring mission** *Hektor*	**Ocean observation technologies Company pitches**	FIELD TRIP
LUNCH	LUNCH	LUNCH	
T5 Intro - Marine object detection using MARUS generated dataset *Ivan Lončar, Natko Kraševac, Juraj Obradović* **T6 intro - Localization challenge** *challenge, University of Haifa*	**T7 Intro - Guidance and control of UMVs** *CNR, MONUSEN*	**Public, stakeholders, users presentations**	
BREAK	BREAK	BREAK	
T5 *simulator, Ivan Lončar* **T6** *University of Haifa* **DEMO** *MDM Team*	**T7** *CNR* **DEMO** *Buoys* **DEMO** *ASV Korkyra*	**Panel discussion** **Challenge presentations**	
DINNER	DINNER	GALA DINNER AND CLOSING CEREMONY	
	PUB QUIZ	BTS KARAOKE NIGHT	

SOCIAL EVENTS

25.9.
SUNDAY
16:30 – 18:00
HOTEL ADRIATIC
REGISTRATION

25.9.
SUNDAY
18:00 – 18:30
LAVENDER BAR
WELCOME DRINKS

26.9.
MONDAY
FROM 20:30
DEMO POOL
IEEE OES UNIZG PARTY

27.9.
TUESDAY
FROM 20:30
LAVENDER BAR
WOMEN IN BLUE

29.9.
THURSDAY
FROM 20:30
LAVENDER BAR
PUB QUIZ

30.9.
FRIDAY
19:30 - 20:30
HOTEL ADRIATIC
CLOSING CEREMONY AND GALA DINNER

30.9.
FRIDAY
FROM 20:30
LAVENDER BAR
BTS KARAOKE NIGHT

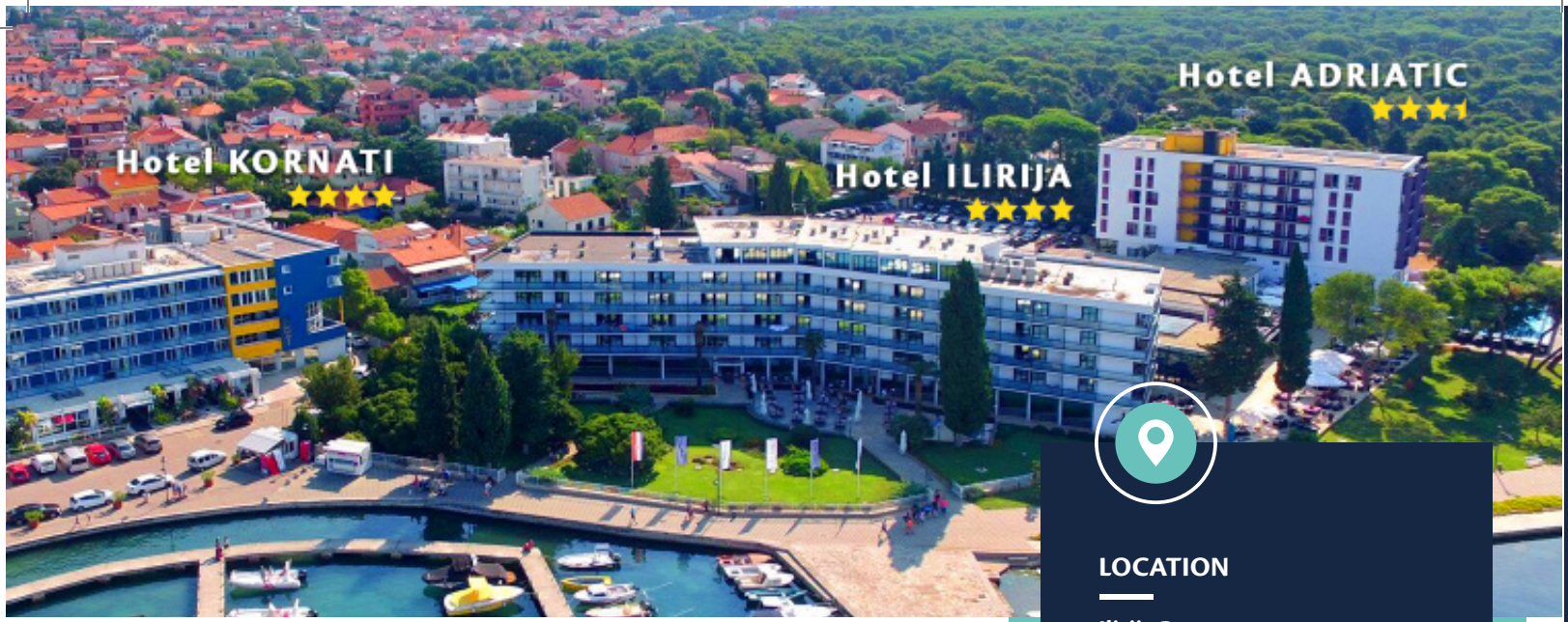
1.10.
SATURDAY
09:00 - 16:00
FIELD TRIP

RESTAURANT HOURS

BREAKFAST
07:30 - 09:00

LUNCH
13:00 - 14:30

DINNER
19:30 - 20:30



LOCATION

Ilirija Resort
Tina Ujevića 7
23200 Biograd na Moru
Croatia

VENUE

BTS 2022 is taking place in Ilirija Resort hotels in Biograd na Moru, Croatia. The resort consists of three hotels that are within one minute of walk from each other.

REGISTRATION

The registration package includes:

- accreditation which allows participation in all technical and social programmes
- accommodation with three meals per day in single rooms (Standard registrations) or shared double rooms (Student registrations) in a 4* hotel for 7 nights (from 25th September until 2nd October)

A Corporate registration includes:

- 2 full Standard registrations (accreditations and accommodation)
- a 30-min time-slot for the presentation of the product gamut
- logistical/infrastructural local support and organization collaboration for an expo/hands-on demonstration activity at the prescribed site

TYPE	EARLY BIRD BY 1ST JULY	REGULAR BY 2ND SEPTEMBER
Student	600 €	720 €
Standard	850 €	950 €
Accompanying person	420 €	420 €
Corporate	3500 €	4000 €

LECTURES

The Chagos Remote Ocean Voyager Expedition (C-Rove)

Bridget Buxton, University of Rhode Island, USA

We (Bridget Buxton, John Potter (NTNU), Casper Potter (NTNU)) present preliminary results from the 2021-22 C-Rove Expedition and the voyage of the 18m private sailing yacht Jocara to the Chagos Archipelago (British Indian Ocean territory). The 6-week project supported by OceanGate Foundation included oceanographic research activities such as water sampling for Environmental DNA analysis, underwater surveying and acoustic recording, in addition to terrestrial DNA sampling and wildlife observation (birds and mammals). We explore some of the challenges and lessons of conducting an extended remote ocean research expedition from a small sailing vessel, and share thoughts on the potential of this new marine research model. As underwater vehicles and their payloads become ever more capable and compact, crewed oceanographic research vessels have trended in the opposite direction: larger in size, fewer in number, and accessible to only a privileged few. Another irony is that so much of the world's oceanographic research undertaken with aspirations of environmental conservation and sustainability uses the least environmentally friendly platforms imaginable – a point noted by Greenpeace when they recently replaced their large diesel-burning MV Esperanza with a new smaller sailing vessel, the SY Witness. The question is no longer if, but when, oceanographic research will follow the maritime freight and cruise industries in pursuit of carbon neutrality. Our experiences on the C-Rove expedition show that this low-carbon model can be very efficient, economical and effective in the right circumstances and suggests design choices for small vehicles and sensor packages produced with this future in mind.

26.9.2022
09:00-09:45
Marine Archeology
Bridget Buxton

Dr. Bridget Buxton *is an underwater archaeologist and historian based at the University of Rhode Island, and chief archaeologist of the June-August 2021 Oceangate Titanic expedition. Bridget grew up in New Zealand and completed her PhD at Berkeley as a Fulbright scholar in ancient history and Mediterranean archaeology. She specializes in classical underwater archaeology, and has been at the forefront of introducing new robotic technologies to underwater research. She has worked on and co-directed archaeological expeditions all over the world, including the Mediterranean, Adriatic, Black Sea, and the South Pacific, discovering and investigating dozens of historic shipwrecks and the two important ancient harbors of Akko and Caesarea in Israel.*

The Role of Acoustics in Underwater Robotics

Nuno Alexandre Cruz, INESC TEC, Portugal

Radio signals hardly propagate underwater, therefore radio-frequency based solutions that are routinely used above water (like GPS and other GNSS) are virtually useless in the underwater domain. On the other hand, sound waves propagate better in water than they do in air, therefore acoustics has been a major source of solutions to help solving the underwater localization challenges. In the domain of underwater robotics, the main task of the onboard navigation system is to estimate its own position and attitude in real time. This serves for the control system to make necessary corrections in trajectory, and, at the same time, it allows sensor data to be spatially tagged. A typical navigation system fuses together data from multiple sensors, like pressure sensors, digital compasses, IMUs, accelerometers, gyroscopes, and Doppler velocity meters. Even with the best of specs, these data alone produce position estimates with errors that grow in time due to continuous integration of biases. The use of acoustic signals to provide range and bearing to specific locations can provide absolute measurements and avoid divergence. The Center for Robotics and Autonomous System of INESC TEC in Porto, Portugal, has been involved in many R&D projects developing cutting-edge technology for the underwater environment. One example of specialization is underwater navigation, a topic of active research for more than 20 years. This lecture will address some of the flagship projects of the Center in underwater robotics, with an emphasis on acoustic based devices and algorithms developed to maximize their usefulness in marine scenarios.

26.9.2022
09:45 - 10:30
Maritime Robotics
Nuno Alexandre Cruz

Nuno Alexandre Cruz *was born in Porto, Portugal, in 1970. He graduated in Electrical and Computer Engineering at the Faculty of Engineering of the University of Porto (FEUP), Portugal, in 1993. He received the MSc. in Digital Systems Engineering from UMIST, UK, in 1994, and the PhD in Electrical and Computer Engineering from the University of Porto in 2016. He is currently a Coordinator at the Centre for Robotics and Autonomous Systems of INESC TEC, in Portugal. He is also an Assistant Professor at FEUP, where he has been teaching for over 20 years, and serves as a member of the Department Council. His research interests include marine robotics, underwater navigation systems, and efficient use of autonomous vehicles at sea. Nuno Cruz has led and actively participated in numerous R&D projects, both national and international. He was the leader of the PISCES team, finalist of the Shell Ocean Discovery Xprize, in 2018, splitting the 1 million dollars prize. Under this effort, he led the development of DART, a portable deep water hovering AUV to map the ocean floor up to 4000 meters of depth, among other significant advances in collaborative robotics. He has been the author or co-author of more than 100 publications in international journals, book chapters, and proceedings of conferences, with regular presentations in top international conferences, such as the IEEE/MTS Oceans or IEEE UT.*

Nuno Cruz is a Senior Member of the IEEE Oceanic Engineering Society (a member since 1997), where he serves as an Associate Editor of the Journal of Oceanic Engineering, in the topics of AUV design, underwater navigation, acoustic navigation, and adaptive sampling. He is the Chair of the Portuguese Section of IEEE OES.

Autonomous platforms for oceanographic data collection

Riccardo Gerin, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Italy

In recent decades, technological developments and the miniaturisation of sensors have made the development of autonomous and unmanned remote sensing oceanographic platforms possible. These platforms can move through the water, provide long-term and real-time monitoring and, in addition, reduce costs compared to other traditional measurement approaches. They are very efficient and important tools to complement and extend conventional oceanographic observations.

26.9.2022
11:00 - 11:45
Marine Oceanography
Riccardo Gerin

Riccardo Gerin *obtained his MSc in Physics (2001) and a PhD in Environmental Sciences (2005) both from the University of Trieste. He works at OGS since 2005 and has a long experience in the technical aspects of autonomous instruments (drifters and gliders) and oceanographic instrumentation in general and in data processing and interpretation. He has also recently worked on low-cost platforms for developing countries and is currently coordinator of the OGS Centre for Oceanographic Calibration and Metrology (CTMO).*

Longterm deployment – does AUVs really need to surface

Antonio Vasilijević, Applied Underwater Robotics Laboratory, Norwegian University of Science and Technology, Norway

Present-day offshore operations rely almost exclusively on remotely operated vehicles deployed from support vessels. However, resident autonomous robotic systems that are docked and ready to operate at or near the offshore site, or towed docking units allowing charging and data transfer in motion, have potential to become a game changer in offshore exploration and exploitation. The clear benefits are much shorter response time and significant reduction of cost and greenhouse gas emissions as support vessels are almost not needed. Nevertheless, there are still some challenges to be addressed before the concept becomes state-of-the-art. This talk will give an insight into NTNU's AURLab relevant results from various national and EU projects and touch upon some of these challenges such as subsea docking, residency, communication and USV-AUV integration. The talk will also present subsea part of the full scale OceanLab research infrastructure developed for remote experimentation, validation, and operation of underwater vehicles/technology from shoreside control room or any remote location.

26.9.2022
11:45 - 12:30
Maritime Robotics
Antonio Vasilijević

Dr. Antonio Vasilijević *is a research project manager at the Applied Underwater Robotics Laboratory (AURLab), Norwegian University of Science and Technology where he is responsible for full lifecycle of research projects related to marine robotics as well as operation and further development of the Laboratory research infrastructure. He is a part of a team of engineers and researchers with vast experience in developing marine and autonomous technologies. Previously, Antonio acted as a Leading Researcher at the Laboratory of Underwater Systems and Technologies at University of Zagreb Croatia where he was project coordinator or key researcher in number of national or EU funded projects. Before returning back to academia in 2009, he worked on various engineering and senior positions in marine industry. His research interests cover broad area of marine robotics and marine technology in general and their applications.*

Motion capture for underwater communication and diver health monitoring

Iain Anderson, Biomimetics Lab, Auckland Bioengineering Institute, New Zealand

SCUBA divers visit a world that is 1000 times denser than air, and that is often murky, with strong currents and other surprises. To mitigate risk divers are taught to go down in pairs, where each buddy looks out for the other. Yet many divers dive alone for a variety of reasons including buddy unavailability or accidental separation. The Diver Alert Network has reported that 86% of diving fatalities were alone when they died. For the buddy system to work well divers have developed gesture-based communications for hazard alerting, assessing each other's wellbeing and relaying intentions. Gesture based communication is line-of-sight and works well in clean non-murky water but can be hard to achieve when the water is murky and turbulent. And it is useless if the diver is alone or separated from a buddy. In collaboration with LABUST at the University of Zagreb we are using direct motion capture of fingers in a smart glove that processes gestures and turns them into commands that can be acoustically transmitted directly to a robot or a buddy that is out of sight. The motion-capture technology can also be used in a wetsuit to monitor diver breathing and movement. In this talk we describe the technology of the motion capture sensors and how they are well suited for the ocean environment. We demonstrate the glove, and relate our experimental results. Finally we report our preliminary work using wetsuit sensors for diver condition monitoring, demonstrating motion capture as a means for improving diver safety.

27.9.2022
09:00 - 09:45
Maritime Robotics
Iain Anderson

Iain Anderson *is Group Leader for the Biomimetics Laboratory of the Auckland Bioengineering Institute (www.abi.auckland.ac.nz/biomimetics (http://www.abi.auckland.ac.nz/biomimetics)). Iain completed his PhD (Engineering Science, University of Auckland) in 1996, and has worked as a whiteware product designer (Fisher and Paykel Ind.), a vibrations consulting engineer (NZ Department of Scientific and Industrial Research) and a research scientist associated with hip and knee implant design and surgery (Industrial Research Ltd., New Zealand). In 2000, Iain returned to the Department of Engineering Science as a staff member, and was one of the founding members of the Auckland Bioengineering Institute. Iain's interest in artificial muscles led to the formation of the Biomimetics Laboratory in 2004. The lab's research is currently focused on the control and self-sensing of electronic artificial muscles and the development of soft electroactive polymer sensors for underwater applications. Iain is involved in two Biomimetics Lab spin-out companies: StretchSense (2012) and PowerOn Ltd. (2019). StretchSense produces motion-capture gloves using soft elastomer dielectric elastomer sensors. PowerOn is commercializing the lab's electroactive polymer actuator technology. For his efforts in developing and commercializing electroactive polymer technology he was awarded the Royal Society of New Zealand's 2016 Pickering Medal.*

Monitoring biodiversity with a wired underwater camera

Neven Cukrov, Ruđer Bošković Institute, Croatia

Monitoring marine life and its biodiversity requires technological implementation to achieve the standards required for advanced ecosystem management in Marine Protected Areas (MPAs). We chose the Krka River Estuary Natura 2000 site in Croatia as a pilot area. A wired underwater surveillance camera is positioned at 5 m depth. The image acquisition is based on a motion sensing method with a self-developed software ("Fish Monitoring") running on a Windows OS environment. The images of mobile megafauna taken during daylight hours from 10th January to the end of April 2018 were selected for further processing. A total of 13808 images were analysed from which 136195 individual animals were identified. From 10026 images, a total of 16216 fish specimens belonging to 35 species were identified. These included 24 species of commercial interest, including the billfish Thunnus thynnus (Atlantic bluefin tuna) and animals of conservation interest such as the loggerhead turtle, Caretta caretta. The data collected in the time series showed an increase of fish biodiversity from winter to spring.

27.9.2022
09:45 - 10:30
Marine Biology
Neven Cukrov

Neven Cukrov *is a Senior Scientist at the Division for Marine and Environmental Research, Ruđer Bošković Institute from Zagreb and currently runs the Martinska marine station near Šibenik. He is also a full-time lecturer at the undergraduate and graduate studies of the University of Zadar, and at the doctoral study of oceanology, University of Zagreb. His field of research includes anthropogenic impact on recent sedimentation and precipitation of travertine, then research on biogeochemical processes of metals, natural and artificial radionuclides, and microplastics in aquatic systems (part sediment). In addition, he deals with development of automatic system for metals detection and biodiversity monitoring. His research area are water systems, including groundwater karst systems.*

Control of Autonomous Underwater Vehicles for Hydrobatics

Ivan Stenius, Sriharsha Bhat, KTH Engineering Mechanics, Sweden

The term hydrobatics refers to the agile maneuvering of underwater vehicles. Hydrobatic capabilities can enable exciting new use cases for autonomous underwater vehicles (AUVs) in aquacultures, inspections, under-ice sensing, docking, and manipulation. These ideas are being explored at KTH within the Swedish Maritime Robotics Centre (SMaRC). Modeling the flight dynamics of such AUVs at high angles of attack is a key challenge – we use Simulink to perform real-time simulations of hydrobatic maneuvers. Furthermore, these robots are underactuated systems, making it more difficult to obtain elegant control strategies – we can use the Nonlinear Model Predictive Control toolbox to generate optimal controls. Finally, the controllers and simulation models developed can be tightly linked to SMaRC's AUVs and simulation environments through ROS.

27.9.2022
11:00 - 11:45
Maritime Robotics
Ivan Stenius,
Sriharsha Bhat

Ivan Stenius *received his M.Sc. in Lightweight structures from the Royal Institute of Technology (KTH) in 2003 and a degree of Doctor in Technology KTH, Lightweight Structures on hydroelasticity and fluid structure interactions on high-speed craft in 2009. Stenius is currently full-time associate professor at the department of aeronautics and vehicle engineering at KTH. Stenius has expertise in underwater vehicle modelling design and construction. He has been PI for a number of research projects in collaboration with the Swedish Defence Material Administration, involving cross-disciplinary collaboration between the research groups – computer vision and perception, applied electrochemistry, and networked control at KTH. Stenius has in the recent years been involved in building up a research group in maritime robotics at KTH and he is now PI of the Swedish Maritime Robotics Centre (SMaRC) hosted by KTH that involves research on underwater robotics.*

Sriharsha Bhat *received a bachelor's degree in Mechanical Engineering from the National University of Singapore in 2013, and a master's degree in Vehicle Engineering from the Royal Institute of Technology (KTH), Stockholm, Sweden in 2016. He is currently a PhD student at KTH focusing on the control and simulation of underwater robots. From 2013-2014, he was a Research Engineer at the Singapore MIT Alliance for Research and Technology (SMART), Singapore focusing on aerial and underwater robotics; and from 2016-2018, he was a Technology Development Engineer at Continental, Hannover, Germany. His research interests include optimal and model predictive control, motion planning, reinforcement learning, simulation/modeling, and system identification for robots and autonomous vehicles in challenging field applications.*

Data Policy and Challenges for Marine Robotics

Roberta Ferretti, Simona Aracri, National Research Council of Italy - CNR, Italy

Data are a fundamental product of marine robotics. The growth of novel unconventional platforms gave rise to a new generation of data, for which there is no standardization and, hence, no coordination. The importance of codifying these data is twofold: robotic and observational. Sharing the platform performance data will aid novel technology in accelerating their commercialisation. Bringing new robotics platforms to the market is the crucial point of technological advancement, it is effectively the rite of passage that marks the difference between impactful robotics and base research. The global observational effort needs the unprecedented information gathered from state of the art robots. Therefore, the data protocols applied to these newborn environmental data have to match the quality of those applied to traditionally collected data. Ultimately, classifying robotic and environmental data feeds into the widely welcomed concept of fair and open science.

The lecture focuses on the meaning of self-describing data, i.e. minimum metadata required. It describes the difficulties that arise analysing non-standardised data and it highlights the best practices to be used to create a seamless data treatment approach, from acquisition to interpretation. Whilst in marine sciences data policies are relatively defined, in marine robotics this is an unexplored ground. The purpose of the lecture is to stimulate a discussion and to lay out a common path to define a set of metadata and shared vocabulary for the data gathered by novel robotic platforms.

Roberta Ferretti *is a researcher at the Italian National Research Council. She received her Master's Degree in Physics in 2008. After working at CERN as high energy physicist (2008-2010), in 2013 she joined the Institute of Marine Engineering in Genoa. Her activity dealt with the sensing capability of autonomous marine vehicles, focusing on data acquisition and analysis for the seabed characterization using automatic methods for the detection of Posidonia oceanica. During her Ph.D. (2017-2021) in cooperation with the Italian Navy Hydrographic Institute, she worked on the development of new approaches for the observation of transient phenomena in critical marine environments using autonomous marine vehicles for the data collection in different Arctic and Mediterranean field campaigns. Currently she is working on standardization of autonomous vehicles data acquisition for fair data management and open science.*

Simona Aracri, *is a permanent Researcher at the National Research Council of Italy – Institute of Marine Engineering. Previously Post-Doctoral Research Associate, University of Edinburgh, working on offshore robotic sensors. She holds Bachelor's and Master's degrees in Marine Engineering and*

27.9.2022
11:45 - 12:30
Maritime Robotics
Roberta Ferretti,
Simona Aracri

Naval Architecture . She also holds a Ph.D. in Physical Oceanography from the National Oceanography Centre – University of Southampton. She has spent more than 6 months at sea on oceanographic sampling campaigns, in the Mediterranean Sea, Pacific Ocean and the North Sea. Her research interests encompass: the application of robotics for observational oceanography and environmental monitoring. She is interested in the entire process of data collections, from the device design to the deployment setting and, ultimately, in the resulting data.

Deep learning computer vision-based obstacle detection for autonomous boats

Matej Kristan, Faculty of Computer and Information Science, University of Ljubljana, Slovenia

Autonomy is transforming most industries, and maritime robotics is no exception. With 90% of goods moved across the world in vessels, unmanned surface vehicles (USVs) present a considerable market opportunity. Small-sized USVs, in particular, present affordable devices for automated inspection of hazardous areas and periodic surveillance of coastal waters and have a strong potential for a wide-spread use. Apart from efficient control and high-level planning, safe and uninterrupted navigation relies on environment perception, in particular on obstacle detection and timely collision avoidance. The inherent dynamics of aquatic environment combined with a large variety of potential obstacles presents considerable challenges to computer vision systems, leaving robust obstacle detection an open research problem. In this talk an overview of recent work in the ViCoS laboratory (https://www.vicos.si/) on camera-based obstacle detection for USVs and the datasets created to facilitate the research in the USV obstacle detection will be given.

28.9.2022
09:00 - 09:45
Maritime Robotics
Matej Kristan

Matej Kristan *received a Ph.D. from the Faculty of Electrical Engineering, University of Ljubljana in 2008. He is a full professor in the Visual Cognitive Systems Laboratory (https://www.vicos.si) and a vice chair of the Department of artificial intelligence at the Faculty of Computer and Information Science, University of Ljubljana. He leads the Visual object tracking VOT initiative, is the president of the IAPR Slovenian pattern recognition society and Associate Editor of IJCV. He has co-organized over thirteen workshops and conferences, he received fourteen research excellence awards and four teaching excellence awards. His students regularly receive research excellence awards as well. His research interests include visual object tracking, anomaly detection and segmentation, perception methods for autonomous boats and machine-learning-based geophysics prediction models. According to Google scholar, his works have been cited over 8000 times, his h-index is 35.*

Development of a secure, interoperable and highly scalable standard for underwater acoustic communications

Jeff Neasham, Newcastle University, UK

Since 2019, Newcastle University have worked, in collaboration with MoD/DSTL and Sonardyne international, to develop a open waveform standard for underwater acoustic communications. This is a highly scalable waveform capable of supporting everything from very short command/control messages up to streaming compressed voice between divers. It can also be used in a wide range of frequency bands to trade off data rate/packet duration versus maximum range. A key feature of the waveform is that it has been designed from the beginning with security in mind, including a number of physical layer security features which reduce probability of detection, interception and exploitation, in addition to more traditional data encryption techniques. This talk will describe the waveform design/capabilities, recent field testing results in UK waters and the Mediterranean, and potential application in the control and navigation of marine robots.

28.9.2022
09:45 - 10:30
Maritime Robotics
Jeff Neasham

Jeff Neasham *received the B.Eng. degree in electronic engineering from Newcastle University, Newcastle upon Tyne, U.K., in 1994. He then worked at Newcastle University until 2007 as a Research Associate on research and commercial product development in underwater acoustic communication, sonar imaging, and wireless sensor networks, before taking up an academic post. He is currently a Professor of Acoustic Signal Processing with the School of Engineering, Newcastle University. He has published over 100 conference and journal publications and his work on underwater acoustic communication and positioning has been commercialised by 3 UK companies and 1 Italian company. His research interests are in underwater acoustic signal processing and device design, wireless communication networks and biomedical instrumentation.*

Integrated observations and monitoring solutions for exploration and sustainable exploitation of marine abiotic resources

Marzia Rovere, Institute of Marine Sciences - CNR, Italy

Hydrocarbons are organic compounds that contain only carbon and hydrogen atoms. Marine environments are ideal for their formation, because organic matter rapidly undergoes anaerobic degradation while high and fast sedimentation rates, typical of marine settings such as the Adriatic Sea, favor rapid burial and decomposition of organic matter. Hydrocarbon generation can be either microbial or thermic, at different temperatures and depths. Hydrocarbons tend to migrate to shallower sedimentary horizons, giving rise to seafloor features such as pockmarks and mud volcanoes with varying scales. When the flow is sufficiently high, hydrocarbons escape the seabed and form gas plumes in the water column. The plumes can be detected as density anomalies by marine acoustic and geophysical sensors, that combined with geochemical and hydrological data, allow to quantify the upward flux of gas.

Hydrocarbon seepage is overlooked in the marine environment, mostly due to the lack of adequate space-time resolution environmental monitoring data that consider also the climate variability. This contribution is about the set-up of relocatable, customizable, scalable and cost-effective monitoring systems that can be operated from mobile platforms in the Adriatic Sea. Their applications include monitoring of: coastal areas shifting water dynamics due to changing seasons; monitoring of leakage from abandoned or decommissioned wells/boreholes/sealines, reservoirs, shallow gas accumulations.

Data and information collected with innovative and autonomous technology is essential to reduce uncertainties of offshore multi-hazards and can help strengthening the integrated, interoperable sharing of marine environmental information with decision makers, civil protection and the public.

28.9.2022
11:00 - 11:45
Maritime Robotics
Marzia Rovere

Marzia Rovere *has a PhD in Earth Sciences and is researcher in marine geology at the Institute of Marine Sciences (ISMAR) of the National Research Council of Italy since 2009. Her scientific research deals with a variety of different topics related to seafloor and sub-seafloor mapping, including among others submarines landslides and their potential to trigger tsunamis, sediment transport in coastal areas, fluid flow along faults and the threads they pose to offshore installations. Her interests focus also on marine mineral resources, including aggregates on continental shelves, cold seep and hydrothermal habitats as unconventional sources of non-energy raw materials in the deep-sea through innovative recovery processes. Marzia participates in several EU projects, including EMODnet Bathymetry where she coordinates the public-access to ocean data of the Central Mediterranean, and is leading different*

national projects sponsored by public stakeholders. She is vice-chair of the joint IOC-IHO GEBCO Guiding Committee and participated in the establishment team of the GEBCO-NF Seabed 2030 project. She is the Italian alternate head of delegation to the works of the International Seabed Authority, where she served in the Legal and Technical Commission in 2015-2016. Marzia sailed in dozens of oceanographic cruises in the Mediterranean and Atlantic Ocean.

Developing imaging technologies to search for, discover, and understand life in the deep sea

Kakani Katija, Monterey Bay Aquarium Research Institute, USA

The ocean is a vast three-dimensional space that is poorly explored and understood, and harbours unobserved life and processes that are vital to ecosystem function. Ocean-going platforms are integrating high-resolution, multi-camera feeds for observation and navigation, producing a deluge of visual data. The volume and rate of this data collection can rapidly outpace researchers' abilities to process and analyse them. Additionally, to fully interrogate the space, novel algorithms and innovative robotic platforms are required to scale up our observational capacity. Two applications, locating animals of interest and conducting extended visual observations of animals in the water column, are particularly challenging objectives that require advances in imaging, robotic vehicles, and navigational algorithms. Here I will share collaborative advances that our group, the Bioinspiration Lab at MBARI, have been involved in to address imaging (DeepPIV, EyeRIS), vehicle (MiniROV, Mesobot, LRAUV), and algorithmic needs (FathomNet, ML-Tracking) to enable and sustain observations of life in the deep sea. Together, these efforts clearly demonstrate the potential that robotic platforms can have on exploration in unexplored environments and discovery of undiscovered life in our ocean.

29.9.2022
09:00 - 09:45
Maritime Robotics
Kakani Katija

Dr. Kakani Katija *is a Principal Engineer at the Monterey Bay Aquarium Research Institute, a Research Associate at the National Museum of Natural History (Smithsonian Institution), and a Visiting Associate Professor in Aerospace at the California Institute of Technology (Caltech). Originally an Aerospace Engineer (BSc from University of Washington and MSc from Caltech), Kakani received a PhD in Bioengineering from Caltech. As lead of the Bioinspiration Lab, Kakani and her group investigates ways that imaging can enable novel observations of life in the deep sea. By developing imaging and illumination tools (e.g., DeepPIV and EyeRIS), automating the classification of underwater visual data using artificial intelligence (FathomNet), and integrating algorithms on vehicles (ML-Tracking) for robotic vehicle missions (e.g. Mesobot, LRAUV) to consistently and persistently observe ocean life, her group's efforts will help increase access to biology and related phenomena in the deep sea. Kakani was named a National Geographic Emerging Explorer in 2011, a Kavli Research Fellow of the National Academy of Sciences in 2013, and a Frontiers of Engineering Fellow of the National Academy of Engineering in 2020. She has received generous funding support for the Bioinspiration Lab's work from a number of funding organisations including the Packard Foundation, National Geographic Society, NSF, NOAA, Schmidt Ocean Institute, and the Moore Foundation. In her spare time, Kakani, along with her husband and dog, like to roam the outdoors by foot and participate in random sporting events (e.g., figure skating, keg tossing, tobogganing, etc.).*

Fantastic cold – water corals and where to find them

Johanna Järnegren, Norwegian Institute for Nature Research (NINA), Norway

The continental slope off the Norwegian coast have some of the most extensive cold-water coral reefs in the world. Offshore waters also intrude into the numerous deep fjords that incise the Norwegian coast, providing ideal conditions for deep-water species to colonise their steep rocky walls. Cold-water coral ecosystems are valuable, vulnerable and notoriously difficult to study. Their habitat is deep, with high currents making it challenging to navigate ROV and AUV, and sometimes dangerous due to entangled fishing lines and nets. During autumn 2022 we are mapping three marine protected areas in the Trondheimfjord to position cold-water corals. The main part of the corals are located on vertical walls where more traditional mapping methodology comes short. In our investigations we try to understand and implement the best and most (cost) efficient ways to do this, but are we succeeding? How can we best study these areas and what methods should be used? We invite to discussion!

Johanna Järnegren *is a Senior scientist at the Norwegian institute for nature research (NINA). She is a marine biologist focusing on cold-water coral ecosystems with an emphasis on reproduction, anthropogenic effects from oil exploration, ocean acidification and aquaculture and mapping and monitoring of corals in coastal and fjord systems.*

29.9.2022
09:45 - 10:30
Marine Biology
Johanna Järnegren

AUVROVA-autonomous low-cost resident inspection underwater drone concept

Kjetil Eik, Norwegian Institute for Nature Research (NINA), Norway

Underwater inspections in the energy sector are typically costly, limiting what's inspected and the frequency. The value from inspections is in the collected data and application of that data. AUVROVA is a concept to create a fleet of low cost autonomous collaborative inspection drones enabling simultanous monitoring of many assets spread over larger areas.

29.9.2022
11:00 - 11:45
Maritime Robotics
Kjetil Eik

***Kjetil Eik** has worked in Norway's largest energy company, Equinor ASA since 1998 in various roles. For the last five years he has been embedded in the Emerging IT Sandbox team. A large part of this time has been devoted to supporting Equinor's various underwater robotics initiatives through building multi-disciplinary prototypes and one-off units to enable research and validation of internal concepts and vendor provided equipment and solutions.*

Heterogeneous Autonomous Robotic System in Viticulture and Mariculture

Zdenko Kovačić, Nadir Kapetanović, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

For millennia, viticulture and mariculture have been a component of human society. Both viticulture and mariculture are heavily reliant on human labor, with workers generally doing arduous, repetitive, sometimes even dangerous tasks for long periods of time. HEKTOR (Heterogeneous Autonomous Robotic System in Viticulture and Mariculture) project is looking for solutions to these issues. The main objective of the HEKTOR project is to realize a systematic solution for the coordination/cooperation of smart heterogeneous robots/vehicles (marine, land-based, and aerial vehicles) that are able to cooperate autonomously and assign tasks to each other in an open unstructured space. HEKTOR is designed as a modular and autonomous system, adapted for various missions in viticulture and mariculture with the foreseen possibility of human intervention during the performance of various inspection and intervention tasks. The lecture will cover the development and integration of various robotic platforms (all-terrain vehicle, autonomous catamaran, aerial drone, and remotely operated vehicle) and their cooperation-enabling subsystems (landing platform, tether management system, and underwater acoustic localization). Furthermore, results of autonomous monitoring, spraying and suckering tasks in viticulture, and biofouling estimation in mariculture will be presented.

29.9.2022
11:45 - 12:30
Maritime Robotics
Nadir Kapetanović
Zdenko Kovačić

Zdenko Kovačić *is full professor at the Faculty of Electrical Engineering and Computing in Zagreb and head of the Laboratory for Robotics and Intelligent Control Systems (LARICS). In 1990/91 he was a visiting researcher at the Virginia Polytechnic Institute and the State University, Blacksburg, USA. For contributions to the fields of robotics, automation, and control, he received the University of Zagreb Award "Fran Bošnjaković" for the year 2013 and the Faculty of Electrical Engineering and Computing Award "Josip Lončar" for the year 2018. He was the principal researcher of more than 40 international and Croatian R&D projects including 3 ongoing ESF funded R&D projects and 3 R&D projects with industrial partners. He is the MC member of COST Action CA19104 Advancing Social inclusion through Technology and Empowerment (a- STEP). He is the author of 3 books in the fields of robotics, manufacturing systems and intelligent control. He is a member of the EuRobotics PhD Award Jury (2016-2022). He is the Senior Member of IEEE. He was president of Croatian Robotics Society 2005-2010. In the years 2012-2015 he was the elected president of Croatian Robotic Association. He is also a member of Croatian Society for Communication, Computer, Electronics, Measurement and Control. He is active in editorial boards of international journals and participated in the organization of numerous international conferences, workshops and academic seminars, and other events aimed at popularizing science.*

Nadir Kapetanović *(MSc, 2015) is a Ph.D. student and a researcher as a member of the Laboratory for Underwater Systems and Technologies (LABUST) at the University of Zagreb Faculty of Electrical Engineering and Computing. He is currently involved in ESIF project HEKTOR, and previously he was involved in research in Interreg Mediterranean co-funded project BLUEMED, NATO project MORUS, and several other EU and national funded projects. His research interests include model predictive control, path and coverage planning for underwater marine vehicles, and state estimation techniques. He is the Secretary of the IEEE Oceanic Engineering Society Student Branch Chapter of the University of Zagreb.*

TUTORIALS

Meet the Expectations:Accuracy Aspects in Underwater Photogrammetry

Fabio Menna, Fondazione Bruno Kessler, Italy
Erica Nocerino, Department of Humanities and Social Sciences of the University of Sassari, Italy

Underwater photogrammetry has become a key technique for studying and understanding the underwater world in many application fields, such as exploration and mapping, industry and metrology, archeology, biology, etc. Nevertheless, producing accurate three-dimensional measurements underwater is still a challenge if compared to photogrammetric applications on land. The availability of highly customizable and non-standardized underwater photography equipment (e.g. different pressure housings designs, size and materials, dome and flat ports, corrective elements such as the Ivanoff-Rebikoff) poses additional complexity to the process of image formation underwater with subsequent adverse effect to the accuracy of photogrammetric measurements. The tutorial aims at providing the audience with an introduction to the crucial aspects of underwater photogrammetry as 3D surveying technique and independent methods for the assessment of its accuracy potential. We will go through the optical fundamentals of underwater imaging, camera calibration approaches like implicit vs explicit modelling of refraction and their influence on the accuracy of the derived 3D photogrammetric products. During the hands-on session the participants will experience with real as well as simulated underwater datasets to critically understand the limits and the benefits of current state-of-the-art photogrammetric processing techniques. Covered topics will include camera network design, requirements for self-calibration in structure from motion approaches, methods of control and underwater reference systems.

Dr. Fabio Menna *is a researcher at the 3D Optical Metrology (3DOM – http://3dom.fbk.eu) unit of FBK (Fondazione Bruno Kessler) Trento, Italy. His main interests are in photogrammetry, range sensors, geodetic surveying, 3D modelling where he has published more than 70 articles among journals and conference proceedings. He is a scientific diver and has more than ten years' experience in the domain of underwater photogrammetry, in particular for engineering and industrial applications (Costa Concordia photogrammetric survey, research and development for the COMEX ORUS3D subsea photogrammetry systems). From 2012 to 2016 he served as secretary of ISPRS Commission V and since 2016 he is Chair of the ISPRS Working Group on Underwater Data Acquisition and Processing. He has organized a number of scientific events related to underwater photogrammetry and tutored more than 15 international summer schools and tutorials.*

Dr. Erica Nocerino *is currently tenure-track assistant professor in Geomatics at the Department of Humanities and Social Sciences of the University of Sassari (Italy). For more than ten years, her*

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Tutorial
Lecture Room
Fabio Menna
Erica Nocerino

research has focused on 3D measurement and digitization techniques, in particular photogrammetry. She is interested in all the aspects related to quality improvement and assessment of the generated 3D to meet the requirements of the specific application. She is secretary of the ISPRS Working Group II/7 on Vision Metrology. She has been appointed chair of the 2022-2026 ISPRS Working Group II/7 on Underwater Data Acquisition and Processing.

Underwater localization of acoustic sources – principles and approaches

Bruno Ferreira, INESC TEC, Portugal

This tutorial introduction will serve to provide foundation material that will be explored during the hands-on acoustic data processing and implementation of localization methods. The session will briefly describe some models of underwater acoustic propagation, together with the algorithms to estimate ranges and bearings between underwater devices. This will be followed by a comparison of different methods to estimate position with respect to geographic references, including Long Baseline and Ultra-short Baseline, for example. One typical application of these methods is the localization of underwater pingers, such as the ones of airplane black boxes. A similar example will be provided, with the description of the steps taken to determine the location of a sunk glider off the coast of Portugal in the autumn of 2021. The final part of the session will serve to announce the BTS underwater localization challenge, describing the characteristics of the deployed pinger, such as ping rate and frequency.

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14:30 - 15:15
Tutorial
Ilirija Room
Bruno Ferreira

Bruno Ferreira *(MSc 2009, Ph.D. 2014) is a researcher at the Center for Robotics and Autonomous Systems at INESC TEC and an Invited Assistant Professor at the Faculty of Engineering of the University of Porto. He holds a Ph.D. in Electrical and Computer Engineering from the Faculty of Engineering of the University of Porto. The focus of his work has been on autonomous underwater and surface vehicles, in the areas of control and estimation. He has 50+ peer-reviewed publications on these topics, in co-authorship with 84 researchers, 13 supervisions of M.Sc. theses, and he is currently supervising 3 Ph.D. theses. He made contributions to the development of marine vehicles such as TriMARES, SHAD, FLEXUS, leading the latter two. He has participated in 12 R&D projects. He is a guest editor and topic panel member for JMSE, and guest editor for Remote Sensing journal. Bruno is currently the vice-chair of the IEEE OES Portugal Chapter.*

Getting started with Reeds, the world's largest dataset for perception algorithms

Dr. Ola Benderius, Chalmers University of Technology, Sweden
Ted Sjöblom, RISE - Research Institutes of Sweden, Sweden

Reeds is a new dataset for research and development of robot perception algorithms. The design goal of the dataset is to provide the most demanding dataset for perception algorithm benchmarking, both in terms of the involved vehicle motions and the amount of high quality data. The logging platform consists of an instrumented boat with six high-performance vision sensors, three high-fidelity lidars, a 360° radar, a 360° documentation camera system, as well as a three-antenna GNSS system and a fibre optic gyro IMU used for ground truth measurements. All sensors are calibrated into a single vehicle frame. The tutorial will introduce the dataset and give the participants hands-on experience on how to replay data into self-developed algorithms, with examples available in both Python and C++. The take-away is that participants easily can get started using the data in their own research and development, as well as getting insight into the capabilities of the latest sensors. Read more about the dataset here (currently being updated): https://reeds.opendata.chalmers.se

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Tutorial
Lecture Room
Dr. Ola Benderius
Ted Sjöblom

Dr. Ola Benderius *is Associate professor of Autonomous mobile systems at the Department of mechanics and maritime sciences at Chalmers University of Technology. His research focus is mainly on biologically inspired AI for mobile autonomous vehicles, both inspired by human driving and deep neural functions connected to self-motion and machine operation. He did in 2014 find the solution to a 70-year old mystery connected to human control and the so called remnant within control theory, by using inspiration from biological studies. In 2015 he was involved in forming the Chalmers vehicle research laboratory Revere, where he is currently leading research connected to autonomous driving, computer vision, software engineering in cyber-physical systems, and next generation HMI for both road and marine vehicles. He is one of the two architects behind the open-source software architecture OpenDLV for autonomous systems, the leader of Sweden's first autonomous racing team, and the initiator of Reeds, the world's largest dataset for fair benchmarking of robot perception algorithms.*

Ted Sjöblom *received a bachelor of Maritime captain, management and technology from Novia University in 2015, and in 2022 a Master's in Business, information system and a minor in Computer science from Åbo Akademi University, Finland. He is currently a Research and development engineer at RISE (Research Institutes of Sweden) in the department of Safety and transport and Maritime operations, focusing on the digitalization of sea transport. He has a background as a navigation officer*

on various ship types, from coastal tankers to cruise ships. From 2019 he worked with R&D within maritime digitalization in Finland and from 2021 in Sweden with task-related simulations, marine sensors, and navigation support tools.

Multibeam echosounder (MBES)

Matej Ćurić, Ivor Meštrović, GEOmar, Croatia

The principle of Multibeam echosounder (MBES) work, technical characteristics and capabilities, problems arising from work, data processing principles and the final product. Practical Exercise to show MBES work with the help of a boat for a hydrographic measure (an 8-meter ship that optimally can accommodate 6 interested participants).

Matej Ćurić *MSc, geodetic engineer and hydrographer with 7 years of experience with MBES through various jobs like marine objects and infrastructure projects (3D models of seabed, plans and maps for designing, monitoring underwater constructions and excavating, surveying as-built state after works, detection of existing underwater installations, etc.)*

Ivor Meštrović *MSc, geodetic engineer and hydrographer with 10 years of experience with MBES through various jobs like marine objects and infrastructure projects (3D models of seabed, plans and maps for designing, monitoring underwater constructions and excavating, surveying as-built state after works, detection of existing underwater installations, etc).*

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Tutorial
Sea
Matej Ćurić
Ivor Meštrović

Marine object detection using MARUS generated dataset

Ivan Lončar, Natko Kraševac, Juraj Obradović, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

Simulators play a key role in the development of mobile robots. Simulating vehicle models and their environment without depending on actual hardware has proven beneficial for reducing cost and development time while facilitating safety during testing. One motivation for developing MARUS (https://github.com/MARUSimulator) was to have a simulator that can offer advanced capabilities of generating realistic environment allowing for closer-to-reality validation and verification (V&V) of applications developed for maritime vehicles. The simulator offers synthetic dataset generation with perfect annotations for various sensors (cameras, lidar, sonar) and allows for interaction with the environment for closed loop simulation. In this tutorial, we will show you how to train and validate deep neural network used for object detection in marine environment. You will learn how to generate an annotated dataset consisting of images from single or multiple cameras in MARUS. Generated dataset will be used to train a deep neural network for detecting and classifying chosen objects.

Ivan Lončar *received a MSc in Control Engineering and Automatization from the University of Zagreb Faculty of Electrical Engineering and Computing – UNIZG FER (Croatia). Even before graduation, he started working in Laboratory for Underwater Systems and Technologies – LABUST at UNIZG FER. As of 2017, Ivan is pursuing a PhD in Marine Robotics, specifically in Underwater localization. During his time in the laboratory, he was involved in multiple research projects including ONR NICOP Adriatic, H2020 subCULTron, H2020 EXCELLABUST, HrZZ project CroMarX. As of latest he is a project team leader working on development of an autonomous ship.*

Natko Kraševac *received a MSc in Computer Science from the University of Zagreb Faculty of Electrical Engineering and Computing – UNIZG FER in Zagreb (Croatia) in 2020. During the studies, his background was mainly computer vision, deep learning and AI with focus on application in autonomous driving. After graduation, Natko worked in web development field before diving into marine robotics. Since 2021. he started working in Laboratory for Underwater Systems and Technologies – LABUST at UNIZG FER where he is currently involved in a project developing an autonomous ship.*

Juraj Obradović *is a researcher in the Laboratory of Underwater Systems and Technologies (LABUST) at the University of Zagreb Faculty of Electrical Engineering and Computing (FER). He received his MSc in electrical engineering and information technology from FER in 2021 and joined LABUST right after graduation. During his time at college, he worked on various projects and developed an interest in*

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Ivan Lončar
Natko Kraševac
Juraj Obradović

SLAM, reinforcement learning, and formation control. He is currently enrolled in the development of an autonomous ship.

Localization challenge

Roee Diamant, University of Haifa, Israel

In this tutorial we will provide in-depth meetings with groups willing to take the localization challenge. We will introduce the acoustic equipment, go over the teams' plans for localization, and describe the procedure of the localization challenge. The tutorial will take place in small groups, with one-to-one feedback. This way, the groups could take advance of a peer-review for their localization methodology. The tutorial will also include demonstration of localization solutions, with analysis of real data. Challenges in acoustic localization will be highlights, and know-how solutions will be introduced.

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Tutorial
Pool
Roee Diamant

Roee Diamant *received his PhD from the Department of Electrical and Computer Engineering, University of British Columbia, in 2013, and his B.Sc. and the M.Sc. degrees from the Technion, Israel Institute of Technology, in 2002 and 2007, respectively. From 2001 to 2009, he worked in Rafael Advanced Defense Systems, Israel, as a project manager and systems engineer, where he developed a commercial underwater modem with network capabilities. In 2015 and 2016, he was a visiting Prof. at the University of Padova, Italy. In 2009, he received the Israel Excellent Worker First Place Award from the Israeli Presidential Institute. In 2010, he received the NSERC Vanier Canada Graduate Scholarship. Prof. Diamant has received three Best Paper awards and serves as an associate editor for the IEEE Journal of Ocean Engineering. He is the coordinator of the EU H2020 project SYMBIOSIS (BG-14 track) and leads the underwater Acoustic and Navigation Laboratory (ANL) as an Associate Prof. at the Dept. of Marine Technologies, University of Haifa. His research interests include underwater acoustic communication, underwater localization and navigation, object detection and classification, and sonar signal processing.*

Guidance and control of UMVs

Massimo Caccia, CNR - Institute of Marine Engineering, Italy

The tutorial shows how guidance and control systems of Unmanned Marine Vehicles of CNR-INM are designed, implemented and tuned. Gain-scheduling PI velocity controller design and tuning is supported by basic model definition and identification experiments and allows easy design and implementation of guidance functions, heading control, line-following, path-following. Demonstration of the proposed approach will be available with SWAMP ASV.

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13:45 - 15:15
Tutorial
Sea
Massimo Caccia

Massimo Caccia *graduated in Electronic Engineering at the University of Genova in 1991. In the period October 16, 2013 – October 15, 2017 and October 16, 2017 – May 10, 2018 he served as Director and Acting Director, respectively, of the CNR Istituto di Studi sui Sistemi Intelligenti per l'Automazione (ISSIA-CNR). After joining CNR in 1993, his theoretical and applied research activities focused on marine robotics, mainly addressing the topics of modelling and identification, cooperative guidance and control, vision-based motion estimation and control, and embedded real-time platforms and architectures for Unmanned Marine Vehicles. He is among the European pioneer researchers in the field of unmanned surface vehicles and, with his research group, he developed pioneer research projects on the application of robotic technology to maritime safety. Research results, certified by more than 200 publications in international books, journals and conferences, led to the partnership in a number of EC, national and regional projects. He recently coordinated the projects Blue RoSES (EMFF), and MATRAC-ACP (Interreg Maritime Italy-France), and is coordinating the projects ARES (PON), and MODA (PNRM), that represent state-of-the-art R&D in the definition of guidelines and codes of practice for the operation of robotic vehicles in harbour waters and coastal water, and in the integration of shipbuilding and robotics according to the vision identified by Blue Italian Growth National Technology Cluster.*

DEMOS

Stationary H2Orbit

Vladimir Djapic, H20 Robotics, Croatia

Founded in December 2017, H2O Robotics, Ltd. is a company specialized in maritime robotics, both underwater and surface, for different purposes and missions. Its flagship product is H2Omni-X, an USV capable of very low-power dynamic positioning, obstacle avoidance, autonomous operation and advanced communication capabilities under and above water.
H2O Robotics, Ltd. provides services in maritime robotics, such as:

- manufacturing and selling H2Omni-X vehicle
- development of custom navigational algorithms
- adaptation of H2Omni-X for different use-cases
- development of custom vehicles
- R&D in the area of maritime technologies

H2Omni-X – smaller, lighter, smarter autonomous marine surface vehicle is an innovative robotic solution which outruns the current state of the market due to: high portability (easy operation and lightweight), high manoeuvrability (overactuated), long-term deployment capabilities (fault tolerant and energy efficient control), open source software architecture and competitive price. For marketing purposes, the vehicle is renamed to "H2Omni-X", conveying the message of omnidirectional vehicle, manufactured by H2O Robotics (name chosen for the company).

Base vehicle H2Omni-X, developed at LABUST/UNIZG-FER, was licensed to H2O Robotics company with a licensing fee which allows H2O Robotics to exploit, modify, improve, manufacture and sell vehicle to clients without any limitations.
Since the commercialization of H2Omni-X, H2O Robotics developed functional prototypes of 3 new products: 1) H2Orologio – an underwater pager, enables divers to communicate with other divers, topside (boat) units, other underwater or sea surface assets. We utilize a smart dive watch to accomplish the functionality of messaging underwater up to 1000 m; 2) H2Observe – small, low-cost, digital underwater modem. Our app runs on a smartphone and a dive boat can communicate with divers or other assets in the water, as well as track them; 3) H2Orbit – smaller version of H2Omni-X, dive flag buoy, tracks and trails underwater assets, enables Internet of Underwater Things.

This demo will include the demonstration of Stationary H2Orbit supporting several H2Observe systems as a prototype for Underwater localization & communication system. This system takes the form of one or more groups of three buoys, placed on the surface of the water, and one or more acoustic units, immersed under the water. A central unit, located on the shore or onboard a boat controls it.

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Demonstration
Pool
Vladimir Djapic

Vladimir Djapic *received the B.S., M.S., and the Ph.D. degree from the University of California, in 2000, 2001 and 2009, respectively, all in electrical engineering. He is an accomplished manager and scientist with over 19 years of US and international experience (2 patents and over 50 publications) with a focus on advanced mapping, navigation, control, planning, and sensing methods for heterogeneous robotic systems. Since 2020 Dr. Djapic serves as a CEO of H2O Robotics. More recently, 2017-2020, Vladimir acted as a Mapping & Localization Manager and Technical Lead for Autonomous Driving Systems at American Haval Motor Technology (AHMT) whose mission was to design and develop a self-driving car capable of autonomous driving on public roads. From 2013 to 2017, Dr. Djapic was a Chief Scientist and a lead Principal Investigator (PI) for projects that utilize Maritime Autonomous Systems (air, surface, and subsurface), where he also led numerous international collaborative efforts.*

Hydrobatics with underactuated AUV

KTH Engineering Mechanics, Sweden

In this demo we plan to demonstrate hydrobatic manoeuvres with a slender underactuated AUV for the purpose af maximising the usability of the sensor suite on board. As an example one could think of a hybrid mission where the AUV is first doing a lawn mover pattern as part of a search mission and if the AUV identifies a target of interest the mission can be momentarily interrupted in order to perform a detailed inspection with cameras. During the detailed inspection the AUV hoovers around the object of interest and aims the cameras to collect a complete set of video/images. We will demonstrated this close range hoovering and inspection manoeuvre and show how different control strategies can be utilised (classic PID control to more advanced methods such as LQR and MPC).

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Demonstration
Pool
KTH Engineering Mechanics

MDM TEAM

Vincenzo Calabrò, Lorenzo Marini, MDM team, Italy

MDM Team is an Italian SME, founded in 2012 with core business focused on marine robotics. MDM Team combines several leading experts to support consultancy and designing for a large number of engineering applications, such as Design and prototyping of complex mechatronics systems, CAD design, FEM analysis, Development of mathematical models and software for real-time simulations, Homologation/certification of systems and components. MDM Team has a core team with many years of experience in prototyping of complex robotics systems, including underwater vehicle design and control (AUV/ROV), surface vehicle design and control (USV), inertial navigation systems and inertial measurement units (MRU), sensor fusion, human machine interface design, simulation of mathematical models, numerical optimization and systems architecture. The interest of MDM Team is focused on the development of proprietary platforms and the integration with third party applications and/or systems and our mission aims at delivering innovative mechatronics products and to support customer need through consultancy services and high-tech solutions.

Vincenzo Calabrò *is the chief technology officer (CTO) of MDM Team. He is a Ph.D. (class 2012 University of Pisa) in Robotics Automation and Bio-Engineering. In MDM Team he is technology roadmap responsible and follows Business development activities. Technically he leads activities on modelling, control and design of robotics systems and human interfaces. He has industrial background and international experience (Principal Engineer at Cybernetics Department in Kongsberg Maritime – Norway; Senior R&D Manager in Norwegian Subsea).*

Lorenzo Marini *is the chief executive officer (CEO) of MDM Team since 2016. He earned a Ph.D. in Industrial Engineering from University of Florence (class 2014). His background covers Vehicle Dynamics, Simulation, Mathematical Modeling and Mechanical Design. In MDM Team is the administrative responsible and follows Business development and sales activities supporting project goals definition and long terms corporate strategies. He has been the project Coordinator of ROMERO project – Robots fOr extreMe EnviROnment (GA ESMERA – GA 780265) (2020 -2022) funded by the Second Open Call of H2020 European SMEs Robotic Application.*

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Demonstration
Pool
Vincenzo Calabrò
Lorenzo Marini

Multifunctional smart buoys as part of a heterogeneous marine robotic system on a monitoring mission

Anja Babić, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

Long-term inspection and monitoring of harbours, marinas, and aquaculture ecosystems, including pollution mapping and marine litter detection, is a highly relevant problem in the area of marine robotics. This demonstration aims to showcase a heterogeneous multi-robot system tackling this issue. A set of complementary platforms with different capabilities and functionalities is featured, forming a single environmental monitoring and surveying system: autonomous catamaran-like surface vehicles SWAMP (CNR-GENOVA) and Korkyra (UNIZG-FER) with the Blueye Pro ROV tethered to it are integrated into the Multifunctional Smart Buoy (UNIZG-FER) system of surface and underwater sensor units. The agents form an ad-hoc communication network spanning both underwater acoustic channels and surface WiFi comms. Blueye ROV collects visual data of the seafloor with an objective to find sea litter and other pollution factors, while acoustic sensor units monitor and report on water quality. ASV Korkyra is controlled to follow the ROV. Once sea litter is detected, its estimated georeferenced location is sent to the ASV SWAMP using the Smart Buoy as a relay, after which SWAMP moves to the given location. Besides serving as a hub transmitting relocation requests and points of interest, the buoy monitors the vehicles and sensor units during the entire length of the mission, collecting their telemetry, sensor, and status data over all communication channels, finally relaying it to be displayed on a user-friendly graphical IoT dashboard.

29.9.2022
15:30 - 18:30
Demonstration
Sea
Anja Babić

Anja Babić *is a researcher and PhD student at the University of Zagreb Faculty of Electrical Engineering and Computing and a member of the Laboratory for Underwater Systems and Technologies – LABUST. She is a senior researcher on the Multifunctional Smart Buoys project. Previously, she was involved in the EU H2020 project subCULTron – Submarine Cultures Perform Long-Term Robotic Exploration of Unconventional Environmental Niches. Other notable work includes implementing tasks for a robot-assisted autism spectrum disorder diagnostic protocol using the humanoid robot NAO for the HRZZ funded ADORE project and developing diver-focused sensing, data processing, and underwater communication as part of the FP7 project CADDY – Cognitive Autonomous Diving Buddy. Her research interests include evolutionary, neural, and bio-inspired robotics, emergent behaviour, task allocation and scheduling, formation control, and communication between both heterogeneous agents and members of a swarm, as applied to marine robotic platforms. She is the Chair of the IEEE Oceanic Engineering Society Student Branch Chapter of the University of Zagreb.*

Autonomous catamaran and tethered ROV as part of a heterogeneous marine robotic system on a monitoring mission

Nadir Kapetanović, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

Automating inspection and monitoring of harbours, marinas, and aquaculture ecosystems, including marine litter detection, is an highly relevant problem in the area of marine robotics. This demonstration aims to showcase a heterogeneous multi-robot system tackling this issue. A set of complementary platforms with a different set of capabilities and functionalities is featured: autonomous catamaran-like surface vehicles SWAMP (CNR-GENOVA) and Korkyra (UNIZG-FER) with the Blueye Pro ROV tethered to it are integrated into the Multifunctional Smart Buoy system of surface and sensor units (UNIZG-FER). The autonomous surface vehicle (ASV) Korkyra is developed as a catamaran to provide better stability and hydrodynamic properties and is made of aluminum for increased robustness. It has a modular design allowing integration of various payloads such as Blueye Pro ROV. Furthermore, the autonomy of the ASV Korkyra is on average 10-11h allowing it to be used in intensive real-life inspection and monitoring missions. All agents from the above-mentioned heterogeneous robotic system form an ad-hoc communication network spanning both underwater acoustic channels and surface WiFi comms. Blueye ROV collects visual data of the seafloor with an objective to find sea litter and other pollution factors, while acoustic sensor units monitor and report on water quality. ASV Korkyra is controlled to follow the ROV. Once sea litter is detected, its estimated georeferenced location is sent to the ASV SWAMP using the Smart Buoy as a relay, after which SWAMP moves to the given location. The buoy monitors the vehicles during the entire length of the mission, displaying their telemetry and status data on a graphical dashboard.

29.9.2022
15:30 - 18:30
Demonstration
Sea
Nadir Kapetanović

Nadir Kapetanović *(MSc, 2015) is a Ph.D. student and a researcher as a member of the Laboratory for Underwater Systems and Technologies (LABUST) at the University of Zagreb Faculty of Electrical Engineering and Computing. He is currently involved in ESIF project HEKTOR, and previously he was involved in research in Interreg Mediterranean co-funded project BLUEMED, NATO project MORUS, and several other EU and national funded projects. His research interests include model predictive control, path and coverage planning for underwater marine vehicles, and state estimation techniques. He is the Secretary of the IEEE Oceanic Engineering Society Student Branch Chapter of the University of Zagreb.*

COMPANY PRESENTATIONS

MDM TEAM

Vincenzo Calabrò, Lorenzo Marini, MDM team, Italy

MDM Team is an Italian SME, founded in 2012 with core business focused on marine robotics. MDM Team combines several leading experts to support consultancy and designing for a large number of engineering applications, such as Design and prototyping of complex mechatronics systems, CAD design, FEM analysis, Development of mathematical models and software for real-time simulations, Homologation/certification of systems and components. MDM Team has a core team with many years of experience in prototyping of complex robotics systems, including underwater vehicle design and control (AUV/ROV), surface vehicle design and control (USV), inertial navigation systems and inertial measurement units (MRU), sensor fusion, human machine interface design, simulation of mathematical models, numerical optimization and systems architecture. The interest of MDM Team is focused on the development of proprietary platforms and the integration with third party applications and/or systems and our mission aims at delivering innovative mechatronics products and to support customer need through consultancy services and high-tech solutions.

Vincenzo Calabrò *is the chief technology officer (CTO) of MDM Team. He is a Ph.D. (class 2012 University of Pisa) in Robotics Automation and Bio-Engineering. In MDM Team he is technology roadmap responsible and follows Business development activities. Technically he leads activities on modelling, control and design of robotics systems and human interfaces. He has industrial background and international experience (Principal Engineer at Cybernetics Department in Kongsberg Maritime – Norway; Senior R&D Manager in Norwegian Subsea).*

Lorenzo Marini *is the chief executive officer (CEO) of MDM Team since 2016. He earned a Ph.D. in Industrial Engineering from University of Florence (class 2014). His background covers Vehicle Dynamics, Simulation, Mathematical Modeling and Mechanical Design. In MDM Team is the administrative responsible and follows Business development and sales activities supporting project goals definition and long terms corporate strategies. He has been the project Coordinator of ROMERO project – Robots fOr extreMe EnviROnment (GA ESMERA – GA 780265) (2020 -2022) funded by the Second Open Call of H2020 European SMEs Robotic Application.*

28.9.2022
15:30 - 18:30
Demonstration
Vincenzo Calabrò
Lorenzo Marini

BTS FRIDAY

Ocean monitoring and protection technologies and services in the Adriatic

09:00 - 09:45

Welcome and Introduction

- Mr. Nikola Mišković - Faculty of Electrical Engineering and Computing/Breaking the Surface - Vice-dean
- Mrs. Sladjana Ćosić - European Investment Bank - Head of Croatian EIB Office
- Mr. Šime Erlić - Ministry of Regional Development and EU funds - State Secretary
- Mr. Josip Bilaver - Ministry of Maritime Affairs, Transport and Infrastructure - State secretary

09:45 - 10:00
SESSION CHAIR
Mr. Nikola Mišković

Keynote Speakers

- Mr. Nikola Mišković - Faculty of Electrical Engineering and Computing/Breaking the Surface - Vice-dean
- Mrs. Sladjana Ćosić - European Investment Bank - Head of Croatian EIB Office
- Mr. Šime Erlić - Ministry of Regional Development and EU funds - State Secretary
- Mr. Josip Bilaver - Ministry of Maritime Affairs, Transport and Infrastructure - State secretary

10:00 - 10:30
SESSION CHAIR
Mrs. Antonella Calvia Goetz - EIB

Ocean Technology Funding 1/2

- Mrs. Antonella Calvia Goetz - European Investment Bank - Head of Division – Lead Advisor on Space and Ocean Technologies
- Mrs. Renata Almeida Peloso - BlueInvest and PwC Luxembourg - Manager
- Mr. Miguel Alves - European Investment Fund - Expert on Blue Investment

11:00 - 11:40
SESSION CHAIR
Mr. Miguel Alves

Ocean Technology Funding 2/2

- Mr. Ante Bobetko - Representative of Hamag-Bicro - Deputy General Manager
- Representative of Ministry of Regional Development and EU funds
- Ocean 14 - VC fund for Blue Economy
- Faber Blue Pioneers - VC fund for Blue Economy

11:40 - 12:30
SESSION CHAIR
Mr. Stephane Petti - EIB

Ocean Observation Technologies

- Mr. Mario Špadina - SeaCras - CEO
- Mr. Shep Smith - XOcean - CTO
- Mrs. Chiara Petrioli / Mr. Claudio La Torre - W-sense - CEO/CFO
- Mr. Tomislav Grubeša - Geolux - CEO
- Mr. Josip Rukavina - Vectrino - CEO
- Mr. Vladimir Djapić - H2O Robotics - CEO
- Mrs. Marija Stupalo - Salonavar - CEO
- Mr. Emanuel Rocco - Witted - CSO
- Mr. Niccolo Rubini - River cleaning - BDO

13:30 - 15:15
SESSION CHAIRS
Mr. Ivica Vilibić
Mr. Neven Cukrov
- Ruđer Bošković Institute

Public, Stakeholders, Users

- Mrs. Tina Silovic - Mercator Ocean International
- Mr. Mathieu Belbeoch - Ocean OPS, Manager
- Mr. Christian Ferrarin - CMEMS, speaker from CNR ISMAR
- Mrs. Daniela Iasillo - Planetek Italia
- Mr. Joaquín Brito - The Oceanic Platform of the Canary Islands - Director
- Mrs. Emma Reyes - SOCIB - Balearic Islands Coastal Observing and Forecasting System, Spain - Head of the HF Radar Facility

15:30 - 16:30
MODERATOR
Mr. Mateo Ivanac
- Croatian Chamber of Economy

Panel Discussion

- Mrs. Marina Dujmović Vuković - Regional development Agency Zadra Nova
- Mr. Sandro Dujmović - NP Brijuni
- Mrs. Sanja Slavica Matešić - Šibenik Knin County, temp. Head of Department
- Mr. Stipe Lukin - SeaCras, CTO
- Representative of the Italian Stakeholders

LIST OF PARTICIPANTS

Registered participants until 15th September:

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LABUST

CUST

IEEE OES IEEE Oceanic Engineering Society

Interreg Italy - Croatia InnovaMare European Regional Development Fund

EUROPEAN UNION

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