2021

26.09. - 3.10.
Biograd na Moru, Croatia

BREAKING THE SURFACE

13th 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

LABUST
Laboratory for Underwater Systems and Technologies

CUST
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 2020 IN NUMBERS

6
COUNTRIES

50
ATTENDEES (IRL)

10
LECTURES

10
PhD PRESENTATIONS

6
VEHICLES

1
SOCIAL EVENT

COMMITTEES

COMMITTEES CHAIRS

Prof. Zoran Vukić, PhD
General Chair

Assoc. Prof. Nikola Mišković, PhD
Programme Committee Chair

Ana Golec
Organizing Committee Chair

Igor Kvasić
Technical Committee Chair

PROGRAMME COMMITTEE

Prof. João Sousa; Roee Diamant; Massimo Caccia; Ralf Bachmayer; Prof. Bridget Buxton, PhD; Bill Kirkwood; Fausto Ferreira; Irena Radić Rossi

ORGANIZING COMMITTEE

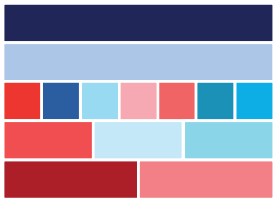
Ana Golec

TECHNICAL COMMITTEE

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

LEGEND

SESSION COLOURS



Lectures

Workshops

Tutorials

Demonstrations

Company programme

CATEGORIES

Marine Robotics (MAROB)

Maritime Archaeology (MARCH)

Marine Biology (MARBIO)

Demonstrations

Tutorials

Company Presentation

Workshops

LOCATIONS

LECTURE HALL – HOTEL ADRIATIC
All lectures and presentations, tutorials

DEMO POOL AND OPEN WATERS NEARBY
Equipment demonstrations

TUTORIALS ROOM – HOTEL ADRIATIC
Tutorials

LAVENDER BAR – HOTEL ADRIATIC
Social events

	MONDAY, 27.09.	TUESDAY, 28.09.
09:00 - 09:15	OPENING SESSION	
09:15 - 09:30	Robots for Karstic Exploration *Lionel Lapierre*	
09:30 - 09:45		
09:45 - 10:00		
10:00 - 10:15	Leveraging ocean data harvesting by heterogenous robotic organizations and autonomous vehicles as sensor carrying platforms *Asgeir J. Sørensen, E. Bremnes*	
10:15 - 10:30		Making sense of marine and maritime processes through intelligent information acquisition and sharing *Ioannis Kyriakides*
10:30 - 10:45		COFFEE BREAK
10:45 - 11:00	COFFEE BREAK	
11:00 - 11:15	Low cost does not come cheap: Working towards a low cost deep-sea autonomous observation system *Ralf Bachmayer*	Multidisciplinary applications of robotic solutions in shallow coastal environments *Fantina Madricardo, Francesca De Pascalis*
11:15 - 11:30		
11:30 - 11:45		Formal and risk-based methods for designing, testing and verifying autonomous marine control systems *Renan G. Maidana, Thomas Johansen, Tobias R. Torben, Asgeir J. Sørensen*
11:45 - 12:00	Titanic Revisited *Bridget Buxton*	
12:00 - 12:15		
12:15 - 12:30		Underwater Archaeology at BTS: A Decade of Innovation *Bridget Buxton, Jacob Sharvit*
12:30 - 12:45	Present status and achievements at the Swedish Maritime Robotics Centre SMaRC – An invitation to collaborate *Ivan Stenius*	
12:45 - 13:00		
13:00 - 14:30	LUNCH	LUNCH
14:30 - 14:45		T2 intro – AI ZEROKALIBER: Edge Computing for Maritime IoT *Ilias Alexopoulos*
14:45 - 15:00		
15:00 - 15:15	T1 intro – KTH: Using Physics-informed Learning for Nonlinear System Identification of Underwater Robots *Sriharsha Bhat, Christopher Sprague*	T3 intro - Marine Unity Simulator *Ivan Loncar*
15:15 - 15:30		
15:30 - 16:00	COMPANY DEMO H2ORobotics products *Ivo Kutlesa*	DEMO 1 PLURATO SAILFIN T1 hands-on
16:00 - 16:30		DEMO 2 Project Hektor – Korkyra *Nadir Kapetanović* T2 hands-on T3 hands-on
16:30 - 17:00		
17:00 - 17:30		
17:30 - 18:00		
18:00 - 18:30		
19:30 - 20:30	DINNER	DINNER

WEDNESDAY, 29.09.	THURSDAY, 30.10.	FRIDAY, 01.10.
Interreg Italy-Croatia Project InnovaMare	Introduction to the workshop – The challenge of data processing from marine observatories *Roee Diamant*	**Underwater Hyperspectral Imaging as a Tool for Benthic Habitat Mapping** *Aksel Alstad Mogstad*
	Introduction to the workshop – The need for standardization in marine observatories *Nuno Alexandre Cruz*	
T5 intro – ADRIATIC *Dula Nad*	**Unmanned Ocean Vehicles: Filling the Gaps in Ocean Observing** *Carlos Barrera*	**Data Driven Methods for Deriving Bathymetric Maps from Side-Scan Sonars** *John Folkesson*
	Management and processing of geophysical data from continuous monitoring onboard the ship NRP Sagres *Susana Barbosa*	
COFFEE BREAK	**Open discussion and dissemination of data**	COFFEE BREAK
Underwater Human Robot Interaction (U-HRI): An overview of the history, challenges, and methods *Andreas Birk*	COFFEE BREAK	**An ROV revolution? Using the new generation of low-cost battery powered ROVs for subsea archaeological work** *Graham Scott*
	Quality assurance for data from the THEMO marine observatory *Roee Diamant*	
Informative spatial sampling with autonomous underwater vehicles *Jo Eidsvik*	**Using AUVs for in-situ calibration of sensors onboard marine observatories** *Nuno Alexandre Cruz*	**Robotic systems in mariculture** *Nenad Antolović, Nikša Glavić*
Explorations in AI for Marine Robotics *Kanna Rajan*	**Open discussion and dissemination of data**	**Accurate qLBL acoustic positioning of multiple fast moving underwater targets in confined waters** *Konstantin Kebkal, Oleksiy Kebkal*
LUNCH	LUNCH	LUNCH
T5 intro – LSTS Toolchain: Overview and e-Infrastructure Access *Maria Costa*	**ODYSSEA: Operating a Network of Integrated Observatory Systems in the Mediterranean Sea** *Georgios Sylaios*	**T6 intro: Citizen engagement: learning by imitation in marine robotics** *CNR-INM Genova Robotics & AI team*
COMPANY PRESENTATION **HYDROMEA** *Igor Martin, Alexander Bahr*	**New Findings from the DeepLev Deepwater Marine Observatory** *Ayah Lazar*	**T7 intro – CYPRUS SUBSEA: Efficient and scalable sensor-platform integration** *Ehsan Abdi*
	THEMO – Science Discoveries from the First Three Years of Observations *Steve Dimarco*	
	Panel discussion on challenges of collaboration between marine observatories	
T4 **hands-on** / *T5* **hands-on** / *COMPANY DEMO* **Hydromea**		*DEMO 3* **Evologics** / *T6* **hands-on** / *T7* **hands-on**
DINNER	DINNER	DINNER

SOCIAL EVENTS

26.9.
SUNDAY
16:30 – 18:00
HOTEL ADRIATIC
REGISTRATION

26.9.
SUNDAY
18:00 – 19:30
LAVENDER BAR
WELCOME DRINKS

27.9.
MONDAY
FROM 20:30
DEMO POOL
IEEE OES UNIZG PARTY

28.9.
TUESDAY
FROM 20:30
LAVENDER BAR
WOMEN IN BLUE

30.9.
THURSDAY
FROM 21:00
LAVENDER BAR
BTS KARAOKE NIGHT

1.10.
FRIDAY
19:30 - 20:00
HOTEL ADRIATIC
CLOSING CEREMONY

1.10.
FRIDAY
20:00 - 21:00
HOTEL ADRIATIC
GALA DINNER

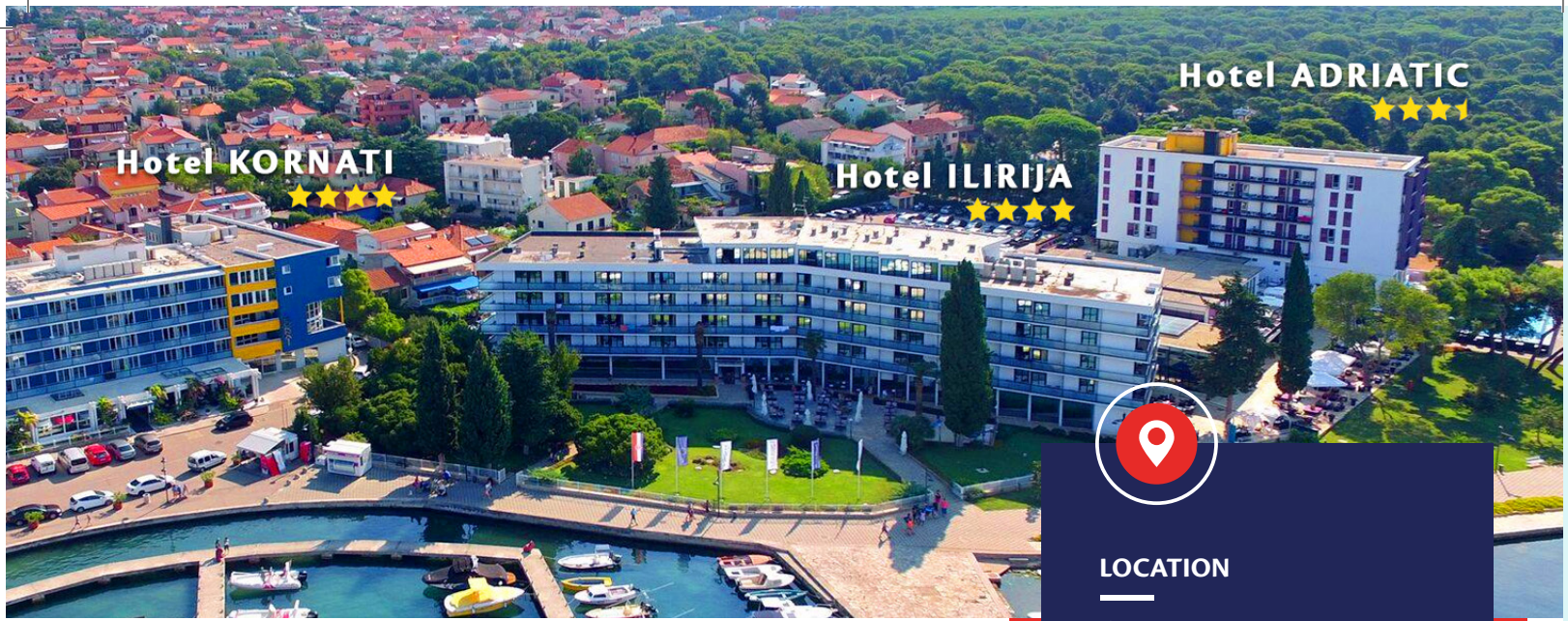
2.10.
SATURDAY
09:00 - 16:00
FIELD TRIP

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 2021 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 26th September until 3nd 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	560 €	670 €
Standard	780 €	900 €
Accompanying person	420 €	420 €
Corporate	3500 €	4000 €

LECTURES

Opening session

Nikola Mišković, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

27.9.2021
09:00-09:15
Nikola Mišković

Opening words by organizers.

Robots for Karstic Exploration

Lionel Lapierre, University of Montpellier, France

Karst generally comprises a network of underground natural conduits, resulting from the dissolution of soluble rocks, limestone, dolomite and gypsum, which may drain groundwater on a large scale. Karst aquifers, which supply drinking water to millions of people worldwide, can be seen as underground conduits corresponding to preferential groundwater flow paths. Assessing the geometry of flow paths network in karst, which constrain the dynamics of groundwater and transport processes, is an ambitious scientific objective that requires field information, which may be difficult to acquire. Cave diver is heroic, but faces obvious physiological limitations. The use of a robotic solution may induce a significant evolution, in its capacity to go further and deeper in the karst maze. This requires an interdisciplinary scientific journey where hydrogeologists, mathematicians, electronic and control scientists share the same objective. This speech proposes to present the global strategy of this scientific initiative and the latest results we have obtained.

Lionel Lapierre *obtained his PhD in 1999 in Montpellier (France) and then joined the Team of Prof. A. Pascoal in Lisbon (Portugal). He is now associate professor at LIRMM, robotic institute of University of Montpellier. His research focuses on underwater robotics. He recently opened a research initiative on Karstic Exploration, a challenging multidisciplinary action dedicated to underground water resource exploration and management.*

27.9.2021
09:15-10:00
Maritime Robotics
Lionel Lapierre

Leveraging ocean data harvesting by heterogenous robotic organizations and autonomous vehicles as sensor carrying platforms

Asgeir J. Sørensen, Jens E. Bremnes, Norwegian University of Science and Technology, Norway

Sensor carrying platforms may be stationary devices, such as landers and buoys, or mobile platforms, such as marine robotics, ships, aerial systems, and remote sensing satellites from space. The development of low-cost small satellites with customized payload sensors and accessible mission control centers has opened for a democratization of the space for remote sensing. The mapping and monitoring strategy may be carried out by each type of sensor carrying platform suitable for the mission, or by operating heterogenous autonomous sensor carrying platforms for the most efficient mapping and monitoring in spatial and temporal scales. There have been several research efforts to improve the technology and methodology by improving payload and navigation sensors, autonomy functions such as situation awareness, planning capabilities and risk handling, and not at least collaborative control across boundaries. We are facing a paradigm shift in terms of resolution and coverage capabilities. Today, we see that the mapping coverage may be 100-1000 times higher than the state-of-the-art technology six years ago. The entailed increase in data harvesting does also create new challenges in handling of big datasets. The presentation will cover various aspects to of ocean data harvesting and autonomous vehicles. Example from field operations will be shown.

*Professor **Asgeir J. Sørensen** obtained MSc degree in Marine Technology in 1988 at NTNU, and PhD degree in Engineering Cybernetics at NTNU in 1993. Since 1999 Sørensen has held the position of Professor of Marine Cybernetics at the Department of Marine Technology, NTNU. He is currently acting as key scientist and the Director of the Centre for Autonomous Marine Operations and Systems (NTNU AMOS) and NTNU VISTA CAROS. Sørensen has also worked several years for the companies ABB and Marine Cybernetics.*

***Jens E. Bremnes** received his M.Sc. degree in Marine Technology from NTNU in 2019, specialising in marine cybernetics. He is currently pursuing a Ph.D. degree in Marine Technology at NTNU. His research interests include guidance, navigation, control, and online risk-based reasoning and decision-making applied to Arctic operations of autonomous underwater vehicles.*

27.9.2021
10:00 - 10:45
Maritime Robotics
Asgeir J. Sørensen,
Jens E. Bremnes

Low cost does not come cheap: Working towards a low cost deep-sea autonomous observation system

Ralf Bachmayer, MARUM, University of Bremen, Germany

During the past five years, the development and availability of marine robotic components such as propulsion and control systems, higher energy density batteries, pressure vessels and shared and open source software solutions have led to a significant increase in affordable marine robotic systems. The quality of the available components is often referred to as prosumer grade and is quite suitable for applications within the euphotic zone of our oceans (~200m). But how does this translate into scientific applications in general and for the deeper ocean beyond the upper 200m in particular? Using our current developments towards a small deep-sea autonomous observation system, this presentation will highlight some of the main driving and limiting factors in terms scientific applicability, and how we are planning to overcome some of them. But they do not come cheap!

27.9.2021
11:00 - 11:45
Maritime Robotics
Ralf Bachmayer

Dr. Bachmayer *is Professor for Marine Environmental Technology and Deepsea Engineering as part of the Innovation Center for Deep-Sea Environmental Monitoring supported by the Werner Siemens-Foundation at MARUM – University of Bremen, Germany. His main research interests lie in the domain of marine robotics with a focus on unmanned marine systems. In particular he is interested in the design, control and networking of heterogeneous marine observation systems. He has been working in the field of underwater robotics since 1993, working on various aspects of underwater robotic systems, including identification and control of marine thrusters. For his Post-doctoral research he was conducting research on multi-vehicle applications and adaptive sampling with AUVs and underwater gliders. As an Associate Professor, he started the Autonomous Ocean Systems Laboratory (AOSL) at Memorial University of Newfoundland. There, with his research team he developed and deployed unmanned marine vehicles and systems for harsh environments. One of them an autonomous iceberg profiling system consisting of the semi-submersible USV SEADRAGON working in tandem with a hybrid underwater glider to perform autonomous iceberg profiling above and below water. Since joining the University of Bremen's Center for Marine Environmental Sciences (MARUM) and Department of Computer Science and Mathematics he holds the Professorship in Marine Environmental Technology/ Deep-Sea Engineering where his research group is currently developing a new generation of AUVs for minimally invasive seafloor exploration.*

Titanic Revisited

Bridget Buxton, University of Rhode Island, USA

In July and August of 2021, Washington-based company OceanGate Expeditions made multiple dives to the wreck of RMS Titanic in the North Atlantic with its prototype Titan 5-person submersible. The expedition was the culmination of six years of planning and technological development of the light-weight five-person sub. Titan has a revolutionary carbon fiber and titanium hull and portable deployment system that enables it to dive up to 4000m anywhere in the world without the need for a dedicated support vessel, dramatically cutting the cost and logistical challenges of manned deep sea exploration. By completing a season of successful scientific dives and archaeological exploration of the Titanic, the "Mount Everest" of deep sea shipwrecks, OceanGate has achieved proof-of-concept for a vehicle and business model that will further open up civilian access to the deep oceans. This lecture reports on the 2021 mission from a marine researcher's perspective and offers thoughts on how ocean scientists and technologists can respond to the new opportunities created by this transformative model of manned deep ocean exploration.

27.9.2021
11:45 - 12:30
Maritime 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.*

Present status and achievements at the Swedish Maritime Robotics Centre SMaRC – An invitation to collaborate

Ivan Stenius, Royal Institute of Technology (KTH), Sweden

SMaRC brings together key industrial and academic partners in an internationally unique collaborative environment. The vision is to demonstrate and enable technology transformation towards the next generation of maritime robots, that are able to operate in unknown environments for longer times and with less need for human intervention than what is currently possible. Focus is on four research areas, autonomy, endurance, perception, and underwater communication. Within these research areas, we will be working cross-disciplinary to develop a number of capabilities to address the future challenges.

SMaRC has already made some ground-breaking achievements by e.g. participating in the first ever under Twaites glacier expedition (Antarctica), and developing novel ways of combining machine learning and side-scan sonars to collect accurate bathymetry. SMaRC has built and performed sea-trials of two completely new AUV platforms. One with capacity to carry large sensor suites, battery packs, pay-loads and even drop objects, and one which is small, compact and agile with a fully integrated ROS-based software architecture and behaviour three mission execution structure for improved robustness and easy implementation and testing. SMaRC has developed and synthesised an open-source mission planning & simulation environment. The simulation environment is fully ROS compatible and is a digital twin of the ROS-based software architecture. Further, completely new "5-G" directive communication strategies for underwater communication are being developed and a prototype sensor is under testing. SMaRC has also developed and tested a small-scale modular DVL. Finally, a number of test sites around in Sweden are accessible for demonstrations and experiments (e.g. smarc algea-farm test site).

27.9.2021
12:30 - 13:15
Maritime Robotics
Ivan Stenius

Ivan Stenius *received his MSc in Lightweight structures from the Royal Institute of Technology (KTH) in 2003. He received a Technical licentiate from KTH, Lightweight structures, in 2007 and PhD in Technology KTH, Lightweight Structures on hydroelasticity and fluid structure interactions on high-speed craft in 2009. He is currently a full-time associate professor at the Department of Engineering Mechanics at KTH. He has expertise in underwater vehicles modelling design and construction, as well as manoeuvring and navigation. He has been the lead developer of design and analysis software tools in collaboration with FMV and the Swedish Coast Guard. 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 on computer vision and perception, applied electrochemistry, and networked control at KTH. In the recent years, he has been heavily involved in building up a research group in underwater technology and 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.*

Whaling in the European Arctic 1600-1900 – technological innovation and adaptation

Øyvind Ødegård, Norwegian University of Science and Technology, Norway

This talk will give a brief overview of the technological developments that characterize the first European oil age – Arctic whaling in the period 1600-1900. From coastal land-based activities in the beginning, whaling ships soon had to move offshore and operate in the ice. This transition led to technological adaptation and innovation to mitigate risk and ensure effective production. Our current understanding of this development is mainly based on contemporary written accounts and a few archaeological investigations on Svalbard. Several hundred shipwrecks from this period rests on the seabed, potentially holding answers to all the numerous questions that could fill the gaps in our knowledge of this important part of European history. So far, only a few marine archaeological efforts have been made to locate and investigate this underwater cultural heritage. The talk will present some of these efforts and demonstrate how underwater robotics are essential for such work in the high Arctic.

28.9.2021
09:00 - 09:45
Maritime Archeology
Øyvind Ødegård

Øyvind Ødegård *received his cand. philol. degree in Archaeology in 2002 with a thesis on symbolic aspects in Viking age and medieval ship building in Northern Europe. Since 2003 he has held a position as marine archaeologist at NTNU University Museum, working with underwater cultural heritage management in Norwegian territorial waters. He has led numerous marine archaeological projects, both diver and robot based. From 2007 to 2013 he was GIS manager at the same institution, working with the transition from analog to digital data recording in archaeological field projects. Since 2011 he has been a board member of NTNU's Applied Underwater Robotics laboratory (AUR-Lab) and has been principal scientist for archaeology at many of AUR-Lab's multidisciplinary research cruises. In 2018 he received his PhD in marine technology at NTNU and has since been affiliated with the Centre for Autonomous Marine Operations and Systems (NTNU AMOS). He currently holds a position as a senior researcher at the University Museum's department of Archaeology and Cultural history, tasked with building a research group in the intersection between marine archaeology and underwater robotics.*

Making sense of marine and maritime processes through intelligent information acquisition and sharing

Ioannis Kyriakides, University of Nicosia, Cyprus

Protecting the marine environment and promoting social and economic progress requires understanding the complex interactions between marine and maritime processes. Due to limited sensing, processing, communications, and power resources the required level of understanding can only be reached through agile information acquisition and information sharing. This talk describes two research and innovation projects that support environmental, social, and economic sustainability via intelligent data acquisition and information sharing and environmentally sustainable food production. The first is the MARI-Sense project that develops intelligent open-access decision support systems that enable human operators to make sense of the complex marine and maritime environment and optimally plan activities. The MARI-Sense project will drive the development of disruptive solutions in maritime IoT, classification and sequential estimation software, optimization and swarm intelligence methods, and a visualization pipeline. The second is the OS Aqua project that will provide a roadmap for establishing an Open Sea Aquacultural Industry in the Eastern Mediterranean. OS Aqua will significantly increase food production while minimizing impact on the natural environment. OS Aqua will define maritime zones, design facilities, automatization and monitoring systems, and conduct a financial sustainability study. The talk will also include an overview of work done at the Maritime Digitalization Center of the Cyprus Marine and Maritime Institute.

28.9.2021
09:45 - 10:30
Maritime Robotics
Ioannis Kyriakides

Dr. Ioannis Kyriakides *received his B.S. degree in Electrical Engineering from Texas A&M University. He received his M.S. and Ph.D. degrees from Arizona State University. He held a research associate position throughout his graduate studies, funded by the Integrated Sensing and Processing program and the Multidisciplinary University Research Initiative of the USA Department of Defence. In the final year of his Ph.D. work, he received the University Graduate Fellowship of the Arizona State University. His research interests include Bayesian target tracking, sequential Monte Carlo methods, and cognitive fusion for heterogeneous data fusion and heterogeneous sensing node configuration. His research work includes localization of multiple RF sources, tracking surface vehicles using passive acoustic sensing, tracking multiple targets with constraints in motion, tracking multiple targets using heterogeneous cognitive sensors. Dr. Kyriakides is currently an Associate Professor at the Engineering Department at the University of Nicosia, a Senior Scientist at the Maritime Digitalization Center of the Cyprus Marine and Maritime Institute, and the CEO of Cognitive Fusion Systems. He was the PI for projects with total budget of over € 2 M.*

Multidisciplinary applications of robotic solutions in shallow coastal environments

Francesca De Pascalis, Fantina Madricardo, CNR-ISMAR, Italy

Coastal and transitional environments are highly populated and are valuable areas, which provide crucial ecosystem services. Particularly, lagoons are very dynamic areas where physical and biogeochemical characteristics can lead to challenges for innovative robotic and technological solutions. The management of these areas calls for a deeper understanding of their functioning also in view of climate change and relative sea-level rise. In this contribution, we illustrate different possible applications where the implementation of robotic solutions equipped with cutting-edge technology could radically improve the monitoring approaches to support an ecosystem-based management of the shallow coastal environments. As a case study we will focus on the Venice Lagoon, the largest lagoon in the Mediterranean, surrounding the historical city of Venice, Italy. We will present different applications of robotic solutions that, together with the collection of in-situ samples, can be applied to: a) monitor the geomorphological evolution of highly dynamic areas and sediment transport, b) map and monitor the seafloor habitats; c) highlight the presence of marine litter hotspots and possible removal actions; e) preserve the submerged archaeological heritage; and f) inspect coastal infrastructures. The aim of the talk is to highlight the required technological innovations to fulfil the monitoring/intervention needs of shallow coastal environments and the challenges that can be encountered by robotic solutions in these environments. The research on this topic is carried out by CNR-ISMAR (Venice, Bologna, La Spezia) in cooperation with CNR-INM Genova.

PhD Francesca De Pascalis, *researcher at CNR-ISMAR since 2004, master degree and PhD in environmental sciences. The main scientific interests are focused on hydrodynamic modelling, hydrodynamical processes in the coastal environments and studies of anthropic and natural impacts on lagoons and coastal areas. New interests are in areas of marine litter dispersal processes and innovative applications for studies in coastal environments. She is the coordinator of the Interreg Italy-Croatia INNOVAMARE (https://www.italy-croatia.eu/web/innovamare) . She is one of the Italian ambassadors of the IOI-International Ocean Institute and involved in the construction of the ESFRI DANUBIUS Research Infrastructure (https://www.danubius-ri.eu/).*

Fantina Madricardo*, laurea (equivalent of MSc) in Physics (1999) University of Padova, PhD in Physics (2002), University of Hamburg, Germany, Post-Doc position (2008) at the Université Pierre et Marie Curie, Paris, France. She is staff member researcher at ISMAR since 2012. Her main research topics are applied geophysics and underwater acoustics, focussing on seafloor mapping and geomorphology, and, more recently passive acoustics. She interested in development of methods for semi-automatic*

28.9.2021
10:45 - 11:30
Marine Biology
Francesca De Pascalis, Fantina Madricardo

classification of multibeam echosounder data for seabed sediment characterization, benthic habitat mapping and seafloor marine litter mapping, geomorphometric analysis of seafloor morphologies and anthropogenic physical change. Within the national research project RITMARE, she coordinated an extensive multibeam survey in the very shallow waters of the Venice Lagoon obtaining extremely high resolution seafloor data. She was the coordinator of the EASME/EMFF marGnet project (www.margnet.eu) and she is currently the project coordinator of the H2020 MAELSTROM (www.maelstrom-h2020.eu) focusing on new technologies to face the marine litter issue. She coordinates for CNR-ISMAR the Italy-Croatia Interreg Project SOUNDSCAPE (https://www.italy-croatia.eu/web/soundscape) and she is involved in the H2020 SATURN (https://www.saturnh2020.eu/) focussing on the undewater noise issue. She is also involved in the projects H2020 ENDURUNS (https://enduruns.eu/) and 4S (https://cordis.europa.eu/project/id/101004221) and in the Interreg Italy-Croatia INNOVAMARE developing robotic solutions for the marine environment observation.

Formal and risk-based methods for designing, testing and verifying autonomous marine control systems

Renan G. Maidana, Thomas Johansen, Tobias R. Torben, Asgeir J. Sørensen, Norwegian University of Science and Technology, Norway

This presentation will discuss recent research performed at NTNU on formal and risk-based methods applied to autonomous marine systems, introduced by prof. Asgeir J. Sørensen. Thomas will present his work on risk-based control for autonomous surface ships. The work is based on an extended System Theoretic Process Analysis (STPA) that is used to build a Bayesian Belief Network (BBN) risk model. The risk model is used in a supervisory risk controller to set high-level control objectives for the ship control system. Tobias will present his PhD work on using formal methods to design and verify autonomous surface ships. This includes an automated method for simulation-based verification using Signal Temporal Logic and Gaussian Processes and early-stage work on using formal contracts to design modular and verifiable autonomous systems. Renan will present his work on decision-making in Autonomous Marine Vehicles (AMV) based on dynamic risk assessment. A Dynamic Probabilistic Risk Assessment (DPRA) framework was conceived, which uses component-based simulation to identify and quantify all possible accident scenarios in AMV operation. The output from DPRA will then be used for autonomous decision-making – e.g., modifying existing plans to avoid hazardous events.

Renan G. Maidana *received his M.Sc. degree in Computer Science in 2018, with emphasis in mobile robotics. He is currently a PhD student in Marine Technology at NTNU. His research interests include simulation-based risk assessment (i.e., dynamic risk assessment), risk-aware hybrid control, and automated planning, with applications to autonomous surface vessels.*

Tobias R. Torben *received his M.Sc. degree in Marine Technology in 2019, specializing in marine cybernetics. He is currently pursuing a PhD in Marine Technology. His research interests include simulation-based verification, formal methods and risk-aware control design, with applications to autonomous surface vessels.*

Thomas Johansen *received his M.Sc. degree in Marine Technology in 2019, specializing in marine cybernetics. He is currently pursuing a PhD in Marine Technology. His research interests include risk based decision-making, and risk-aware control design, with applications to autonomous surface vessels.*

Professor ***Asgeir J. Sørensen*** *obtained MSc degree in Marine Technology in 1988 at NTNU, and PhD degree in Engineering Cybernetics at NTNU in 1993. Since 1999 Sørensen has held the position of Professor of Marine Cybernetics at the Department of Marine Technology, NTNU. He is currently acting as key scientist and the Director of the Centre for Autonomous Marine Operations and Systems (NTNU AMOS) and NTNU VISTA CAROS. Sørensen has also worked several years for the companies ABB and Marine Cybernetics.*

28.9.2021
11:30 - 12:15
Maritime Robotics
Renan G. Maidana,
Tobias R. Torben,
Thomas Johansen,
Asgeir J. Sørensen

Underwater Archaeology at BTS: A Decade of Innovation

Jacob Sharvit, Israel Antiquities Authority, Israel, **Bridget Buxton,** University of Rhode Island, USA

After the hiatus imposed by Covid-19, underwater archaeologists are returning to the world's oceans to pursue new research questions in ever-more challenging environments: logistical, environmental, and economic. Now more than ever, advancement in the frontiers of underwater archaeology will depend upon creating successful multidisciplinary partnerships with scientists and ocean engineers to develop unique responses to each challenge. International workshops such as BTS provide one of the few structured forums currently available to create such non-commercial research partnerships outside traditional home university and national networks. This update provides a summary and retrospect on the authors' field projects that were made possible or at least greatly facilitated by technological developments and partnerships forged through BTS over the past decade. The focus is, however, on the decade ahead: the oceanographic tools for archaeological expeditions currently in development, and the new opportunities these plans represent for technological innovation and the marine sciences.

Jacob Sharvit's *work is focused on underwater archaeology excavations and surveys along the Mediterranean coast of Israel and Sea of Galili, Red-Sea. He is also doing Underwater Archaeology research on the Akko harbor and Caesarea Herods harbor for tsunami evidence.*

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.*

28.9.2021
12:15 - 13:00
Maritime Archeology
Jacob Sharvit,
Bridget Buxton

Interreg Italy-Croatia Project InnovaMare

29.9.2021
09:00 - 09:45

The Interreg Italy-Croatia InnovaMare project aims to enhance collaboration on technology transfer by creating an innovative network for underwater robotics and sensors in the Adriatic region. In this talk, a general overview of the project will be presented by Mateo Ivanac from the Croatian Chamber of Economy (Lead Partner). Then, the use cases, target groups and tasks that can be tackled with the underwater robots and sensors being developed will be introduced. The preliminary design of several of these solutions will be presented by Angelo Odetti (National Research Council – Institute of Marine Engineering) and Fausto Ferreira (Faculty of Electrical Engineering and Computing, University of Zagreb).

Underwater Human Robot Interaction (U-HRI): An overview of the history, challenges, and methods

Andreas Birk, Jacobs University Bremen, Germany

Underwater robotics requires very reliable and safe operations. This holds especially for missions in cooperation with divers who are – despite the significant advancements of marine robotics in recent years – still essential for many underwater operations. Possible application cases of underwater human-robot collaboration include marine science, archeology, oil- and gas production (OGP), handling of unexploded ordnance (UXO), e.g., from WWII ammunition dumped in the seas, or inspection and maintenance of marine infrastructure like pipelines, harbors, or renewable energy installations – to name just a few examples. There is accordingly research in Underwater Human Robot Interaction (U-HRI) since many years. A survey of the different research activities in this field is presented that gives an overview of the history, challenges, and methods in this area.

29.9.2021
10:45 - 11:30
Maritime Robotics
Andreas Birk

Andreas Birk *is since Nov. 2011 a full professor in Electrical Engineering and Computer Science at Jacobs University Bremen where he leads the robotics group. He started at Jacobs University in fall 2001 as associate professor while rejecting an offer for a professorship (C3) at the University of Rostock. Before he joined Jacobs University, he held a research-mandate of the Flemish Society for Applied Research, IWT. He was in addition from October 1997 on appointed as visiting professor (docent) at the Vrije Universiteit Brussel (VUB). He also worked as a visiting professor (C3) at the Universitat Koblenz-Landau in the winter-semester of 1999/2000. During the almost six years at the VUB, Andreas Birk was a member of the Artificial Intelligence Lab, which he joined as Postdoc in April 1996. In 1995 he received his doctorate from the Universitat des Saarlandes, Saarbrucken, where he previously studied Computer Science from fall 1989 to spring 1993.*

Informative spatial sampling with autonomous underwater vehicles

Jo Eidsvik, Norwegian University of Science and Technology, Norway

To understand complex spatio-temporal phenomena in our ocean, there have recently been increased efforts in using numerical process modeling, methods for data assimilation, novel computing and sensor technology. Autonomous robots such as AUVs with onboard computing resources provide rich opportunities for oceanographic sampling, and fill in the gap by adjusting ocean models with in-situ observations. Ideas from statistical sampling design are highly useful in this field, because they enable coherent data assimilation and can help guide AUVs to informative spatial locations. We present approaches of AUV sampling in coastal ocean domains, using a Gaussian process proxy model onboard the AUV. This model can be trained from numerical ocean models, and the Gaussian process is easy to update with in-situ data over the AUV sampling time. With the limited time and resources, we build on the onboard proxy model to develop adaptive sampling design algorithms that enable effective AUV exploration of the ocean domain of interest. Common design criteria here include variance reduction and entropy-based sampling. We further suggest more targeted criteria aiming to find hotspots or map excursion sets where the variables are above a threshold. Such criteria relate the sampling efforts to value of information or active learning approaches. We illustrate these approaches on various real-world experiment example cases. We show how the AUV track the maximum concentration depth within a phytoplankton volume. Another case illustrates river plumes characterisation, where the goal is to use the AUV to explore the boundary between fresh water and the saline ocean water. Yet another application shows mine tailings monitoring efforts using informed AUV sampling. Kanna Rajan will give a connected presentation following this one.

29.9.2021
11:30-12:15
Maritime Robotics
Jo Eidsvik

Jo Eidsvik *is Professor of Statistics at the Norwegian University of Science and Technology, Trondheim, Norway. His research interests are spatio-temporal statistics, computational statistics and experimental sampling designs. He works mainly on Earth sciences applications. Eidsvik has co-authored the book on 'Value of Information in the Earth Sciences', Cambridge University Press, 2015. Eidsvik is associate editor of Statistics and Computing and Mathematical Geosciences. He leads the research project Marine Autonomous Sampling and Control, where the goal is to develop methods and algorithms for effective AUV sampling of river plumes and ocean fronts. He is Research Director of the Centre for Geophysical Forecasting at the Norwegian University of Science and Technology.*

29th SEP
Wed

Explorations in AI for Marine Robotics

Kanna Rajan, SIFT LLC & University of Porto, Portugal

Ocean Sciences the world over is at a cusp, with a move from the Expeditionary to the Observatory mode of doing science. With the advent of ocean observatories, a number of key technologies have proven to be promising for sustained ocean presence — Robotics and AI are some of these. In this context robots will need to be contextually aware and respond rapidly to evolving phenomenon, especially in dynamic waters due to the diversity of atmospheric, oceanographic and land-sea interactions. They will need to respond by exhibiting scientific opportunism while being aware of their own limitations in the harsh oceanic environment. We have designed, built, tested and deployed deliberative techniques to dynamically command autonomous underwater vehicles (AUVs) with deep roots in work to command and control deep space probes for NASA. Our effort is aimed to use a blend of generative and deliberative Artificial Intelligence Planning and Execution techniques to shed goals, introspectively analyze onboard resources and recover from failures. In addition we are working on Machine Learning techniques to adaptively trigger science instruments that will contextually sample the seas driven by scientific intent. The end goal is towards unstructured exploration of the subsea environments that are a rich trove of problems for autonomous systems. This work is a continuum of efforts from research at NASA to command deep space probes and Mars rovers, the lessons of which we have factored into the oceanic domain.

29.9.2021
12:15 - 13:00
Maritime Robotics
Kanna Rajan

Kanna Rajan *is a Fellow at SIFT, LLC a small think tank working on AI related projects for the US Department of Defense. He is also a Visiting Professor, Faculty of Engineering, University of Porto. He was the Principal Researcher in Autonomy at the Monterey Bay Aquarium Research Institute. He spent 10 years at NASA as a Senior Research Scientist and his software flew on 2 deep space missions, including on the surface of Mars. He is also the Co-Founder of a Cybersecurity startup in California's Silicon Valley. Kanna's focus is on the use of decision-theoretic AI techniques to enable maritime robots sample the oceans intelligently. This is to ensure that robotic vehicles, with no human control, can make the 'right measurements at the right places at the right time' in the upper water-column. He will be a Fulbright Scholar in Spring 2022 in Portugal.*

Introduction to the workshop – The challenge of data processing from marine observatories

Roee Diamant, University of Haifa, Israel

30.9.2021
09:00 - 09:15
Workshop
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. Dr. 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 Assist. Prof. at the Dept. of Marine Technologies, University of Haifa. His research interests include underwater acoustic communication, underwater navigation, object detection, and classification.*

Introduction to the workshop – The need for standardization in marine observatories

Nuno Alexandre Cruz, INESC TEC, Portugal

30.9.2021
09:15 - 09:30
Workshop
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 Research 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. He has actively participated in numerous R&D projects, both national and international, and 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.

Unmanned Ocean Vehicles: Filling the Gaps in Ocean Observing

Carlos Barrera, PLOCAN, Spain

30.9.2021
09:30 - 10:00
Workshop
Carlos Barrera

Management and processing of geophysical data from continuous monitoring onboard the ship NRP Sagres

Susana Barbosa, INESC TEC, Portugal

The marine boundary layer pays a key role in the Earth's climate. However, current knowledge on marine boundary layer processes is still very incomplete, partly due to the lack of observations over the ocean, resulting from the difficulty of performing in-situ marine measurements. Project SAIL (Space-Atmosphere-Ocean Interactions in the marine boundary Layer) aimed to improve understanding on the marine boundary layer through a monitoring campaign onboard the tall ship NRP Sagres. The campaign focused on the measurement of the Earth's atmospheric electric field, a key parameter of the Earth system, influencing not only climate and atmospheric properties, but also the human activities which depend on the state of the upper atmosphere and ionosphere, such as satellite navigation and communication systems. Despite its relevance, oceanic measurements of the atmospheric electric field are scarce since typically oceanic measurements tend to be focused on ocean properties rather than on the atmosphere above. In addition to the electrical properties of the atmosphere, the SAIL campaign included detailed monitoring of GNSS signals, solar and cosmic radiation, environmental radioactivity and atmospheric ionisation. The atmospheric measurements were complemented by underwater monitoring of the ocean state (temperature, conductivity, dissolved oxygen, pH, spectral radiance) using a tow-fish. All the observations, in air as well as underwater, were linked to the

same rigorous temporal reference frame and precise positioning through kinematic GNSS observations. This presentation addresses the management and processing of the data acquired in the SAIL campaign, focusing on data management and quality-control activities up to data publication and distribution.

Susana Barbosa *is a senior researcher at INESC TEC (Porto, Portugal) working at the interface of data science, earth observation, and robotics. Her research is highly interdisciplinary crossing the domains of data science and earth system science, particularly time series analysis of environmental data. Her current research interests focus on the use of ambient radioactivity for the study of space-atmosphere-ocean interactions.*

30.9.2021
10:00 - 10:30
Workshop
Susana Barbosa

Open discussion on dissemination of data

30.9.2021
10:30 - 10:45
12:15 - 12:30
Workshop

Quality assurance for data from the THEMO marine observatory

Roee Diamant, University of Haifa, Israel

Measuring and forecasting changes in coastal and deep-water ecosystems and climates requires sustained long-term measurements from marine observation systems. One of the key considerations in analyzing data from marine observatories is quality assurance (QA). The data acquired by these infrastructures accumulates into Giga and Tera bytes per year, necessitating an accurate automatic identification of false samples. A particular challenge in the QA of oceanographic datasets is the avoidance of disqualification of data samples that, while appearing as outliers, actually represent real short-term phenomena, that are of importance. In this talk, we show case a novel cross-sensor QA approach that validates the disqualification decision of a data sample from an examined dataset by comparing it to samples from related datasets. This group of related datasets is chosen so as to reflect upon the same oceanographic phenomena enable some prediction of the examined dataset. In our approach, a disqualification is validated if the detected anomaly is present only in the examined dataset, but not in its related datasets. Results for a surface water temperature dataset recorded by our Texas A&M – Haifa Eastern Mediterranean Marine Observatory (THEMO) over a period of 7 months, show an improved trade off between accurate and false disqualification rates when compared to two standard benchmark schemes.

30.9.2021
11:15 -11:45
Workshop
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. Dr. 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 Assist. Prof. at the Dept. of Marine Technologies, University of Haifa. His research interests include underwater acoustic communication, underwater navigation, object detection, and classification.*

Using AUVs for in-situ calibration of sensors onboard marine observatories

Nuno Alexandre Cruz, INESC TEC, Portugal

Quality assurance is one of the most important challenges of marine observatories. Data acquired around the globe are used to derive conclusions about climate changes, marine biodiversity, and general ocean health. This has a tremendous impact on public opinion, drives legislation and ultimately affects the life of a significant fraction of the worlds' population. Most sensors used in long-term deployments require periodic calibration according to an estimated use pattern indicated by the manufacturer. The calibration process impacts the availability of data and may have significant operational costs, particularly in remotely located observatories. Is this presentation, we will discuss the possibility of using external sensors mounted on an autonomous underwater vehicles to estimate the sensors' calibration parameters, by comparing the long-term behavior of their outputs. To verify the calibration of sensors deployed in deep seas, autonomous vehicles can be programmed to approach the observatory and stay in a close vicinity of the sensor. This requires the implementation of state estimation enabling precise localization and positioning, as well as novel guidance and control techniques that mitigate any bias/contamination set by the vehicle; for example, the use of hovering to avoid turbulence, and motor silencing to avoid the influence of cavitation on salinity and temperature.

30.9.2021
11:45 - 12:15
Workshop
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 Research 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. He has actively participated in numerous R&D projects, both national and international, and 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*

ODYSSEA: Operating a Network of Integrated Observatory Systems in the Mediterranean Sea

Georgios Sylaios, Democritus University of Thrace (DUTH), Greece

ODYSSEA is a user-centred project aiming to make Mediterranean marine data easily accessible and operational to multiple end-users, by harmonizing existing Earth Observing systems; upgrading operational oceanographic capacities; supporting EU policy implementation; improving interoperability in monitoring; fostering blue growth jobs creation, and opening participation to non-EU member states. ODYSSEA is a system bridging the gap between operational oceanography capacities and the need for information on marine conditions from the community of end-users. ODYSSEA's ambition is to develop an interoperable, fully-integrated and cost-effective multiplatform network of observing and forecasting systems across the Mediterranean basin. ODYSSEA will integrate information obtained from existing observation platforms and databases in the Mediterranean Sea, held by hundreds of institutions, towards a more systematic, unifying, cost-effective and user-driven system. While a key role of ODYSSEA is to manage primary measurements and data, many end-users, such as industry end-users and policy makers, are interested in higher-level, on-demand data and information products that are derived from measurements rather than the measurements themselves. Both primary data and on-demand derived data services will be made available and accessible through a single command and via a single public portal.

30.9.2021
14:30 - 15:00
Workshop
Georgios Sylaioss

Georgios Sylaios *is a Full Professor at the Democritus University of Thrace (DUTH), Department of Environmental Engineering, Xanthi, Greece. He was the Department Chair in the period 2014-2016. At present he is the Head of the Laboratory of Ecological Engineering and Technology. He is physical oceanographer by training, with long experience in the coordination of European and nationally-funded research projects. Overall, he has coordinated 34 research projects with a total budget DUTH of 4.8 MEuros. Currently he is the coordinator of the Blue Growth research project entitled ODYSSEA, funded by Horizon 2020 with a budget of 8.4 MEuros. His publication list includes 261 scientific publications, 80 of which are published in peer-reviewed international journals, 76 in peer-reviewed international proceedings, 51 in national proceedings, 42 technical reports, 1 e-book, 9 book chapters and 4 special issues as Guest Editor. His works have received 1,200 citations (h-index 19). Sylaios research interest lie in the field of environmental monitoring and operational modeling in coastal aquatic systems; hydrography and biogeochemistry of marine systems; hydrology and nutrients management of streams and rivers (mostly heavily modified); precision irrigation and water saving technologies at farm scale; numerical models nesting, coupling and predictive operation; artificial intelligence, machine learning and neuro-fuzzy modeling.*

30th SEP
Thu

New Findings from the DeepLev Deepwater Marine Observatory

Ayah Lazar, Israel Oceanographic & Limnological Research (IOLR), Israel

30.9.2021
15:00 - 15:30
Workshop
Ayah Lazar

THEMO – Science Discoveries from the First Three Years of Observations

Steve Dimarco, Texas A&M University, USA

30.9.2021
15:30 - 16:00
Workshop
Steve Dimarco

Panel discussion on challenges of collaboration between marine observatories

30.9.2021
16:00 - 16:15
Workshop

Underwater Hyperspectral Imaging as a Tool for Benthic Habitat Mapping

Aksel Alstad Mogstad, Centre for Autonomous Marine Operations and Systems (NTNU AMOS), Norway

Underwater hyperspectral imaging (UHI) represents a relatively new seafloor mapping technique. As opposed to conventional digital cameras, which render colors using a red (R), a green (G) and a blue (B) waveband within the visible light spectrum, hyperspectral imagers quantify colors as contiguous spectra. This provides a substantially improved foundation for color-based identification and mapping of biogeochemical seafloor targets. In this presentation, it is demonstrated that a considerable biological color diversity can be found among benthic organisms. It is also shown that this diversity not necessarily is well represented in RGB imagery. Through a series of examples, it is further demonstrated that underwater hyperspectral imagers can be deployed on a range of sensor-carrying platforms, all of which have associated benefits and limitations. Although the focus of the presentation is on marine biological applications, the presented work also features an archaeological case study. This example illustrates that UHI may be used interdisciplinarily, with actors from multiple scientific fields involved. Ultimately, the potential role of UHI in future marine research is discussed in context with other currently employed seafloor mapping techniques.

Aksel Alstad Mogstad *received the M.Sc. degree in marine biology from the Norwegian University of Science and Technology (NTNU), Trondheim, Norway, in 2017. He recently finished a Ph.D. at the Centre for Autonomous Marine Operations and Systems (NTNU AMOS), Trondheim, Norway, researching marine biological applications of underwater hyperspectral imaging.*

1.10.2021
09:00 - 09:45
Marine Biology
Aksel Alstad Mogstad

Data Driven Methods for Deriving Bathymetric Maps from Side-Scan Sonars

John Folkesson, KTH Royal Institute of Technology, Sweden

Accurate higher resolution bathymetric mapping currently requires multibeam echo sounders, MBES, and excellent navigation. Therefore it is carried out by ships or large AUVs. A hand launched AUVs can not carry the type of MBES needed but they can carry rather good quality sidescan sonars. The challenge is to then extract the missing spatial information from the sidescan signal which gives the intensity, in a 'plane' and at a range from the sonar. Furthermore, thenavigation accuracy of a small AUV will be far worse than from a surface vessel. We propose to use data driven methods and simultaneous localization and mapping, SLAM, to address these issues. We will show the progress we have made towards the goal of accuate mapping by teams of smaller AUVs.

John Folkesson *Is an Associate Professor at KTH, Royal Instutute of Technology, in Stockholm, Sweden. He has been at KTH since 2010. From 2006 to 2010, he was a research engineer at Massachusetts Institute of Technology in USA. He has a PhD in Robotics from KTH in 2006. His research is on simultaneous localization and mapping, navigation, and perception for robots.*

1.10.2021
09:45-10:30
Maritime Robotics
John Folkesson

An ROV revolution? Using the new generation of low-cost battery powered ROVs for subsea archaeological work

Graham Scott, Wessex Archaeology, UK

A new type of very low-cost remotely operated vehicle (ROV) has been introduced in the last few years, benefitting from advances in drone and battery technology. Substituting high capacity LIPO batteries for surface power whilst still retaining useful performance, these subsea vehicles are easy to deploy, pilot and maintain. For their size and cost they offer impressive inspection and survey capabilities, including photogrammetry, imaging sonar and acoustic positioning, at a fraction of the cost of similar small ROVs of more traditional design. They also offer opportunities to carry out survey at deeper depths, more efficiently and with less risk than deploying archaeologist divers. Furthermore, imminent advances in low-latency satellite broadband services may enable remote participation in subsea archaeological survey work carried out by these vehicles, as well as facilitating new forms of live client and public engagement. Using examples of subsea archaeological survey linked to heritage protection carried out in the last three years for UK public bodies Historic England and Historic Environment Scotland, including surveys of a Spanish post-medieval wreck site and a 19th century clipper, this paper will explore the pros and cons of using a 100m depth rated ROV of this type for archaeological work and the opportunities that could be developed from it. It will also consider whether the future relationship between the use of divers and the use of ROVs for subsea archaeology generally will echo the way in which these respective capabilities have been developed in other marine sectors, such as oil and gas and offshore wind/renewables.

1.10.2021
10:45-11:30
Maritime Archaeology
Graham Scott

Graham Scott *is the Subsea Superintendent for Wessex Archaeology, one of the UK's major archaeological contractors and a heritage charity. With a background in both terrestrial archaeology and oil and gas industry diving, Graham is one of the most experienced marine archaeologists currently working in the UK, specialising in post-medieval and modern historic ship and aircraft wrecks. The wrecks he has worked on range from 16th and 17th century warships and merchant ships to 20th century battleships, submarines and bombers, many of which are amongst the most important marine archaeological sites in the UK. Leading both diving and remotely operated vehicle (ROV) operations, Graham has helped pioneer the introduction of a number of key cost-saving technologies to marine archaeological work in the UK, including acoustic tracking, imaging sonar and photogrammetry. Graham has also been responsible for the introduction and development of Wessex Archaeology's current in-house ROV capabilities.*

Robotic systems in mariculture

Nenad Antolović, Nikša Glavić, University of Dubrovnik, Institute for marine and coastal research, Croatia

Robotics has gained both high popularity and interest in solving multiple problems in recent years. Though single task robots have served humanity for some time, an idea of multiple heterogenous robots working together is only gaining momentum, and project Hektor is exploitinig such a possibility. Since the robotic system is intended to work on mariculture fish production cage, several tasks were devised to complement the system in real time operations. On underwater robot (ROV) a multi-parameter water quality logger probe will be mounted, which will be able to measure water parameters near-or within cage net, and thus determine throughput of water to andfrom the cage. We will be able to determine water exchange within the netted cage. Further, camera system will capture photo and video material of cage net and fish within the cage. That photo and video material shall be analysed with software (Lolitrack, Loligo systems, Denmark) and several parameters of net, such as the free area, biofouling intensity can be quantitized. Also, the free swimming fish can be analyzed in terms of population measure (the number of the fish, average size, possible skin colour change indicating health hazards) that can help us to determine the state of fish population in the cage. In adition to this, our divers shall photodocument, both in photo and video material, the working of robotic system in real time. This will aid to management and adjustments of parameters of heterogenous robotic system. The role of University of Dubrovnik, Institute for marine and coastal research team within the project is to assess mariculture and oceanographic (water quality) data gathered through the work of robotic system on mariculture fish farm.

1.10.2021
11:30-12:15
Marine Biology
Nenad Antolović,
Nikša Glavić

Nenad Antolović *has been working in the Institute for Marine and Coastal Research in Dubrovnik since 2006. He obtained his PhD in 2012 at University of Zagreb in the field of biotechnology. He has been involved in several project regarding fish biology and aquaculture.*

Nikša Glavić *has been research associate in the Institute for Marine and Coastal Research in Dubrovnik since 2009. He obtained his PhD in 2007. in Zagreb University, and has been working on ecology and physiology of marine organisms of interest to mariculture. Generally he has been involved in laboratory and nature experiments with mollusks.*

Accurate qLBL acoustic positioning of multiple fast moving underwater targets in confined waters

Oleksiy Kebkal, Konstantin Kebkal, Evologics GmbH,Germany

Q Quick-LBL (qLBL) is an underwater acoustic positioning system designed to track a target in confined waters (test or industrial pools, port areas) with high update rates. Same as a conventional LBL (long-baseline) system, the qLBL system comprises a number of baseline nodes, deployed around the perimeter of confined water area. In the experiments were used six nodes for the first system developed, four baseline nodes is the minimum required for system operation. Positions of the baseline nodes in the local coordinate frame were measured and then more accurately estimated during the system calibration. The system times of all baseline nodes were in precise sync with each other (due to timekeeping with integrated atomic clocks). The system allowed for high update rates of target's positions, as all acoustic communication was unidirectional: the modem on the target acted as a pinger and transmitted short acoustic pulses. The S2C communication technology allowed the baseline nodes to detect these pulses from the target even in high-multipath environments. The baseline nodes estimated ranges to the target based on time differences of the target signal arrivals (multilateration) – the time differences were known since the internal clocks of the baseline nodes and the mobile target were synchronized with 1 PPS signals. The position of the target was calculated along with an estimation of positioning error. In different experiments in confined waters (pools) the system allowed for update rates of target position of up to 10 Hz, achieved for 1 target in a narrow, 100 m long pool. The update rate depended on the number of targets and the maximum distance towards the target in the baseline area. Multiple targets were supported, the update rate resource is shared between the targets – i.e. when one target can be tracked at 10 Hz, two targets would be tracked at 5 Hz.

With a MS in computer science and applied mathematics, ***Oleksiy Kebkal*** *is an expert in underwater acoustic signal processing, embedded programming, algorithms/protocols design for underwater acoustic communications. He is the leading developer of Evologics proprietary D-MAC software (proprietary protocol stack), and of media access and networking software of the EviNS Framework (Evologics intelligent Networking Software Framework).*

Dr. Konstantin Kebkal *received his engineering degree from the Technical University Sevastopol in 1995 and his PhD in Electronic Engineering from the Technical University Berlin in 2000. Extensive experience in underwater acoustics, signal processing, applied mathematics and electrical engineering. His studies of the physics of dolphin communication laid the groundwork for EvoLogics' Sweep Spread Carrier (S2C) technology for underwater data transmissions: based on results of these studies he has developed a patented ultra-broadband communication system providing high reliability*

10.10.2021
12:15 - 13:00
Maritime Robotics
Oleksiy Kebkal ,
Konstantin Kebkal

needed for applications in the oceanographic and offshore applications. In 2000 he co-founded R&D company EvoLogics GmbH aimed at developing flexible and reliable solutions for the maritime industry, especially underwater communication, navigation and positioning systems and networks for increasing the flexibility of operations whilst reducing risks and costs. More than 100 scientific publications, 2 international patents.

COMPANY PRESENTATIONS

H2ORobotics products

Ivo Kutleša, H2O Robotics, Croatia

H2ORobotics is a marine technology company founded in 2017 in Zagreb, Croatia as a LABUST spin-off.
Our first product is H2Omni-X, a multifunctional autonomous marine surface vehicle capable of very low-power dynamic positioning, autonomous operations and advanced communication capabilities under and above water. H2Omni-X 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.

Also, we are developing underwater communication technology:
1) H2Orologio is an underwater pager, enabling divers to communicate with other divers, boat (topside unit), 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.

Ivo Kutleša *graduated Control Engineering and Automation at the Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia, in 2020. He currently works in H2ORobotics as software engineer, developing underwater communication protocols, underwater localisation algorithms and applications related to H2ORobotics products.*

27.9.2021
15:30 - 18:30
Company programme
Ivo Kutleša

The LUMA family of compact, fast optical underwater modems

Igor Martin, Alexander Bahr, Hydromea, Switzerland

*Hydromea CEO **Igor Martin** has over 15 years of corporate business management experience in a Fortune 100 company. Prior to joining Hydromea, he ran a $40mln global biocides business, responsible for its P&L and all aspects of the company (Strategy, M&A, R&D, Sales, Marketing, Regulatory and Operations). Igor has an MBA from St. Louis University.*

*Hydromea COO **Alexander Bahr** is an expert in the cooperation and navigation of large groups of Autonomous Underwater Vehicles (AUV), he has hands on experience with the design, testing and deployment of underwater sensing equipment. Alex has a PhD in Underwater Navigation from the Massachusetts Institute of Technology.*

29.9.2021
COMPANY PRESENTATION
15:00-15:30
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Igor Martin,
Alexander Bahr

TUTORIALS

Using Physics-informed Learning for Nonlinear System Identification of Underwater Robots

Sriharsha Bhat, Christopher Sprague, KTH Royal Institute of Technology, Sweden

Accurate dynamics models are crucial for simulation, control design and state estimation for robotic systems. In the case of underwater robots and AUVs in particular, the dynamics can be highly nonlinear — this makes it difficult to simulate, control and estimate their motion in complex tasks such as docking, inspection and obstacle avoidance. Data-driven approaches can help identify nonlinear dynamics models for AUVs. Such identified models can be useful in applications including adaptive Model Predictive Control and Extended Kalman Filters. In this tutorial, we will present a workflow using JAX and physics-informed learning to learn a dynamics model from AUV pose data (positions, orientations, linear and angular velocities). We will teach the audience how to perform simulations to validate this model against a ground truth. We will also share the code for this tutorial in an open repository.

27.9.2021
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Sriharsha Bhat,
Christopher Sprague

Sriharsha Bhat *is a PhD student at the Department of Aeronautical and Vehicle engineering at KTH Royal Institute of Technology, in Stockholm, Sweden. His research project on 'Hydrobatics' with the Swedish Maritime Robotics Center (SMaRC) focuses on developing new methods for simulating and controlling autonomous underwater vehicles (AUVs) in agile and acrobatic maneuvers. In the past, he has performed research on aerial and underwater robotics at the Singapore-MIT Alliance for Research and Technology (SMART), Singapore and has been in the automotive industry as a development engineer at Continental in Hannover, Germany. His research interests include optimal and model predictive control, motion planning, reinforcement learning, simulation/modelling, and system identification for robots and autonomous vehicles in challenging field applications.*

Christopher Sprague *is a PhD student at the Robotics, Perception, and Learning department at KTH Royal Institute of Technology, in Stockholm, Sweden. His work focuses on developing algorithms for robust, flexible, and transparent mission planning and execution. In the past, he researched using optimal control theory and deep learning for spacecraft trajectory optimisation at organisations such as the European Space Agency and Japan Aerospace Exploration Agency. His main research interests include optimal control, automated planning, and deep learning, with an emphasis on challenging remote domains.*

AI ZeroCaliber: Edge Computing for Maritime IoT

Ilias Alexopoulos, AI ZeroCaliber Ltd, Cyprus

The maritime environment requires reliable IoT sensing systems that work with limited resources of energy and link budgets. In this tutorial we will focus on embedded systems design for maritime applications. We will present the physical constraints and challenges and the types of embedded systems in terms of system, hardware, and software. We will also discuss common algorithms used, computational acceleration methods, sensors, and actuators. We will focus on heterogenous computing platforms and power management solutions while we will demonstrate a performance comparison of different implementations. Part 1: Power management unit (PMU) developed for a smart-float surface vehicle. The unit accepts battery and solar panel inputs and provides regulated outputs for different devices and voltages. Each output can be disabled to conserve energy (powering down unnecessary equipment), measure each module's power consumption, and provide a platform for smart energy handling on-board. Part 2: Custom IoT heterogeneous board prototype with a hydrophone input. We examine the performance impact of different cross-correlation implementations. Power and speed will be shown for each case explaining the benefits of each implementation. Part 3: A light version of the previous platform will demonstrate the expansion capabilities of hardware demonstrating control of different number of motors (DC, Stepper, R/C Servo) and the software simplification. Part 4: We will also present our agile heterogenous embedded platform which is under development that can scale up from smaller to complex functions and applications, based on the prototype boards presented. The Tile IoT System will have a small form factor, mechanical integration, and a variety of scalable capabilities.

28.9.2021
TUTORIAL INTRODUCTION
14:30 - 15:00
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Ilias Alexopoulos

Alexopoulos Ilias *received his B.S. degree from the Automation department of the Technological Educational Institute (T.E.I.) of Piraeus in Athens Greece in 1996 and his MS degree from Brunel University in 1999. He is currently a PhD student at the University of Nicosia. He has more than 20 years of experience in embedded system design, product development, sensing, DC motors, prototyping, control systems, DSP, FPGAs, RF, Instrumentation, Certifications, testing and system engineering. He is also an inventor with international patents and recognition of work within companies and the open-source community. He is the founder of AI Zerocaliber Ltd, a company currently focused on developing heterogenous embedded platforms and frameworks for edge processing.*

Marine Unity Simulator

Ivan Loncar, Natko Krasevac, Juraj Obradovic, University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG FER), 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. Robotic Operating System (ROS) is a tool most used in robotic communities because the code written for the simulation can be integrated to the robot with minor adaptations. Most often, the performance of the developed application won't be the same when using on a physical robot due to simplifications taken during system modelling. Closer the simulation is to real life, less effort will need to be spent on modification of the application in order to function with same level of performance in real life. That's why we chose to use Unity, an engine primarily used for game development but it offers a suite of tools useful for mimicking real-world environment. Since it is a widely popular game engine for rendering, lighting, and physics in 3D virtual environment, together with the Asset Store, where a large community shares their code, models and solutions. Unity offers simple and intuitive UI tool for virtual world generation which makes it a perfect choice for robotic test scene creation. Algorithms for robots are implemented in ROS so we developed an adapter for Unity which allows ROS to access data from the simulated environment. In this tutorial, we will demonstrate the capabilities of the simulator developed by LABUST. You will learn to make, edit and execute scenes in Unity, integrate developed sensors modules most commonly used in maritime environment, and familiarize yourself with getting simulated measurements from Unity to ROS.

Ivan Loncar *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 which is developing an autonomous ship.*

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

28.9.2021

TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30

Tutorial

Ivan Loncar,
Natko Krasevac,
Juraj Obradovic

Adriatic

Dula Nad, University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG FER), Croatia

A new type of very low-cost remotely operated vehicle (ROV) has been introduced in the last few years, benefitting from advances in drone and battery technology. Substituting high capacity LIPO batteries for surface power whilst still retaining useful performance, these subsea vehicles are easy to deploy, pilot and maintain. For their size and cost they offer impressive inspection and survey capabilities, including photogrammetry, imaging sonar and acoustic positioning, at a fraction of the cost of similar small ROVs of more traditional design. They also offer opportunities to carry out survey at deeper depths, more efficiently and with less risk than deploying archaeologist divers. Furthermore, imminent advances in low-latency satellite broadband services may enable remote participation in subsea archaeological survey work carried out by these vehicles, as well as facilitating new forms of live client and public engagement. Using examples of subsea archaeological survey linked to heritage protection carried out in the last three years for UK public bodies Historic England and Historic Environment Scotland, including surveys of a Spanish post-medieval wreck site and a 19th century clipper, this paper will explore the pros and cons of using a 100m depth rated ROV of this type for archaeological work and the opportunities that could be developed from it. It will also consider whether the future relationship between the use of divers and the use of ROVs for subsea archaeology generally will echo the way in which these respective capabilities have been developed in other marine sectors, such as oil and gas and offshore wind/renewables.

Dula Nad *is a post-doc at the Laboratory of Underwater Systems and Technologies (LABUST), part of the University of Zagreb Faculty of Electrical Engineering and Computing. He is currently involved in the nationally funded project CroMarX and has participated in multiple European projects over past years. His research interest includes navigation, guidance, and control of underwater vehicles, localization aiding, and diver-robot cooperation.*

29.9.2021
TUTORIAL INTRODUCTION
09:45 - 10:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Dula Nad

LSTS Toolchain: Overview and e-Infrastructure Access

Maria Costa, Laboratório de Sistemas e Tecnologia Subaquática, Portugal

In this tutorial we will showcase the LSTS Toolchain, a set of software tools developed at the University of Porto by the Underwater Systems and Technology Lab (LSTS) to control, plan, monitor and supervise teams of heterogeneous vehicles, in communication-challenged environments. In this session, an overview of the main components of the toolchain will be given and a demonstration on how to use it will take place (local simulation and access to a remote testbed will be covered).

Maria Costa *is a Robotics Engineer and has been a Researcher at LSTS (Underwater Systems and Technology Laboratory), in University of Porto since 2014. Maria Costa holds an Electrotechnical and Computer Engineering degree and a MSc degree in Autonomous Systems from School of Engineering Polytechnic of Porto. She works mainly with the onboard software (control, guidance and navigation) and has gained significant experience in maritime operations with multiple AUVs, UAS and ASVs, as one of the main operators of the field operational team.*

29.9.2021
TUTORIAL INTRODUCTION
14:30 - 15:00
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Maria Costa

Citizen engagement: learning by imitation in marine robotics

CNR-INM Genova Robotics & AI team, Italy

"SWAMP learning from humans" experiment @ BTS 2021. The active involvement of citizens and stakeholders from the early stages is fundamental in research projects on the development of autonomous physical agents able to operate in presence of and to cooperate with human beings and manned systems as, for instance, in the case of Unmanned Marine Vehicles working in harbour and coastal areas. Thanks to its innovative mechanical design (pump-jet propulsion, foam-made hull, etc.), SWAMP, a modular reconfigurable lightweight Autonomous Surface Vehicle for ultra-shallow water applications, constitutes an easily deployable and safe platform for carrying out experiments involving citizens and students. A first example was given by the "SWAMP learning from humans" experiment, where citizens attending Festival della Comunicazione in Camogli, Italy, remotely piloted SWAMP to execute a simple task consisting in crossing a couple of doors delimited by buoys in 2019 and 2021. Commands and trajectories recorded while the vehicle executed the goal task remotely controlled by citizens trained an AI control system based on neural networks. Thanks to the control law generated by this learning by imitation system, the robot was then able to autonomously navigate executing the goal task as learnt from people. The tutorial will consist of a general introduction to the topic of learning by imitation in marine robotics followed a replica of the experiment at sea involving BTS participants piloting SWAMP ASV. Suggestions for further experiments and citizens/students engagement in CNR-INM "learning by human" marine robotics research will be encouraged.

1.10.2021
TUTORIAL INTRODUCTION
14:30 - 15:00
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
CNR-INM Genova
Robotics & AI team

The tutorial, carried out in the framework of Interreg Italy-Croatia InnovaMARE project with the support of the EASME-EMFF Blue RoSES project, will be performed by researchers and engineers of the marine robotics and AI groups of ***CNR-INM Genova*** *providing expertise in the different areas involved by the experiment:* ***Cristiano Cervellera****, learning by imitation;* ***Angelo Odetti****, naval-mechanical design;* ***Marco Bibuli, Massimo Caccia, Claudia Presicci, Enrica Zereik****, NGC and software systems;* ***Giorgio Bruzzone*** *and* ***Edoardo Spirandelli****, field operations and logistics.*

Efficient and scalable sensor-platform integration

Ehsan Abdi, Cyprus Subsea, Cyprus

With number of sensors and platforms deployed every day on a constant rise, now more than ever there is a need for plug-and-work solutions. Although fields like IoT have had great success achieving this, easy integration of environmental and scientific sensors together with ensuring data interoperability still remains a difficult problem. In this session we will explore the reasons behind this and offer some possible solutions.

Ehsan Abdi *has a background in electronics engineering and he has been working intensively with ocean-going sensors and platforms for the past six years. He has been involved in a variety of novel sensor integration on autonomous platforms such as gliders.*

1.10.2021
TUTORIAL INTRODUCTION
15:00-15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Ehsan Abdi

DEMONSTRATIONS

PLURATO SAILFIN – Electric Hydrofoil Surf Board

Plurato Sailfin, STATIM, Croatia

27.9.2021
15:30 - 18:30
Demonstration

Researching, development and manufacturing of electric hydrofoil board.

Towards a Heterogeneous Robotic System for Autonomous Inspection in Mariculture

Nadir Kapetanović, University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG FER), Croatia

For millennia, agriculture and aquaculture have been a component of human society. Aquaculture, as well as its component relating to sea water known as mariculture, did not begin to expand exponentially until the 20th century. Globally, mariculture is the fastest growing part of food industry. In the EU 20% of the fish stock comes from aquaculture and this industry branch accounts for around 80.000 employments. Mariculture is heavily reliant on human labor, with workers generally doing arduous, repetitive, sometimes even dangerous tasks for long periods of time. Currently, divers must monitor fish farming cages for lengthy periods of time in all weather situations, even the most extreme. HEKTOR (Heterogeneous Autonomous Robotic System in Viticulture and Mariculture) project is looking for a solution to these issues. The objective of the HEKTOR project in mariculture is to try for the first time in Croatia to include robotic systems (aerial, marine surface and underwater) in the process of cage fish farming for automated monitoring of fish cages. HEKTOR project proposes a heterogeneous robotic system consisting of an ROV, an ASV and a UAV for autonomous fish cage inspection missions. Based on the data fusion of the individually obtained information, the data from all three robots will be utilized for the final assessment of the fish cages. The objective of this demo is to showcase the Blueye ROV acquired in the scope of the HEKTOR project and its integration with ROS2. Moreover, a catamaran-shaped autonomous surface vehicle named Korkyra, developed in-house in the scope of the HEKTOR project, will be presented together with all its subsystems.

28.9.2021
15:30 - 18:30
Demonstration
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.*

EvoLogics

Oleksiy Kebkal, Konstantin Kebkal, Evologics GmbH,Germany

1.10.2021
15:00 - 18:30
Demonstration
Oleksiy Kebkal ,
Konstantin Kebkal

With a MS in computer science and applied mathematics, ***Oleksiy Kebkal*** *is an expert in underwater acoustic signal processing, embedded programming, algorithms/protocols design for underwater acoustic communications. He is the leading developer of Evologics proprietary D-MAC software (proprietary protocol stack), and of media access and networking software of the EviNS Framework (Evologics intelligent Networking Software Framework).*

Dr. Konstantin Kebkal *received his engineering degree from the Technical University Sevastopol in 1995 and his PhD in Electronic Engineering from the Technical University Berlin in 2000. Extensive experience in underwater acoustics, signal processing, applied mathematics and electrical engineering. His studies of the physics of dolphin communication laid the groundwork for EvoLogics' Sweep Spread Carrier (S2C) technology for underwater data transmissions: based on results of these studies he has developed a patented ultra-broadband communication system providing high reliability needed for applications in the oceanographic and offshore applications. In 2000 he co-founded R&D company EvoLogics GmbH aimed at developing flexible and reliable solutions for the maritime industry, especially underwater communication, navigation and positioning systems and networks for increasing the flexibility of operations whilst reducing risks and costs. More than 100 scientific publications, 2 international patents.*

LIST OF PARTICIPANTS

Registered participants until 17th September:

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Center for Underwater Systems and Technologies, Croatia
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Petra Kovačević
Ivona Šarić
Katarina Pavić

CNR, Italy
Marco Bibuli
Ruxandra Lupu
Claudia Presicci
Enrica Zereik

CNR-INM, Italy
Odetti Angelo
Spirandelli Edoardo
Caccia Massimo

CNR-ISMAR, Italy
Francesca De Pascalis
Fantina Madricardo

Croatian Chamber of Economy, Croatia
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Oleksiy Kebkal

GEOmar, Croatia
Marko Bakašun
Matej Čurić

H2O Robotics, Croatia
Ivo Kutleša

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