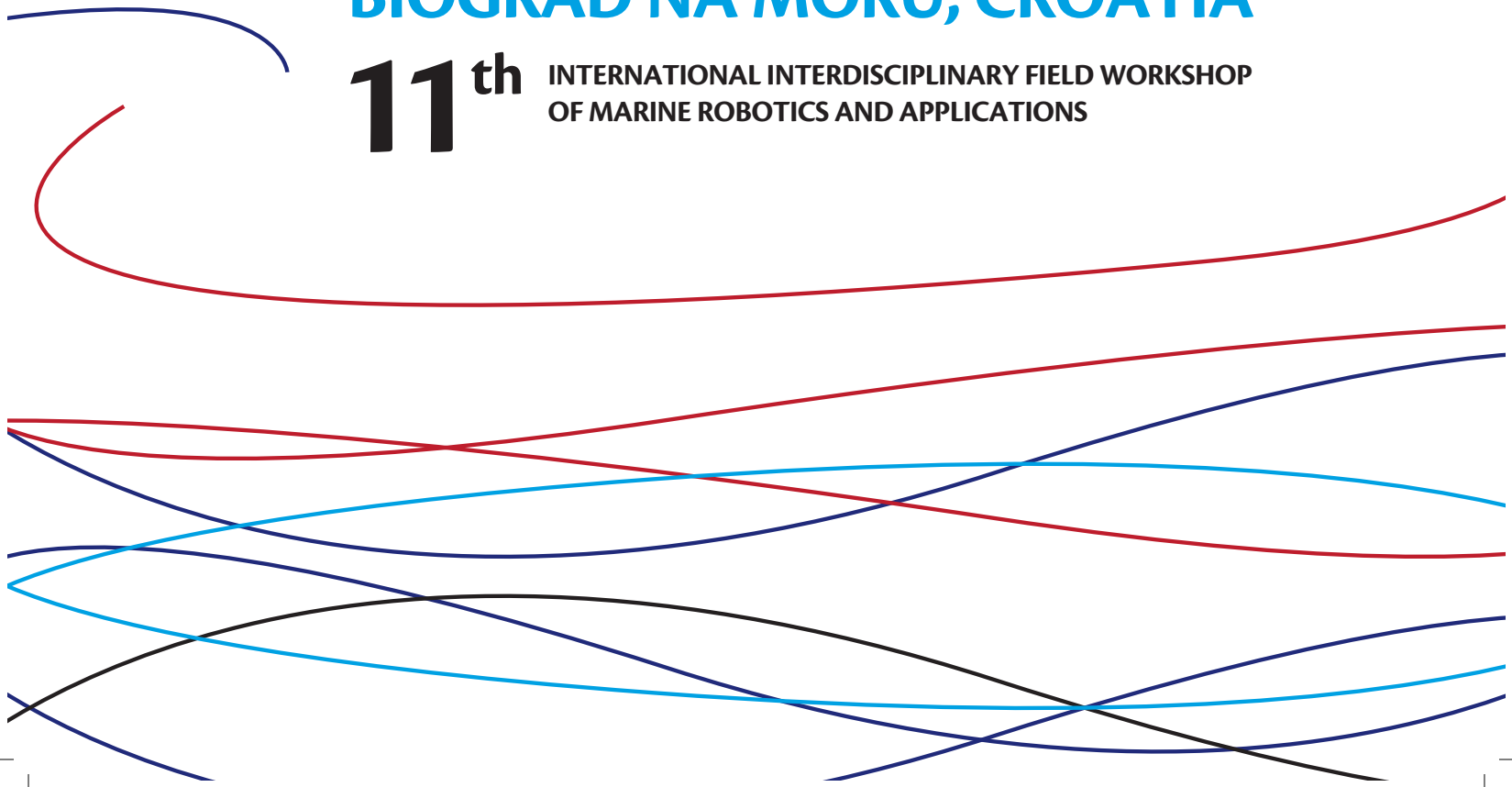
2019 29.09.-06.10.

BREAKING THE SURFACE

BIOGRAD NA MORU, CROATIA

11th INTERNATIONAL INTERDISCIPLINARY FIELD WORKSHOP OF MARINE ROBOTICS AND APPLICATIONS



BTS MAP

HOTEL ADRIATIC

1 / ACCOMODATION

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

12 / BELVEDER BAR
Social events

ORGANIZED BY

University of Zagreb

Faculty of Electrical Engineering and Computing

Laboratory for Underwater Systems and Technologies

Center for Underwater Systems and Technologies

ABOUT BTS

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

BTS 2019 IN NUMBERS

7 DAYS

25 LECTURERS

7 TUTORIALS

10 VEHICLES

5 PROGRAMME TRACKS

>200 ATTENDEES

∞ OPPORTUNITIES TO NETWORK

COMMITTEES

COMMITTEES CHAIRS

Prof. Zoran Vukić, PhD
General Chair

Assoc. Prof. Nikola Mišković, PhD
Programme Committee Chair

Ivana Mikolić, mag. ing.
Organizing Committee Chair

Antonio Vasilijević, PhD
Technical Committee Chair

PROGRAMME COMMITTEE

Ralf Bachmayer, Bridget Buxton, Fausto Ferreira, John Folkesson, Bill Kirkwood, Ivan Petrović, Irena Radić-Rossi, Joao Sousa, Ivan Stenius

ORGANIZING COMMITTEE

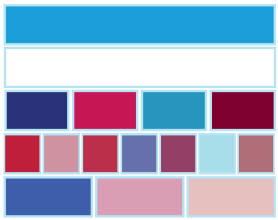
Ivan Đerek, Lovro Kunović, Luka Manjkas, Barbara Mikašek, Petra Mikolić, Ivan Trubić

TECHNICAL COMMITTEE

Anja Babić, Nadir Kapetanović, Nikica Kokir, Kristijan Krčmar, Igor Kvasić, Ivan Lončar, Filip Mandić, Đula Nađ, PhD,

LEGEND

SESSION COLOURS



Lectures

Social events and special programme

Company programme

Tutorials

Demonstrations

CATEGORIES

MAROB

MARBIO

MARCH

OCEANOGRAPHY

COMPANY PRESENTATION

LOCATIONS

LECTURE HALL – HOTEL ADRIATIC
ALL *lectures and presentations*

DEMO POOL AND OPEN WATERS NEARBY
Equipment demonstrations, Gin&tonic pool party

TUTORIALS ROOM – HOTEL ADRIATIC
Tutorial

LAVENDER BAR – HOTEL ADRIATIC
Welcome drinks, Erasmus+ impact multiplier event

BELVEDER BAR
BTS karaoke

	MONDAY 30.09.	TUESDAY 01.10.
09:00	**Opening session** UNIZG FER	**Technological perspectives and new robotics applications in deep-sea ocean sciences** *Jan Opderbecke*
09:45	**Exploring dynamic features of the ocean with coordinated multi- domain robots? Yes, we can!!!** *Joao Sousa*	**Multiple Autonomous Vehicles Applied to Detect, Track and Survey a River Plume** *Renato Mendes*
10:30	COFFEE BREAK	COFFEE BREAK
10:45	**An Orange Submarine Underneath the Doomsday Glacier: Lessons Learned and Main Results** *Anna Wahlin*	**Robots for karstic exploration: an underneath robotic journey** *Lionel Lapierre*
11:30	**Autonomous underwater manipulation from a floating I-AUV: The challenges of moving from the observation to the interaction with the underwater environment** *Patryk Cieslak*	**The Dawn of a New Algae-Based Marine Industry in Sweden** *Fredrik Gröndahl*
12:15	**The entropy based approach to modeling and evaluating autonomy in unmanned systemsy systems** *Kimon Valavanis*	**A brief introduction to deep learning for generative modeling** *Jakob Verbeek*
13:00	LUNCH	LUNCH
14:30	**T1 intro: Autonomous underwater manipulation from a floating I-AUV: Simulation and control strategies** *University of Girona*	*COMPANY PRESENTATION* **Sonardyne**
15:00	**T2 intro: LSTS Toolchain: Bridging interoperability challenges** *University of Girona*	**T4 intro** *ROS/Neptus Integration Tutorial*
15:30	*T1* **hands-on** *Group 1* / *T2* **hands-on** *Group 2* / *T3* **hands-on** *Group 1* / *DEMO* **University of Porto** *Group 1* / *T4* **hands-on** *Group 2* / *DEMO* **Sonardyne** *Group 3*	
16:30	*T1* **hands-on** *Group 2* / *T2* **hands-on** *Group 3* / *T3* **hands-on** *Group 3* / *DEMO* **University of Porto** *Group 2* / *T4* **hands-on** *Group 3* / *DEMO* **Sonardyne** *Group 1*	
17:30	*T1* **hands-on** *Group 3* / *T2* **hands-on** *Group 1* / *T3* **hands-on** *Group 2* / *DEMO* **University of Porto** *Group 3* / *T4* **hands-on** *Group 1* / *DEMO* **Sonardyne** *Group 2*	
18:00		
18:30	DINNER	DINNER
19:30		

WEDNESDAY 02.10.	THURSDAY 03.10.	FRIDAY 04.10.
Improving the accessibility of underwater cultural heritage through digital technologies *Fabio Bruno*	**Development and deployment of an unmanned iceberg observation system for off-shore industry and iceberg modelling** *Ralf Bachmayer*	**Localisation in Marine Robotics** *Francesco Maurelli*
Marine robotics, learning from humans, and communication: the SWAMP example *Massimo Caccia*	**Long-term fluctuations of Cystoseira forests along the west Istrian Coast (northern Adriatic, Croatia)** *Ljiljana Iveša*	**Cooperative Marine Robotics: Theory and Practice** *Antonio Pascoal*
COFFEE BREAK	COFFEE BREAK	COFFEE BREAK
Recording Shipwrecks at the Speed of Light: A Low-Cost, Diver Deployed Underwater Laser Scanning System and Its Efficacy of Use in Maritime Archaeology Compared to Photogrammetry and Sonar in the 4th Industrial Revolution *Michael Murray*	**Autonomous docking and inspection capabilities** *Gerard Dooley*	**Flow Sensors for Underwater Robots and Oceanography** *Maarja Kruusmaa*
Simulation Tools for Underwater Sensor Networks *Marwa Salayma*	**Explainable AI Planning for Robotics** *Daniele Magazzeni*	**The Lusitania Project 17** *Peter McCamley*
Deep Sea Archaeological Survey in the Black Sea – Robotic Documentation of 2,500 Years of Human Seafaring *Rodrigo Pacheco-Ruiz*	**:)** *Martin Ludvigse*	**Underwater Cable Inspection and Dual-arm Intervention** *Xianbo Xiang*
LUNCH	LUNCH	LUNCH
COMPANY PRESENTATION **BluePrint**	**T7 intro: ROSPlan: Task Planning for Robotics** *KING'S College London*	*COMPANY PRESENTATION* **BlueEye**
T5 intro: AUVLib – Sonar data processing for machine learning *KTH*	**T6 intro: JANUS: The first digital underwater communications standard** *NATO CMRE*	**T8 intro:** *EvoLogics*
DEMO **BluePrint** *Group 1*	*T5* **hands-on** *Group 2*	*DEMO* **by Michael Murray** *Group 3*	*T6* **hands-on** *Group 1*	*DEMO* **EvoLogics** *Group 2*	*T7* **hands-on** *Group 3*	*DEMO* **NATO CMRE** *Group 1*	*T8* **hands-on** *Group 2*	*DEMO* **BlueEye** *Group 3*
DEMO **BluePrint** *Group 2*	*T5* **hands-on** *Group 3*	*DEMO* **by Michael Murray** *Group 1*	*T6* **hands-on** *Group 2*	*DEMO* **EvoLogics** *Group 3*	*T7* **hands-on** *Group 1*	*DEMO* **NATO CMRE** *Group 2*	*T8* **hands-on** *Group 3*	*DEMO* **BlueEye** *Group 1*
DEMO **BluePrint** *Group 3*	*T5* **hands-on** *Group 1*	*DEMO* **by Michael Murray** *Group 2*	*T6* **hands-on** *Group 3*	*DEMO* **EvoLogics** *Group 1*	*T6* **hands-on** *Group 2*	*DEMO* **NATO CMRE** *Group 3*	*T8* **hands-on** *Group 1*	*DEMO* **BlueEye** *Group 2*
DINNER	DINNER	CLOSING CEREMONY

SOCIAL EVENTS

29.9.
SUNDAY
16:30 – 18:00
HOTEL ADRIATIC
REGISTRATION

29.9.
SUNDAY
18:00 – 19:30
LAVENDER BAR
WELCOME DRINKS

1.10.
TUESDAY
FROM 21:00
HOTEL ADRIATIC BAR
INTERNATIONAL NIGHT

2.10.
WEDNESDAY
FROM 18:30
WATER POLO POOL
GIN & TONIC POOL PARTY:
IEEE OES UNIZG PRESENTATION

3.10.
THURSDAY
FROM 21:00
LAVENDER BAR
ERASMUS+ IMPACT MULTIPLIER EVENT

4.10.
FRIDAY
19:30 - 21:00
HOTEL ADRIATIC
CLOSING CEREMONY AND GALA DINNER

4.10.
FRIDAY
FROM 21:00
BELVEDER BAR
BTS KARAOKE PARTY

5.10.
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 2018 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 29th September until 6th 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

Exploring dynamic features of the ocean with coordinated multi-domain robots? Yes, we can!!!

João Tasso de Figueiredo Borges de Sousa, Laboratório de Sistemas e Tecnologias Subaquáticas,
Faculdade de Engenharia da Universidade do Porto, Portugal

In this talk I will discuss the problem of finding, tracking and sampling dynamic features of the ocean with coordinated multi-domain vehicles. First, I will briefly describe challenges in ocean observation to introduce the background against which I will discuss recent technological developments and trends. The focus is on synoptic observations, spatial and temporal sampling requirements, as well as on persistence. Second, I will present the Laboratório de Sistemas e Tecnologias Subaquáticas (LSTS) from the University of Porto (https://lsts.fe.up.pt/) and discuss our vision for a sustainable presence in the ocean. This is done with reference to autonomous underwater, surface, air, and space vehicles, as well as to the LSTS software toolchain (https://www.lsts.pt/toolchain) that enables vehicles to have organization-like properties. Third, I will describe recent scientific cruises that took place in the Pacific and Atlantic oceans, as well as large-scale deployments, held in our coastal waters, to illustrate what can be done at the intersection of science and technology and how this is contributing to achieving our vision. There will be an equal emphasis on science and technology, as well as on human factors. This will be detailed with examples from the 2018 Exploring Fronts with Multiple Robots Schmidt Ocean Institute cruise that took place in the Pacific Ocean (https://schmidtocean.org/cruise/exploring_fronts_with_multiple_aerial-surface-underwater-vehicles/). Finally, I will discuss the lessons learned and the way forward in ocean sciences and robotics. This will be done with reference to the Marine Robotics Research Infrastructure Network (EUMR) H2020 infra-structures project (https://www.eumarinerobots.eu/).

30.09.2019
09.45-10:30
Maritime Robotics
João Tasso de Figueiredo Borges de Sousa

João Tasso de Figueiredo Borges de Sousa *is with the Electrical and Computer Engineering Department from Porto University in Portugal. He holds a PhD and a MSc in Electrical Engineering, both awarded by Porto University. His research interests include autonomous underwater, surface and air vehicles, planning and execution control for networked vehicle systems, optimization and control, cyber-physical systems, and applications of networked vehicle systems to the ocean sciences, security and defense. He is the head of the Laboratório de Sistemas e Tecnologias Subaquáticas – LSTS (Underwater Systems and Technologies Laboratory). The LSTS (https://www.lsts.pt/) has pioneered the design, construction and deployment of networked underwater, surface and air vehicles for applications in ocean sciences, security and defense. He received an outstanding teaching award from Porto University in 2008 and the IEEE OES rising star mid-career award in 2018. He has been involved in fostering and growing a world-wide research community in this field with yearly conferences and workshops in the areas of Hybrid Systems, Networked Vehicle Systems and Autonomous Underwater Vehicles. He has been lecturing on networked vehicle systems in renowned universities in the United States of America and Europe. He is a member of the IEEE Robotics and Automation Multi-robots Systems Technical Committee and of the*

International Federation of Automatic Control (IFAC) Marine Systems Technical Committee. He was the chair of the 2013 edition of the IFAC Navigation, Guidance and Control Workshop and the chair of the 2018 IEEE OES AUV Symposium. He is a co-chair of the Oceans 2021 Conference that will take place in Porto, Portugal. He is in the editorial board of several scientific journals. He is a member of several NATO committees. He has authored over 400 publications, including 40 journal papers.

An Orange Submarine Underneath the Doomsday Glacier: Lessons Learned and Main Results

Anna Wåhlin, University of Gothenburg, Sweden

The Swedish AUV Ran, a Kongsberg Hugin AUV with 3000 m depth rating, was operated during the N.B. Palmer expedition to the Thwaites glacier (Antarctica) in February and March 2019. In this presentation, the main challenges and lessons learned will be presented together with some of the key findings from the expedition. The emphasis will be put on the performance of the AUV and the value of the various payload, but more general results from the expedition will also be presented.

30.09.2019
10:45-11:30
Oceanography
Anna Wåhlin

Anna Wåhlin *(ORCID) is a Professor of Physical Oceanography at the Department of Marine Sciences, University of Gothenburg. Her research focus is in the field of Polar Oceanography, mostly in the Southern Ocean. Specifically, her research investigates several aspects of dynamics of polar seas, including physical oceanography, ocean circulation, topographic effects, ice shelf melt processes and air-sea-ice interaction. When Wåhlin was appointed professor in 2015, she became Sweden's first female full Professor of Oceanography. She is project leader for Sweden's national AUV infrastructure funded by the Knut and Alice Wallenberg Foundation. This AUV became the world's first to venture under Thwaites glacier, Antarctica, in 2019. Between 2015 and 2017, Wåhlin was co-chair of the joint Scientific Committee on Antarctic Research (SCAR) and SCOR initiative Southern Ocean Observing System (SOOS). She is an Associate Editor of the journal Advances in Polar Science and member of the IOW scientific advisory board (2016-2019). Her awards include being a Fulbright Scholar (2007-2008), receiving a Crafoord Research Stipend from the Swedish Royal Academy of Science (2010), being a SCAR visiting professor (2013) and receiving the Albert Wallin science prize from the Royal Society of Arts and Sciences (KKVS) in Gothenburg 2018.*

30th SEPTEMBER
Mon

Autonomous underwater manipulation from a floating I-AUV: The challenges of moving from the observation to the interaction with the underwater environment

Patryk Cieślak, Underwater Vision and Robotics Lab (CIRS), ViCOROB Institute, University of Girona, Spain

Autonomous underwater vehicles are around for some time but their capabilities are still limited to the survey, monitoring and search tasks. The industry still relies on using heavy work-class remotely operated vehicles or specialised divers, when any interaction with the underwater infrastructure or environment is needed. Use of these kind of systems and humans involves extremely high costs and risks. This limits the possible applications to the highly profitable and emergency tasks. Therefore, our research group is working to extend the capabilities of autonomous underwater systems to enable underwater mobile manipulation without or with limited supervision of humans, using small, easily deployable robots, lowering the operational costs by several orders of magnitude and practically removing the need of sending humans to the hostile underwater environment. The lecture will focus on presenting possible practical applications of autonomous underwater mobile manipulation, discussing the involved challenges and ways to tackle them, and finally, showcasing the experimental works that have been completed at our laboratory. Some of the works presented during the lecture are part of the EU Marine Robots project, funded by the European Community H2020 Programme, under the grant agreement no. 731103.

30.09.2019
11:30-12:15
Maritime Robotics
Patryk Cieślak

Patryk Cieślak *received his PhD in 2016 from the Department of Robotics and Mechatronics, AGH University of Science and Technology in Kraków, Poland. He was involved in several projects concentrating around control system design in mobile robotics and manipulator systems. He is also a co-author of a commercial rehabilitation robot called Prodrobot, being a stationary lower limbs exoskeleton, used in the relearning and improvement of natural gait patterns of children. Recently, his research interests focus around autonomous underwater mobile manipulation. For the last two years he worked as a Marie Curie postdoc in the Underwater Vision and Robotics Lab (CIRS) by the University of Girona, Spain. During the project he developed control strategies for compliant autonomous underwater mobile manipulation, utilising a wrist mounted force-torque sensor. He was also involved in works on underwater obstacle avoidance and motion planning. Patryk Cieślak is also the author of a modern open-source simulation software, directed towards underwater robotics community, called Stonefish. Recently, he is continuing his research in CIRS, working on cooperative autonomous underwater floating-base manipulation.*

The entropy based approach to modeling and evaluating autonomy in unmanned systemsy systems

Dr. Kimon P. Valavanis, University of Denver, USA

This talk presents the Entropy approach to modeling and performance evaluation of Intelligent Machines (IMs), which are modeled as hierarchical, multi-level structures. It provides a chronological summary of developments related to intelligent control, from its origins to current advances. It discusses fundamentals of the concept of Entropy as a measure of uncertainty and as a control function, which may be used to control, evaluate and improve through adaptation and learning performance of engineering systems. It describes a multi-level, hierarchical, architecture that is used to model such systems, and it defines autonomy and machine intelligence for engineering systems, with the aim to set foundations necessary to tackle related challenges. The modeling philosophy for the systems under consideration follows the mathematically proven principle of Increasing Precision with Decreasing Intelligence (IPDI). Entropy is also used in the context of N-Dimensional Information Theory to model the flow of information throughout such systems and contributes to quantitatively evaluate uncertainty, thus, autonomy and intelligence. It is explained how Entropy qualifies as a unique, single, measure to evaluate autonomy, intelligence and precision of task execution. The main contribution of this review paper is that it brings under one forum research findings from the 1970's and 1980's, and that it supports the argument that even today, given the unprecedented existing computational power, advances in Artificial Intelligence, Deep Learning and Control Theory, the same foundational framework may be followed to study large-scale, distributed Cyber Physical Systems (CPSs), including distributed intelligence and multi-agent systems, with direct applications to the SmartGrid, transportation systems and multi-robot teams, to mention but a few applications.

30.09.2019
12:15-13:00
Maritime Robotics
Kimon P. Valavanis

Dr. Kimon P. Valavanis *is John Evans Professor, Director, Research and Innovation, Ritchie School of Engineering and Computer Science, U of Denver. He is Founding Director of the Unmanned Systems Research Institute. He has been Guest Professor in FER, Department of Telecommunications, U of Zagreb, Croatia, and Visiting Faculty at the Politecnico di Torino under the European Research Council, European Commission, Horizon 2020 Scientific Programme, Part 1–Excellent Science. He has graduated 38 PhD students and more than 100 M.Sc. students, attracted and helped attracting close to $50M in research funds from Federal and State agencies, industry and the private sector. His research interests focus on the areas of Unmanned Systems, Distributed Intelligence Systems, Robotics and Automation. He has published more than 400 book chapters, technical journal, referred conference papers, invited papers, including 19 books. He was Editor-in-chief of the Robotics and Automation Magazine, 1996-2005 and since 2006 Editor-in-Chief of the Journal of Intelligent and Robotic Systems. He served as a member of the Robotics and Automation Society Awards Committee and serves as co-chair/chair of the Aerial Robotics and Unmanned Aerial Vehicles Technical Committee. He has served as General, Program, Registration,*

Local Arrangements Chair in conferences. He was a Distinguished Speaker in the Robotics and Automation Society, IEEE Senior Member, Fellow of the American Association for the Advancement of Science and of the U.K. Institute of Measurement and Control, and Technical Expert of the NATO Science and Technology Organization. He is a Fulbright Scholar. In 2019, he was awarded by IEEE and the Robotics and Automation Society for his 10 years of service as Editor-in-Chief.

Technological perspectives and new robotics applications in deep-sea ocean sciences

Jan Opderbecke, IFREMER, France

Ocean sciences rely on underwater vehicles and observation systems for tasks covering exploration, assessment, medium and long term monitoring in various disciplines. Ifremer develops and manages the underwater vehicle assets for France's scientific community. From the manned underwater vehicle Nautile, through ROVs and AUVs, each type of vehicle plays its role with a historic expertise in deep-sea intervention. With recent advances in robotics, instrumentation and processing capabilities, the underwater systems unit at Ifremer is currently involved in the renewal and extension of the set of assets. Developments of a novel 6000m AUV and the mid-life upgrade of the deep ROV Victor 6000 will be presented. At stakes are a range of topics and functional evolutions that will profoundly modernize the scientific work: multi-system operations, on-board data interpretation and decision making, multi-sensor payload packages and navigation features designed to enhance the capabilities of observing the benthic environment. The talk will give an overview over current vehicle developments and present outstanding scientific operation scenarios.

01.10.2019
09:00 - 09:45
Maritime Robotics
Jan Opderbecke

***Jan Opderbecke** is an electrical engineer and accomplished his PhD in signal processing at Ecole Normale Supérieure de Cachan (France) in 1994. After joining the French Institute for Ocean Research IFREMER, he specialized in underwater robotics focusing on innovative techniques for navigation, mapping and optical inspection of the deep ocean sea-floors. Since 2014 he is head of the Unit for Underwater Systems, which develops and operates underwater vehicles within the French Oceanographic Fleet. The Unit for Underwater Systems carries out numerous R&D projects in cooperation with academic research labs and companies at national and international level.*

Multiple autonomous vehicles applied to detect, track and survey a river plume

Renato Mendes, CIIMAR - University of Porto, Portugal

River plumes are generated by the flow of buoyant river water into the coastal ocean. They are generally a turbid freshwater feature flowing from land and outside the bounds of an estuary or river channel. The Douro is one of the largest rivers of the Iberian Peninsula, representing the most important freshwater input into the Atlantic on the NW Portuguese coast. Traditional methods of in situ measurements are often complicated and expensive due to the high spatial and temporal variability of its dominant drivers. Up until recently, the general dispersion patterns of the Douro River Plume were mostly studied by numerical models and remote sensing imagery, considering the main drivers involved: river discharge, wind, and tide. The development of accurate and reliable plume monitoring systems is a challenging task. This work reports the recent use of robotic systems to detect, track and survey the Douro Plume front autonomously. These systems can survey this dynamic environment and characterize the frontal regions of the plume regarding salinity and temperature under summer conditions when the plume area is small and mainly tidally driven. Results from several frontal crossings, coincident with satellite imagery acquisitions, demonstrated the AUVs capability to fairly detect the front structure. Cross-frontal exchanges observed by AUVs along the front emphasize the importance of new technologies use on the monitoring and detection of high spatial and temporal dynamical phenomena. Coastal phenomena can constitute a foundation for small, local and opportunistic objective-oriented technological tests. Those intermediary steps between the harbor and offshore operations give the opportunity to engineering and science teams to work together in a stress-free environment.

01.10.2019
09:45 - 10:30
Oceanography
Renato Mendes

Renato Mendes *is currently a post-doctoral researcher of a joint project between CIIMAR in the University of Porto and CESAM in the University of Aveiro. His research interests focus mostly on coastal oceanography, using multi-platform data, such as observations, remote sensing, and numerical models. Recently, his studies have addressed the use of networked autonomous vehicle systems (AUVs and UAVs) to detect, track and survey coastal fronts in a coordinated and collaborative manner. Renato Mendes received his PhD from the University of Aveiro in 2016 in Physical Oceanography and completed a Masters in Meteorology and Physical Oceanography in 2010 at the same institution in Portugal. During this period, he participated in exchange research programs in oceanography from Russian, Brazilian, and Spanish universities. He has published 17 articles in journals and in his professional activities he has interacted with 91 collaborator(s), having also co-authored scientific papers.*

1st OCTOBER
Tue

Robots for karstic exploration: an underneath robotic journey

Lionel Lapierre, University of Montpellier / LIRMM, France

Groundwater resources qualification and quantification is an urgent issue, nowadays and for the next generations. The knowledge of the underground hydraulic network is very partial, and requires dangerous and limited cave divers exploration, or indirect and inaccurate measurements. The use of autonomous subaquatic systems will provide the necessary technological breakthrough to understand the dynamics and lucidly exploit this underground water resource. Moreover, the confined chaotic structure of the karstic environment presents exciting robotic challenges in terms of navigation, guidance, control and mission control. The presentation focuses on the recent results on this topic and the remaining open issues.

Lionel Lapierre *received his Ph.D. degree in Robotics, from the University of Montpellier, France, in 1999, and his HDR in 2015. In 2000, he joined the team of Professor A. Pascoal within the European project FreeSub for three years. Since 2003, he has been with the Underwater Robotics Division, Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM), Montpellier, France. He is now leading the project on 'Robotics for Karst Exploration', a Flagship Project of the Labex Numev.*

01.10.2019
10:45 - 11:30
Maritime Robotics
Lionel Lapierre

1st
OCTOBER
Tue

The Dawn of a New Algae-Based Marine Industry in Sweden

Fredrik Gröndahl, Sustainable Development Environmental Science and Engineering (SEED),
KTH Royal Institute of Technology, Sweden

During the last several years, several big projects have studied the possibility to cultivate algae in the sea and on land for the use in integrated bio-refineries producing food, feed, bio-based materials and energy. The projects have so far been successful and the Swedish west coast is now facing the dawn of a new climate-smart maritime industry that doesn't need irrigation and fertilizer, using the vast space in the sea and thus saving valuable land areas. In order to inspect the coming facilities in exposed sea areas, there is a need to reduce the costly use of boats and divers. Thus, there is great interest from this new industry to take part in the development of Autonomous Underwater Vehicles (AUV s) that could be used for the inspection of cultivation rigs. This lecture will focus on the cultivation of algae and the possible impact on the marine ecosystem and the future use of AUVs.

*Associate Professor **Fredrik Gröndahl** is currently running several projects related to algae cultivation and biorefineries. He has a background in marine sciences e.g. marine biology and oceanography. He is also working with sustainability and education and is the author of several text books on that subject. He is also a partner in the SMARC project and he is interested in using AUVs for operation and inspection of algae farms at sea.*

01.10.2019
11:30 - 12:15
Maritime Biology
Fredrik Gröndahl

1st OCTOBER
Tue

A brief introduction to deep learning for generative modeling

Jakob Verbeek, INRIA, France

Visual recognition has experienced drastic transformations due to the adoption of machine learning techniques since the early 2000's, and in particular the widespread adoption of deep Convolutional Neural Networks (CNNs) since 2012. State of the art approaches for tasks such as object detection, image retrieval, or semantic segmentation are now invariably based on CNNs. While extremely successful, supervised deep learning techniques such as CNNs have a number of limitations, including the requirement of large labelled training data sets. In this tutorial we focus on unsupervised deep learning techniques for visual data. These are of interest for a number of reasons, including (i) to learn visual representations without the need for supervised training data, (ii) to learn generative models to synthesize new images, (iii) as a tool to allow structured prediction in supervised tasks. This tutorial covers the basic principles of deep learning and gives an overview of the main paradigms in unsupervised deep learning, including generative adversarial networks, variational auto-encoders, autoregressive models, and invertible flow based models.

01.10.2019
12:15 - 13:00
Maritime Robotics
Jakob Verbeek

Jakob Verbeek *is a senior research scientist at INRIA Grenoble. He obtained "Cum Laude" MSc degrees in Artificial Intelligence and Logic of the University of Amsterdam in 1998 and 2000. In 2004 he received the PhD in Computer Science from the same university. He joined INRIA in 2006 for a PostDoc, was appointment as a permanent research scientist in 2007, and appointed as senior research scientist in 2017. His research interests are on deep and probabilistic machine learning approaches and their applications in computer vision and other domains. He serves an associate editor for the IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI), and formerly for the Image and Vision Computing Journal (2011-2018), and the International Journal of Computer Vision (IJCV, 2014-2018). He has served as an area chair for conferences including BMVC, CVPR, ECCV, and ICCV.*

2nd OCTOBER
Wed

Improving the accessibility of underwater cultural heritage through digital technologies

Fabio Bruno, University of Calabria, Italy

The combined use of acoustic imaging, underwater photogrammetry, Virtual/Augmented Reality (V/AR), and acoustic communications enables the possibility to create high-quality digital 3D reconstruction of underwater cultural assets and to build over them new educational experiences for the large public. The digital reconstructions and the related applications based on VR and AR present an enormous and partially unexploited potential for the tourism sector in order to make the underwater cultural heritage more accessible to both divers and non-divers. Moreover, raising the awareness about the underwater cultural and natural heritage is one of the most effective way to preserve this valuable heritage for the future generations. This presentation describes the studies conducted in the i-MARECulture and BLUEMED projects to document various shipwrecks and ancient submerged structures and the work done for disseminate the results to the large public.
In particular, i-MARECulture aims to develop and integrate serious games, interactive storytelling, immersive technologies and underwater augmented reality for supporting the wide public in acquiring knowledge about the European maritime cultural heritage. On the other side, the BLUEMED project aims to promote the responsible and sustainable access to the underwater cultural heritage for improving the tourism in the Mediterranean coastal areas.

02.10.2019
09:00 - 09:45
Maritime Robotics
Fabio Bruno

Fabio Bruno *is Associate Professor at the Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria (UNICAL). He is cofounder of 2 spin-off companies: 3D Research s.r.l. and Tech4Sea s.r.l.. His research interests include the development of new technologies and systems for the documentation, preservation and exploitation of underwater cultural heritage.*
He has been and is currently in charge of the UNICAL and 3D Research teams in various European projects: INTERREG MED – BLUEMED; H2020 – iMARECULTURE; EASME – "Underwater Cultural Route in Classical Antiquity"; EASME/EMFF Lab4Dive "Mobile Smart Lab for augmented Archaeological Dives"; EASME/EMFF DiveSafe; EASME MedDryDive. He has been the principal investigator of the national project "VISAS – Virtual and augmented exploitation of Submerged Archaeological Sites". He has been in charge of the DIMEG Research Unit in several national projects like: "ITACA – Innovative Tools for cultural heritage ArChiving and restorAtion" and COMAS "Planned in Situ Preservation of Underwater Archaeological Artifacts".

Marine robotics, learning from humans, and communication: the SWAMP example

Massimo Caccia, Consiglio Nazionale delle Ricerche – Istituto di Ingegneria del Mare (CNR-INM), Italy

After a brief overview of how the concept of POrtable Pelagig Autonomous Robotic Technology (POP-ART) is implemented by the Proteus robotic vehicle for polar, harbour and coastal applications in ROV, USSV, and AUV working mode, the prototype USV SWAMP Shallow Water Autonomous Multi-purpose Platform will be presented. In addition to allow applications in ultra-shallow water, being able to operate in less than 30 cm of depth, SWAMP USV paves the way to robotic research in the field of modular distributed self-assembling/disassembling cooperative unmanned marine vehicles as well as in design and implementation of AI-based guidance and control algorithms (machine learning, learning from humans, etc.). Thanks to its innovative mechanical design (pump-jet propulsion, foam-made hull, etc.), SWAMP USV constitutes an easily deployable and safe platform for carrying out experiments involving citizens and students. This is fundamental to support the implementation of research and innovation 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 UMVs working in harbour and coastal areas. Social acceptance of such new technology requires, in the speaker's opinion, the implementation of RDI projects including communication and active involvement of citizens and stakeholders from the early stages of their development. A first example is given by the "SWAMP learning from humans" experiment carried out during the Communication Festival in Camogli on September 14-15, 2019.

02.10.2019
09:45 - 10:30
Maritime Robotics
Massimo Caccia

Massimo Caccia *was born in Genova on the 26 of July1966, and graduated in Electronic Engineering at the University of Genova on the 31st of January 1991. He is currently responsible of the Genova unit of the Institute of Marine engineering (INM-GE) of the Italian National Research Council (CNR). In the period October 16, 2013 – October 15, 2017 and October 16, 2017 – May 10, 2018 he served as Director and Acting Director, respectively, of the CNR Istituto di Studi sui Sistemi Intelligenti per l'Automazione (ISSIA-CNR). After joining CNR on the 2nd of May 1993, his theoretical and applied research activities focused on marine robotics, mainly addressing the topics of modelling and identification, cooperative guidance and control, vision-based motion estimation and control, and embedded real-time platforms and architectures for Unmanned Marine Vehicles. He is among the European pioneer researchers in the field of unmanned surface vehicles. Research results, certified by more than 200 publications in international books, journals and conferences, led to the partnership in a number of EC, national and regional projects. Currently he is the coordinator of the Interreg Maritime Italy-France MATRAC-ACP project, (total budget 863,016.40€), of the Italian PON project ARS01_00682 ARES Autonomous Robotics for the Extended Ship (total budget 9,937,034.33€) and of the EC EMFF-BlueEconomy-2018 Blue RoSES project (total budget 1042725,70€, foreseen to start on December 2019). He was member of the projec steering committee and/or CNR principal investigator in the following EC projects: FP7-SST MINOAS, FP7-SME CART, FP7-ICT MORPH, FP7-ICT CADDY, H2020-TWINNING EXCELLABUST.*

Recording Shipwrecks at the Speed of Light: A Low-Cost, Diver Deployed Underwater Laser Scanning System and Its Efficacy of Use in Maritime Archaeology Compared to Photogrammetry and Sonar in the 4th Industrial Revolution

Michael Murray, University of Southampton, UK

Over the last decade, the modern world has been transitioning into what is known as the Fourth Industrial Revolution. Within archaeology, rapid advancements in the areas of sonar, photogrammetry, LiDAR and 3D Laser Line Scanning are direct products of this transformation and the consequences have been profound. This has dramatically changed the way we record heritage sites in the 21st century as 3D scanning offers an increasing range of versatile and affordably innovative opportunities for collecting, processing, monitoring and disseminating site information using three and four-dimensional datasets in unprecedented ways. As part of a PhD study supported through the University of Southampton's Centre for Maritime Archaeology, underwater laser scanning, its efficacy of use, and its developmental potential in maritime archaeology will be discussed through an experimental methodological approach utlizing a ULS-200 scanner and determining its baselines of operation within different aquatic environments. This may also include more recent laser scanned data of the Gnalic'; a 16th century Venetian shipwreck located off the coast of Croatia, considered to be one of the most important 16th century shipwreck sites discovered in the region. Through scans of its varied features, results are expected to determine the highest degree of relative spatial accuracy of the site at a Beam Intensity of approx. 12% and within an expected +/- 1.7mm of accuracy. Data captured under these settings may also reveal new insights as to its current state of preservation through the generation of reflectivity values indicating the condition of different materials, the resolution of fine linear features that photogrammetry has difficulty resolving, and a determination of the spatial and morphological quality of 3D results obtained on-site in previous years using a novel metrological approach.

02.10.2019
10:45 - 11:30
Maritime Archaeology
Michael Murray

Michael Murray *currently resides in San Diego, California and is a PhD candidate in Archaeology through the University of Southampton where his study involves exploring the use of cutting-edge digital 3D recording techniques for underwater archaeology and marine exploration. He is an accomplished scientific diver, licensed surface-supplied diving technician, traditional sailboat captain, maritime studies educator, and more recently, 3D laser scanning, photogrammetry, and sonar processing specialist. Since 2014, he has been examining the archaeological efficacy of underwater laser scanning compared to close range micro-bathymetry sonar and photogrammetry through a generous grant by 2G Robotics and its post-production interpretive potential using Mixed Reality platforms supported by Oculus. His experience in underwater archaeology dates back to 1997 when he accepted an invitation to work as an assistant for Dr. Jerome Lynn Hall of Texas A&M University excavating the Monti Cristi Pipewreck; a rare 17th century Dutch smuggling ship with the 3rd largest documented cache of clay pipes found in the new world located off the north coast of the Dominican Republic. Mr. Murray has had the good fortune throughout his career of participating*

on several high-profile underwater recording and excavation projects including: a survey of several German and British WWI mine laying submarines in the English Channel in commemoration of the 100th anniversary of the UKs involvement in WWI, the National Geographic sponsored Aucilla River Pre-history project in the Panhandle of Florida looking for evidence of the first Native Americans on the continent, and as one of two lead divers in the 2015 archaeological recording and recovery of artifacts of the CSS Georgia; one of the first Confederate Ironclads built in 1861 during the American Civil War.

Simulation Tools for Underwater Sensor Networks

Marwa Salayma, Institute of Sensors, Signals and Systems, School of Engineering and Physical Sciences, Heriot-Watt University, UK

The combined use of acoustic imaging, underwater photogrammetry, Virtual/Augmented Reality (V/AR), and acoustic communications enables the possibility to create high-quality digital 3D reconstruction of underwater cultural assets and to build over them new educational experiences for the large public. The digital reconstructions and the related applications based on VR and AR present an enormous and partially unexploited potential for the tourism sector in order to make the underwater cultural heritage more accessible to both divers and non-divers. Moreover, raising the awareness about the underwater cultural and natural heritage is one of the most effective way to preserve this valuable heritage for the future generations. This presentation describes the studies conducted in the i-MARECulture and BLUEMED projects to document various shipwrecks and ancient submerged structures and the work done for disseminate the results to the large public. In particular, i-MARECulture aims to develop and integrate serious games, interactive storytelling, immersive technologies and underwater augmented reality for supporting the wide public in acquiring knowledge about the European maritime cultural heritage. On the other side, the BLUEMED project aims to promote the responsible and sustainable access to the underwater cultural heritage for improving the tourism in the Mediterranean coastal areas.

02.10.2019
11:30 - 12:15
Maritime Robotics
Marwa Salayma

Marwa Salayma *is research associate in the Institute of Signals, Sensors, and Systems (ISSS) in the School of Engineering and Physical Sciences at Heriot-Watt University. Marwa is performing research for underwater acoustic sensor networks. Current project: Smart dust for large scale underwater wireless sensing (USMART). Marwa received the PhD degree from Edinburgh Napier University in 2018. She conducted her PhD research in the Centre for Distributed Computing, Networking and Security, and her PhD topic was in the field of Wireless Body Area Networks (WBAN). She received the M.Sc. degree in Computer Science from Jordan University of Science and Technology in 2013, and the B.Sc. degree in Computer Systems Engineering from the Electrical Department, Palestine Polytechnic University in 2007. Her research interests are in wireless communication networks , such as wireless body area*

networks, wireless sensor networks, and underwater acoustic sensor network. Marwa works in proposing Media Access Control (MAC) protocols, cross layering protocols, energy efficient communication, reliable scheduling, and QoS provisioning in wireless networks, and Internet of Things. Marwa is an expert in using networks simulation tools. Her research findings have been published in world leading journals such as IEEE Transactions on Green Communications and Networking, and ACM Computing Surveys, and in prestigious international conferences including IEEE ICC.

Deep Sea Archaeological Survey in the Black Sea – Robotic Documentation of 2,500 Years of Human Seafaring

Rodrigo Pacheco-Ruiz, MMT and The Centre for Maritime Archaeology, University of Southampton, UK

Between 2015 and 2017, the Black Sea Maritime Archaeology Project (Black Sea MAP) discovered and recorded 65 shipwreck sites dating from the 5th/4th Century BC to the 19th Century AD in the Bulgarian EEZ. Using state-of-the-art remotely-operated vehicles to survey the seabed, the team captured more than 250,000 high-definition (HD) photographs, hundreds of hours of ultra-high (UHD) video together with acoustic bathymetric, laser bathymetric, side-scan sonar and seismic data. The wrecks were located in depths from 40 to 2,200 metres – the shipwrecks in the deeper range presented extraordinary archaeological preservation due to the Black Sea's anoxic conditions. This paper will introduce the methods used based on a wide range of deep-sea optic and acoustic survey techniques to create 3D and pseudo 4D models of the shipwrecks. It will focus on a selection of vessels demonstrating the project's survey strategy, as well as adaptations developed in response to operational conditions; the implementation of deep sea robotics to generate georeferenced high-resolution photogrammetric models and the benefits this has as an on-site and post-cruise interpretative tool. It demonstrates that in-theatre acquisition and processing of high-quality datasets is a working reality and has fundamental implications for management, but it also shows the advantages this brings to the archaeological research process: Firstly, in the creation of spatio-temporal models, i.e., 4D representations of a site pre and post archaeological excavation; and secondly, in monitoring effects of change or assessment of threat as part of the long-term management strategy. It also shows the value of a well-funded collaboration between the academia and industry, and that deep water archaeology can and must be totally UNESCO compliant.

02.10.2019
12:15 - 13:00
Maritime Archaeology
Rodrigo Pacheco-Ruiz

Rodrigo Pacheco-Ruiz *is MMT's Underwater Photogrammetry Specialist and resident Maritime Archaeologist. Since joining MMT in late 2018, he has collaborated on the creation and development of MMT's new underwater photogrammetry department, where he is in charge of training and development. He brings expertise as a result of more than 10 years of underwater exploration, mapping and excavation, which he acquired as a member of the Centre for Underwater Archaeology and the National*

Oceanography Centre at the University of Southampton. It is his most recent work in the Bulgarian Black Sea that sees his role as a key member of the Black Sea Maritime Archaeology Project (Black Sea MAP), where he was leading expert in underwater three-dimensional recording mapping using ROVs. More than 65 wrecks were surveyed in a period of two months, ranging from shipwrecks lost in Ancient Greece and Rome to the Medieval period and the Ottoman Empire. Most of them are located below 2000m. His experience in this field has been extensive and varied, participating in a number of commercial and research international projects in the Mediterranean, the North Atlantic Ocean, the Baltic, the English Channel, the Persian Gulf and the Black Sea, as well as inland water sites in the British Isles and Mexico. Rodrigo is a visiting research fellow at the Centre for Maritime Archaeology at the University of Southampton, and an Associate Fellow at the Maritime Archaeology Research Institute (MARIS) at the University of Sodertorn, Sweden. He is also a collaborator at the Institute of Anthropologic Studies from the UNAM in Mexico. Rodrigo is a Nautical Archaeology Society tutor, as well as a HSE Air Commercial Diver.

Development and deployment of an unmanned iceberg observation system for off-shore industry and iceberg modelling

Ralf Bachmayer, University of Bremen, Germany

Besides their apparent beauty and majestic appearance and economic impact on seasonal tourism along the iceberg alley, icebergs represent a significant threat to marine transportation and off-shore operations. Fundamental to the industries iceberg management plan is an escalating iceberg detection-observation-intervention and possible asset relocation plan. In this presentation I will present our approach to provide operators with better and more detailed information about icebergs and their meteorological and oceanographic environment. I will present the development and deployment of an unmanned surface vehicle (USV) SeaDragon. The second part of the overall observation system is a modified Slocum type underwater glider. The co-registered data collected from both platforms, from above and below water will be presented. Both vehicles navigate autonomously around icebergs to collect shape and met-ocean data. To conclude I will show an overview of a new platform under testing, the unmanned submersible surface craft (USSC) SeaDuck. The new vehicle concept is a direct outcome of the operational experience and client input from the operation of USV SeaDragon and the hybrid underwater glider.

03.10.2019
09:00 - 09:45
Maritime Robotics
Ralf Bachmayer

Dr. Ralf Bachmayer *is Professor for Marine Environmental Technology and Deep-Sea Engineering at MARUM – University of Bremen, Germany. His main research interests lie in the domain of marine robotics with a particular focus on unmanned marine systems. In particular he is interested in the design, control and networking of heterogeneous marine observation systems. Dr. Bachmayer received his engineering degree in electrical engineering from the Technical University of Karlsruhe, Karlsruhe, Germany in 1995. He worked at the Woods Hole Oceanographic Institution in the USA as a visiting researcher, received the M.Sc. and PhD degrees in mechanical engineering from the Johns Hopkins University, Baltimore, Maryland and then worked as a Research associate at the Dynamical Control Systems Laboratory at Princeton University and was a Researcher at the National Research Council Canada Institute for Ocean Technology in St. John's. He joined Memorial University in 2008 where he started the Autonomous Ocean systems Laboratory in 2009. He joined MARUM at the University of Bremen in the summer of 2017*

3rd OCTOBER
Thu

Long-term fluctuations of Cystoseira forests along the west Istrian Coast (northern Adriatic, Croatia)

Ljiljana Iveša, Ruđer Bošković Institute, Center for Marine Research, Rovinj, Croatia

The northern Adriatic represents the northernmost and thus the coldest biogeographic sector of the Mediterranean Sea. For this reason, marked changes of the composition of benthic macroalgal communities due to global warming could be expected in this area. The sea bottom along the west Istrian Coast is mainly rocky and therefore particularly suitable for the growth of canopy-forming brown macroalgae of the genus Cystoseira. A series of Cystoseira distribution and demography surveys were conducted during the last 20 years at different depths along the Istrian coast. Comparison with historical data revealed long-term changes of Cystoseira species abundance. A phase of regression, occurring during the last decades of the past century, was followed by a phase of recovery. The composition of Cystoseira forests in the period from 2009-2013 might be considered similar to that assessed during the 1950s. Starting from 2015, a regression of Cystoseira forests was observed at some sites located in the central part of the west Istrian Coast. These sites were not directly threatened by anthropogenic pressure. According to the EU Water Framework Directive, the Ecological Evaluation Index (EEI) and the Cartography of littoral communities (CARLIT), which consider Cystoseira distribution in relation to geomorphological features of the coast, were used for the assessment of the coastal ecological quality. Our recent surveys revealed that along the west Istrian Coast patterns of Cystoseira distribution continuously change likely because of increased seawater temperatures during summer and an intensification unusual benthic microalgal (frequently alien and invasive) and macroalgal blooms (usually filamentous macroalgae of the order Ectocarpales).

03.10.2019
09.45-10:30
Maritime Biology
Ljiljana Iveša

Ljiljana Iveša *is a senior scientific associate at the Center of Marine Research, Institute Rudjer Boskovic. She received her PhD in Biology from the University of Zagreb in 2005. Her fields of research include taxonomy and ecology of macrophytobenthos (seaweeds and seagrasses) with a special interest in ecology of canopy-forming brown macroalgae of the order Fucales and distribution patterns of invasive non-indigenous macroalgal species. Her current research focus on the ecology of coastal habitats of the natural rocky shore as well as the artificial hard surfaces. She is teaching courses for the Bachelor Degree of Undergraduate study programme Marine Science at University Juraj Dobrila in Pula. Since 2009 she is involved in several national projects for the assessment of the ecological status of coastal waters using macroalgal assemblages.*

Autonomous docking and inspection capabilities

Gerard Dooly, University of Limerick, Ireland

The newest addition to the University of Limerick CRIS's infrastructures and equipment is the MRE ROV Étaín – a light weight work class ROV. The ROV was commissioned in Q2 2018 and is controlled using UL's OceanRINGS navigation suite with advanced onboard navigations suite. This talk centers around the first year of operations for the MRE ROV and discusses the technological developments ongoing within the UL research lab. The ROV developments specifically target operations in high energy sites such as offshore wind, with a focus to extend operational weather windows. The discussion also centers on technologies for resident robotics systems such as autonomous intervention, live 3D reconstructions, autonomous docking and advanced imaging systems. Test results are from ship based operations off the Irish coast on a number of sites varying from Shipwreck to Coral Grounds and Oil & Gas infrastructure.

03.10.2019
10:45 - 11:30
Maritime Robotics
Gerard Dooly

Dr. Gerard Dooly *(M) has worked extensively in field robotics at UL for over 10 years. His research interests include real-time 3D reconstruction, optical fibre sensors, subsea structural health monitoring, teleoperation and automated docking & intervention. He is focused on the design and development of robotics and has engaged in numerous field operations and survey missions both here in Ireland and on the continent. Some of his recent offshore operations involved environmental sensing, anti-mine countermeasure ops, remote UAS for incident response, archaeological survey and hybrid long range UAS technologies. He also has a keen interest in underwater shipwreck discovery, survey and identification and has participated in many deep water diving expeditions worldwide. He is a qualified closed circuit trimix rebreather diver and has successfully dived and identified newly discovered shipwrecks to depths of up to 135 metres.*

Explainable AI Planning for Robotics

Daniele Magazzeni, King's College London, UK

As AI systems are increasingly being adopted for the control of robotics and autonomous systems, the challenge of providing explanations and supporting interaction with humans is becoming crucial. Partly this is to support integrated working styles, in which humans and robots cooperate in problem-solving, but also it is a necessary step in the process of building trust as humans migrate greater responsibility to autonomous systems. In this talk we discuss progress made in Explainable AI Planning, particularly in robotics and scenarios involving human-robot teaming.

03.10.2019
11:30 - 12:15
Maritime Robotics
Daniele Magazzeni

Daniele Magazzeni *is an Associate Professor at the Department of Informatics at King's College London, where he leads the Trusted Autonomous Systems hub. He is also the Co-Director of the Centre for Doctoral Training on Safe and Trusted AI. Dan's research interests are in Safe, Trusted and Explainable AI, with a particular focus on AI planning for Robotics and Autonomous Systems, as well as Human-AI teaming. Dan is the President-Elect of the ICAPS Executive Council. He was Conference Chair of ICAPS 2016, Workshop Chair of IJCAI 2017, Program Co-Chair of the Integrated Systems Track at AAAI 2017 and Program Co-Chair of the Robotics Track at ICAPS-18. He is Co-Chair of the IJCAI-19 Workshop on XAI, and Co-chair of the ICAPS-19 Workshop on Explainable Planning.*

Localisation in Marine Robotics

Francesco Maurelli, Jacobs University Bremen, Germany

In recent years, long-term autonomy and persistent autonomy have become key areas of interest for marine robotics researchers. The current generation of Autonomous Underwater Vehicles (AUVs) and Autonomous Surface Vessels (ASVs) have generally limited forms of autonomy and understanding of the environment. This talk addresses the need of greater autonomy and capabilities, improving the cognitive and intelligent layer of marine robotics. The presentation will focus on intelligent localisation techniques, both underwater and on surface, aided by semantic world modelling, fed by sensor processing – sonar underwater, lidar on surface. Results in simulation and in field trials will be presented, and the role of active techniques, involving planning, will be highlighted.

04.10.2019
09:00 - 09:45
Maritime Robotics
Francesco Maurelli

Prof. Francesco Maurelli *obtained his PhD in Electrical Engineering from Heriot-Watt University, in Edinburgh, Scotland, with a thesis focused on intelligent localization of autonomous underwater vehicles. He has worked for more than a decade in the field of autonomous marine robots. He is the Principal Investigator of the Horizon2020 MSCA projet TIC-AUV, in collaboration with Massachusetts Insitute of Technology (MIT), where he spent one year as research scholar, and Jacobs University Bremen. He is the PI of the Erasmus+ IMPACT project for Jacobs University, focused on education and research in marine systems, as well as the PI of the DAAD-funded project "Intelligence and autonomy extension for low cost freshwater inspection vehicles". He is chair of Robotics and Intelligent Systems program at Jacobs University, and co-chair of the IEEE Robotics and Automation Society Marine Robotics Technical Committee. He has been involved in several projects, funded by EU FP6, EU FP7, EU H2020 (FreeSubNet, ARROWS, PANDORA, ECHORD++, TIC-AUV), and from British, Canadian and German national fundings.*

4th OCTOBER
Fri

Cooperative Marine Robotics: Theory and Practice

Antonio Pascoal, Instituto Superior Técnico (IST), University of Lisbon, Portugal

The last decade has witnessed tremendous progress in the development of marine technologies that are steadily affording scientists advanced equipment and methods for ocean exploration and exploitation. Recent advances in marine robotics, sensors, computers, communications, and information systems are being applied to the development of sophisticated technologies that will lead to safer, faster, and far more efficient ways of exploring the ocean frontier, especially in hazardous conditions. As part of this trend, there has been a surge of interest worldwide in the development of autonomous marine robots capable of roaming the oceans freely and collecting data at the surface of the ocean and underwater on an unprecedented scale. Representative examples are autonomous surface craft (ASC) and autonomous underwater vehicles (AUVs). The mission scenarios envisioned call for the control of single or multiple AUVs acting in cooperation to execute challenging tasks without close supervision of human operators. This talk addresses the general topic of cooperative navigation and control of marine vehicles, both from a theoretical and a practical perspective. The presentation builds upon practical developments and experiments. Examples of scientific and commercial missions with ASCs and AUVs, acting alone or in cooperation, set the stage for the main contents of the presentation. From a theoretical standpoint, a number of challenging problems are addressed in the general area of networked systems subjected to stringent communication constraints. Namely, i) cooperative motion control using event-driven control and communications and ii) range-based multiple target localization and tracking using tools from the areas of optimal motion planning and estimation theory. Some of the results obtained are illustrated with videos from actual field tests with multiple marine robots exchanging information over acoustic networks. The core material presented in the talk was obtained in the scope of the following EU-funded projects:

- MORPH (http://cordis.europa.eu/project/rcn/101726_en.html)
- CADDY (http://www.caddy-fp7.eu/),
- WiMUST (http://www.wimust.eu/)
- H2020 EU Marine Robotics Research Infrastructure Network

04.10.2019
09:45 - 10:15
Maritime Robotics
Antonio Pascoal

Antonio Pascoal *has PhD in Control Science from the University of Minnesota, Minneapolis, MN, USA, 1987. Professor of Control and Robotics at IST, University of Lisbon, Portugal. Member, Scientific Council of the Institute for Systems and Robotics (ISR). Founder, Dynamical Systems and Ocean Robotics Lab (DSORLab) of ISR. Coordinator, Thematic Area "Technologies for Ocean Exploration and Exploitation" of the Associate Laboratory of Robotics and Engineering Systems (LARSyS). Adjunct Scientist, National Institute of Oceanography (NIO), Goa India. Expertise in Dynamical Systems Theory, Marine Robotics, Navigation, Guidance, and Control of Autonomous Vehicles, and Networked Control and Estimation with applications to air and underwater robots. His long-term goal is to contribute to the development of advanced robotic systems for ocean resources exploration and exploitation. He has coordinated and participated in a large*

number of international projects that have led to the design, development, and field-testing of single and multiple autonomous marine and air vehicles and systems in cooperation with partners in India (National Institute of Oceanography, Goa), USA (Naval Postgraduate School, Monterey, CA), Korea (KAIST, Daejeon), and Europe. Selected EC funded projects for which he was IST's Principal Investigator include:

i) H2020-ICT-2014-1/ GA 645141 WIMUST: Widely Scalable Mobile Underwater Sonar Technology, 2015-2018;

ii) FP7-ICT-2013-2 GA 611373 CADDY: Cognitive Autonomous Diving Buddy, 2014-2016;

iii) FP7-ICT-2011-7 GA 288704 MORPH: Marine Robotic System of Self-Organizing, Logically Linked Physical Nodes, 2012-2016;

iv) FP7-ICT-2007-3 GA 231378 CO3-AUVs: Cooperative Cognitive Control for Autonomous Underwater Vehicles, 2009-2012;

v) EU-FP6-IST-035223 GREX: Coordination and Control of Cooperating Heterogeneous Unmanned Systems in Uncertain Environments, 2006-2009.

Director, FCT PhD program on Networked Interactive Cyber Physical Systems (NETSyS). Member of the Editorial Board of the Springer Intelligent Systems, Control and Automation Book Series, and Elected Chair, IFAC Technical Committee Marine Systems, from 2008-2014. Member, International Program Committee of numerous conferences on dynamical systems and control as well as marine and aerial robotics. He has published a total of 82 books, book chapters, and peer reviewed journal papers, and 250 conference papers (8161 Citations, h-index 49, i10-index 171 / Google Scholar). He is a co-author of the monograph Time-Critical Cooperative Control of Autonomous Air Vehicles, authors I. Kaminer; A. Pascoal, E. Xargay, N. Hovakimyan, V. Cichella, and V. Dobrokhodov, Elsevier-Butterworth-Heinemann, August 2017. ISBN: 9780128099469

Flow Sensors for Underwater Robots and Oceanography

Maarja Kruusmaa, Tallinn University of Technology, Estonia

This talk will walk the audience through a story of being inspired by extraordinary cognitive skills of fish and sea mammals through see-it-works! laboratory prototypes to field deployable robot sensors and new applications. It will reflect upon how ideas develop and transform while the technology matures. Specifically, we explore the flow sensing of fish and sea mammals, attempts to copy and implement the technology and transformations of the ideas for underwater vehicles sensing and navigation, reconstruction of flow field for problem solving in physical oceanography and applications in aquaculture, harbour security and elsewhere.

04.10.2019
10:45 - 11:30
Maritime Robotics
Maarja Kruusmaa

Prof. Maarja Kruusmaa *is head of the Centre for Biorobotics in the Tallinn University of Technology and a visiting professor in the Norwegian Institute of Science and Technology Centre for Autonomous Marine Operations and Systems. Her research focuses on bio-inspired robotics, soft robotics, underwater robotics, experimental fluid dynamics and flow sensing. She has coordinated and is currently coordinating several European collaborative projects focusing on soft robotics, underwater robots and flow sensing. She has supervised 14 PhD theses and 4 postdoc researchers. Prof. Kruusmaa is a co-founder of the start-up company Fits.me. She serves as a program committee member in various journals and conferences, a member of the advisory board FETAG at European Commission, and is a vice-dean of research and member of the Estonian Academy of Science.*

4th OCTOBER
Fri

The Lusitania Project 17

Peter McCamley, Gas Technologies Ltd, UK

In Sept 16, a very good friend was diagnosed with a possible life threatening illness. All his life he had wanted to dive the Lusitania. Despite many promises to him of being a part of a team, this never materialized. Hence the seeds were sown to put an expedition to the Lusitania together for the summer of 2017. On 23rd February 2017, Team Project 17, were granted a licence to use photographic equipment to ascertain the state of The Lusitania. This work involved using the latest in 4K Technology to map the wreck in 3D and then later the use of photogrammetry software to process the images. This was the first time that this new technology had been used on the wreck. During a six-day period from 25th Aug to 30th Aug 2017, where only one day was lost due to weather, Kari Hyttenin and the team brought back some amazing imagery. This small video relates to two dives on the Bow Section. We would like to thank everybody who assisted in helping to make this objective a reality. returned again in 2018 for to carry on our work, where a team 16 divers had a very successful expedition having met Paddy O Sullivan who has written several books on the Lusitania. Paddy's knowledge of The Lusitania and its particular Cargo in the forward hold has the possibility of explaining the reason why The Lusitania sank in 18 mins. In Aug 2019, we return with a team of 28 divers to carry out three projects:

1: Photogrammetry

2: The use of ROV Equipment, headed by Dr Ger Dooley.

3: Full Ecological Study of the Lusitania, headed by Dr Clare Fitzsimmons

I look forward to seeing you!

04.10.2019
11:30 - 12:15
Maritime Archaeology
Peter McCamley

I have been diving since 1981. I am based in both London & Newry, Co. Down, Northern Ireland. My passion is Closed Circuit Rebreather Technical Deep Wreck Diving and the production of video and photographs of the deep wrecks being dived. My other passion lies in the production of safe fit for purpose gas production for all types of diving. This is carried out through our Company Gas Technologies. I hold the qualification of CCR Rebreather & Open Water Instructor and have been diving a closed circuit rebreather for 10 years, 9 years as a MODIII Diver, with over 3000 hours on Closed Circuit Rebreather. Very fortunate to have been part of dive teams that have dived deep wrecks in Normandy, Italy, Malta, Sardinia, Greece, The Red Sea, Australia, The South China Seas, and particularly ,The Price of Wales and The Repulse, two of the largest British battleships sunk in WWII. In 2012. I was also fortunate to part of a team that dived the USS Saratoga and the Bikini Nuclear fleet that was destroyed by Nuclear Testing in 1946 in the South Pacific in Bikini Atol. In 2017, I was part of a Team to dive HMS Britannic and in 2018 I was very fortunate to be part of a team that dived numerous wrecks, including the WWII wreck of The USS Atlanta that lies in over 130m in Iron Bottom Sound, Guadalcanal in The Solomon

Islands. In 2017, & 2018, I was privileged to lead a Team of International Divers which carried out research projects on the wreck of The Lusitania. In Aug 2019, we will be carrying out 3 Projects on The Lusitania over a 16 day period with a team of 28 CCR Divers. I'm so fortunate to have close to my home, what I consider to be the best wreck diving on the planet, in North Donegal, Ireland.

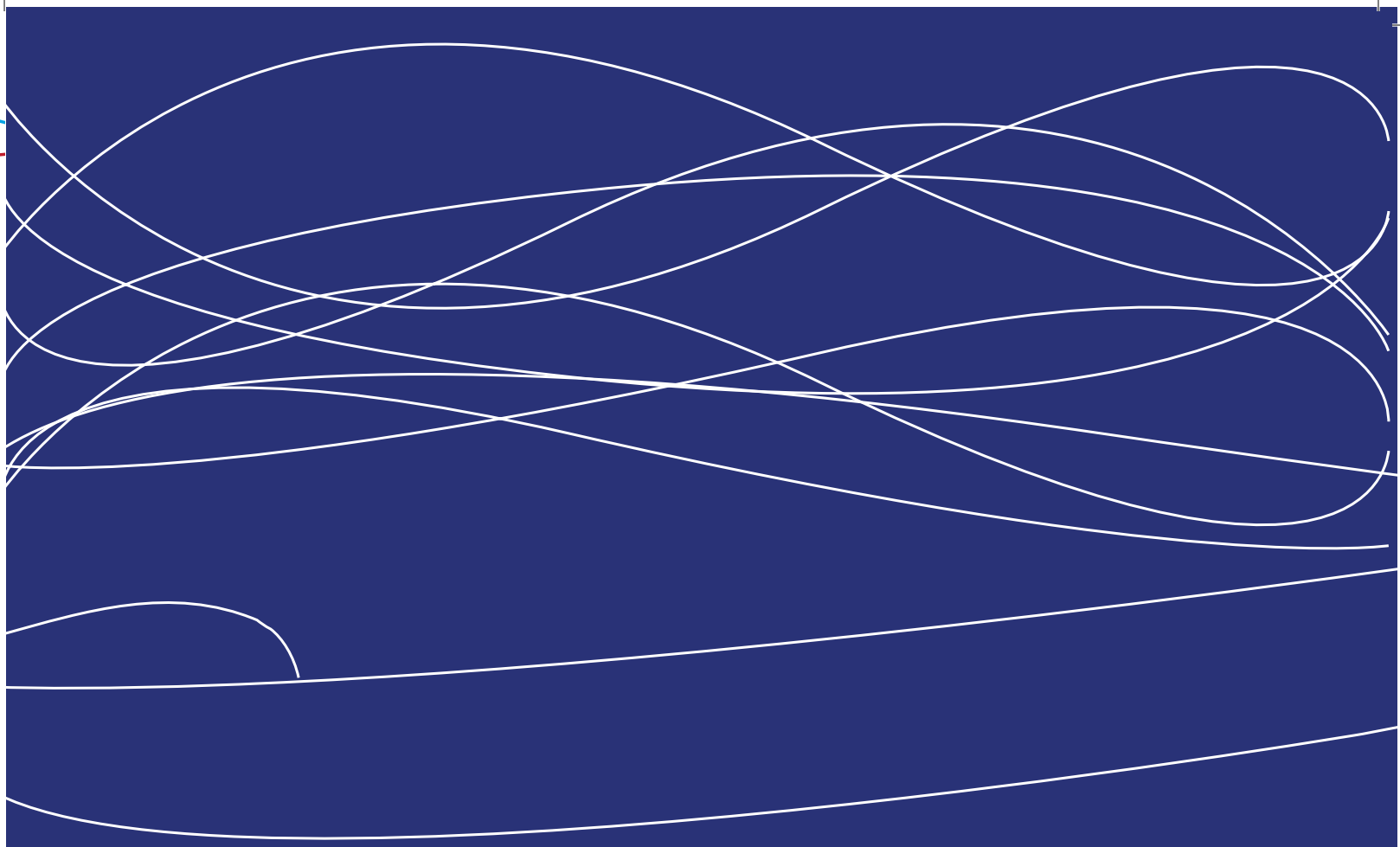
Underwater Cable Inspection and Dual-arm Intervention

Xianbo Xiang, Laboratory of Advanced Robotic Marine Systems (ARMs) Huazhong University of Science and Technology, China

Underwater mission in subsea cable inspection and intervention is quite interesting yet very challenging. Autonomous underwater vehicle (AUV) carrying on dual arms is a promising marine robotic equipment to enable this mission possible. In this talk, firstly, a novel framework integrating the underwater cable localization and robust tracking algorithm is proposed to guide an AUV to inspect subsea cables. Two tri-axial magnetometers mounted on the AUV play an important role to render a simplified magnetic guidance which is capable to localize and track buried cables with very thin diameters. Second, the design of a dual-arm manipulator for underwater intervention is presented, which can be carried on an AUV for possible underwater cable maintenance. This underwater dual-arm tool is highlighted with full electric driven characteristics. Finally, results in numerical simulations and experimental tests in water are disseminated, and some remarks on future work and other running projects at Lab of ARMs conclude this speech.

04.10.2019
12:15 - 13:00
Maritime Robotics
Xianbo Xiang

***Xianbo Xiang**, Ph.D., Professor, Head of Laboratory of Advanced Robotic Marine Systems (ARMs), Deputy Dean of School of Naval Architecture and Ocean Engineering, Huazhong University of Science and Technology (HUST), P.R.China. He received the B.E. and M.E. degrees in automatic control and marine engineering from HUST, Wuhan, China, in 2000 and 2003, respectively, and the Ph.D. degree in System Automation and Mirco-electronics from the University of Montpellier 2, Montpellier, France, in 2011. His research interests include robotic marine vehicles and underwater manipulators. From September 2006 to December 2006, he was an EU Erasmus Mundus Visiting Scholar in the SpaceMaster Project. From February 2008 to March 2011, he was in the European Project FreeSubNet as an EC Marie Curie ESR Fellow at LIRMM, CNRS UMR 5506. Currently, he leads the research Lab of ARMs and builds collaborative connections with international researchers in Croatia, France, UK, USA, etc. He is member of IFAC Technical Committee 7.2 on Marine Systems and IEEE Oceanic Engineering Society. He was the General Chair of 2018 IEEE 8th International Conference on Underwater System & Technology, and serves as the editorial members for International Journal of Intelligent Robotics and Applications, and Journal Brodogradnja/Shipbuilding.*



COMPANY PRESENTATIONS

1st OCTOBER
Tue

Sonardyne Application of Hybrid Navigation and Communication Technology for Marine Robotics

John Houlder, Malik Chibah

The adoption of hybrid navigation and communication technology for marine robotic platforms is increasing. Overview operational case studies where hybrid acoustic, inertial and optical systems have been employed on robotic platforms to improve operational capability and performance. A view on future developments in hybrid navigation and communications will also be presented.

John Houlder *completed a MSC in Hydrographic Survey at University College London in 2013, before going on to work at Swedish survey company MMT. Primarily working offshore as a Hydrographic Surveyor with MMTs fleet of Remotely Operated Vehicles (ROVs) including the world's fastest survey ROV 'Surveyor Interceptor'. Now at Sonardyne, John is responsible for enabling customers to best utilise Sonardyne's range of subsea technologies across a wide range of markets, ensuring that innovative technologies are adopted and used to their full potential.*

Malik Chibah *has over 10 years of experience in the marine technology industry and is the Engineering Director at Sonardyne International, a leading independent global provider of underwater acoustic, inertial, optical and sonar technology. After working in the software industry for 9 years on various development and systems integration projects he gained a Master's Degree in Hydrographic Surveying from University College London in 2007. He then went on to join Sonardyne, initially working in the system test group. His work also includes offshore installation, support, demonstrations and providing training of Sonardyne acoustic products. He then went on to manage the development of Sonardyne's hybrid inertial systems for Subsea vehicles. Following the successful development, launch and roll-out of SPRINT subsea INS into the offshore industry he then became overall manager of Inertial Navigation Systems at Sonardyne in 2014. In his current role as Engineering Director he now oversees the development and delivery of all products and systems, including those for marine autonomy applications.*

01.10.2019
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
John Houlder
Malik Chibah

Blueprint Subsea

Robin Sharphouse, Kevin Webster

02.10.2019
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Robin Sharphouse
Kevin Webster

Founded in 2006, Blueprint Subsea are innovative designers and manufacturers of underwater sonar, positioning and navigation systems. Providing solutions for subsea and offshore markets, Blueprint Subsea offers a diverse and adaptable product portfolio consisting of StarFish sidescan sonars, Oculus dual-frequency multibeam imaging sonars, SeaTrac Micro-USBL acoustic positioning and communication systems, and Artemis, an extensive range of diver navigation and tracking products. Blueprint Subsea continuously strive to incorporate the latest advances in technology while remaining at an affordable cost without compromising on quality or function.

3rd OCTOBER
Thu

Planet Ocean Limited / ecoSUB Robotics Limited

Jérémy Sitbon, Iain Vincent

ecoSUB Robotics Limited is a company spun out of Planet Ocean Limited following a partnership with National Oceanography Centre, Southampton to develop ecoSUB micro AUVs. ecoSUB AUVs are smart, low cost AUV platforms designed to increase access to autonomous systems in the marine environment. ecoSUB AUVs will be at Breaking the Surface to demonstrate up to six AUVs operating together within a network, providing LBL aided localisation and advanced navigation, highlighting how low cost AUVs can cooperate together to enable precise navigation and the ability to respond to dynamic environments.

Jérémy Sitbon *graduated from the engineering school Polytech Paris-UPMC, part of Pierre et Marie Curie University (Paris, France), with a major in Robotics Engineering, where he undertook an internship with the French Defence Procurement working on micro-UAV vision systems. Jérémy joined the ecoSUB team in 2015 as a Software Engineer and is currently appointed as Chief Robotics Engineer, acting as Technical Lead on the ecoSUB range of AUVs. Jérémy is based at the ecoSUB R&D facility at the Marine Robotics Innovation Centre located within the National Oceanography Centre, Southampton.*

Iain Vincent *is a graduate in Marine Environmental Science from the University of Portsmouth, UK. In his current role with the marine science technology supplier Planet Ocean, he has the privilege of working with key marine science institutions across the UK, as well as international manufacturers of sensor technology, and benefits from many productive relationships with members of the science community. Iain has led programs to secure funding for the development of ecoSUB AUVs and has been involved in the concept design, stakeholder engagement, project overview and direction of the ecoSUB program. In 2016, Iain was appointed Director of ecoSUB Robotics Limited, the company formed to spin out the low cost AUV technology developed in collaboration between Planet Ocean and the National Oceanography Centre (NOC)*

03.10.2019
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Jérémy Sitbon
Iain Vincent

4th OCTOBER
Fri

Blueye Robotics

Martin Ludvigsen

The story of Blueye started early 2014. Erik Dyrkoren was working on the idea behind Blueye at Marintek and NTNU AMOS where he met Martin Ludvigsen, Professor of Underwater Technology at NTNU. Together with students, they developed what came to be the first prototype. By now, the Blueye Team consists of over 20 dedicated experts from eight different countries, working on many levels of software, robotics, mechanical- and industrial design, underwater technology, graphical design and business development. Among us are passionate ocean people; be it sailors, cave divers or shark divers. The Blueye Team believes that by empowering people to view, explore and learn about the ocean, people will connect with it and care for it too. This is the reason why the Blueye founders set out on the mission to create and to share the ultimate underwater experience through great product design. All design and development of the Blueye Pioneer underwater drone have taken place in Trondheim, Norway. It is designed for optimal performance in all conditions, from the Arctic oceans to tropical waters, and all the way down to 150 m below the surface.

04.10.2019
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Martin Ludvigsen

Martin Ludvigsen *is Professor and founder of the Applied Underwater Laboratory (AUR-Lab) at NTNU, Trondheim, Norway and has since been managing the lab. Today, the AUR-Lab is considered an essential asset for multidisciplinary marine research at NTNU, facilitating a large body of research. He has also been working with underwater vehicles and operations in the industry inshore and offshore. Since 2014 he has held a Professorship in Underwater Technology at the Department of Marine Technology, NTNU while also being a founder of BlueEye Robotics, a novel portable ROV start-up. He has extensive at-sea experience in arctic waters as well as in benthic environments associated with the Norwegian mid-ocean ridge. He has been involved in a variety of research project both on deep sea research in the upper water column and in the arctic deploying robotic underwater vehicles. Since 2015 has an Adjunct Assoc. Professorship in Marine Technology at the Svalbard University Centre (UNIS) in Longyearbyen. He is currently affiliated scientist of the Centre for Autonomous Marine Operations and Systems (NTNU AMOS).*

TUTORIALS

Autonomous underwater manipulation from a floating I-AUV: Simulation and control strategies

Patryk Cieślak, Underwater Vision and Robotics Lab (CIRS), ViCOROB Institute, University of Girona, Spain

The tutorial will present a set of open-source tools developed by our research group at the CIRS laboratory, directed towards researchers working in all fields of underwater mobile robotics, i.e., control, planning, vision and navigation. This includes a new advanced simulation software called Stonefish and the recently updated AUV software architecture COLA2. The simulator is designed to be a seamless replacement of the real robot or a group of robots, so that the developments can be quickly tested on the real platforms. It is capable of simulating: full dynamics of vehicle-manipulator systems, including hydrodynamics and buoyancy, functioning of underwater sensors and realistic collisions, as well as delivering high quality rendering. The author will present detailed instructions on how to install and use the software so that the listeners can quickly start using it in their research. Apart from the software tools and the topic of robot simulation, the author will discuss control strategies that can be used in autonomous underwater mobile manipulation, focused around the concepts of the Task-Priority control algorithm, supporting both equality and inequality tasks. Using the presented software, the author will show how the control algorithm performs in practical examples, what kind of tasks have to be used to solve specific problems and how to prioritise them. The presented software and the simulated scenarios are part of the EU Marine Robots project, funded by the European Community H2020 Programme, under the grant agreement no. 731103.

30.09.2019
TUTORIAL INTRODUCTION
14:30 - 15:00
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Patryk Cieślak

Patryk Cieślak *received his PhD in 2016 from the Department of Robotics and Mechatronics, AGH University of Science and Technology in Kraków, Poland. He was involved in several projects concentrating around control system design in mobile robotics and manipulator systems. He is also a co-author of a commercial rehabilitation robot called Prodrobot, being a stationary lower limbs exoskeleton, used in the relearning and improvement of natural gait patterns of children. Recently, his research interests focus around autonomous underwater mobile manipulation. For the last two years he worked as a Marie Curie postdoc in the Underwater Vision and Robotics Lab (CIRS) by the University of Girona, Spain. During the project he developed control strategies for compliant autonomous underwater mobile manipulation, utilising a wrist mounted force-torque sensor. He was also involved in works on underwater obstacle avoidance and motion planning. Patryk Cieślak is also the author of a modern open-source simulation software, directed towards underwater robotics community, called Stonefish. Recently, he is continuing his research in CIRS, working on cooperative autonomous underwater floating-base manipulation.*

LSTS Toolchain: Bridging interoperability challenges

José Pinto, Keila Lima, University of Porto, Portugal

In this tutorial, we will showcase the use of Neptus as an interoperability infrastructure for controlling different unmanned vehicles, irrespective of their underlying software platforms. Neptus is a software tool developed at the University of Porto by the Underwater Systems and Technology Lab (LSTS) to plan, monitor and supervise teams of heterogeneous vehicles, in communication-challenged environments. In this session, we will give a Neptus overview and demonstrate how new vehicles can be integrated and become part of a multi-vehicle system by exposing capabilities and performing the assigned behaviors. You will learn how to add your own autonomous vehicles to Neptus and conduct operations by coordinating vehicles running ROS, DUNE and/or MOOS. The tutorial will conclude with a demonstration at sea where vehicles with very different characteristics and control software will be coordinated together using the given approach for an archaeology application.

30.09.2019
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
José Pinto
Keila Lima

José Pinto *is a Researcher at the School of Engineering, University of Porto. He received his Degree in Computer Science from the Faculty of Sciences and a MSc Degree in Computer Engineering at the School of Engineering (both University of Porto). He started conducting research in Autonomous Vehicles back in 2005, when he joined the Underwater Systems and Technology Lab. There he has helped develop the LSTS Toolchain composed of Neptus, IMC and DUNE. He has been at sea numerous times operating multiple AUVs/ASVs/ROVs and is currently responsible for onboard autonomy and planning. His areas of interest include multi-vehicle planning and coordination, onboard autonomy, scientific applications of autonomous vehicles and human-robot interaction.*

Keila Lima *is a Researcher and Software Engineer at LSTS-FEUP, after collaborating with the laboratory during her Masters thesis in 2016. The thesis subject referred to the coordination and command of autonomous vehicles using a domain-specific language, Dolphin, integrated in the LSTS software toolchain. She has been involved in several projects and is currently working on developments on that same software toolchain. She also works on the field as an AUV operator. Her fields of interest include programming languages design and implementation, marine robotics, wireless sensor networks, MANETs (Mobile Ad-hoc Networks), logic and coordination.*

Control and navigation of unmanned robotic systems

Kimon P. Valavanis, University of Denver, USA

The short course provides a comprehensive study of navigation and control of underwater, ground and aerial robotic vehicles. It summarizes kinematics, dynamics and equations of motion, and continues with navigation controller design and implementation. This is followed by an integrated control and diagnostics framework implemented under a modular, hierarchical architecture. Linear, linearized, nonlinear and soft-computing based controller designs are discussed, while specific controller designs are preferred for each family of robotic vehicles. Case studies include simulation and experimental results for several prototype robotic vehicles.

30.09.2019
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Dr. Kimon P. Valavanis

Dr. Kimon P. Valavanis *is John Evans Professor, Director, Research and Innovation, Ritchie School of Engineering and Computer Science, U of Denver. He is Founding Director of the Unmanned Systems Research Institute. He has been Guest Professor in FER, Department of Telecommunications, U of Zagreb, Croatia, and Visiting Faculty at the Politecnico di Torino under the European Research Council, European Commission, Horizon 2020 Scientific Programme, Part 1–Excellent Science. He has graduated 38 PhD students and more than 100 M.Sc. students, attracted and helped attracting close to $50M in research funds from Federal and State agencies, industry and the private sector. His research interests focus on the areas of Unmanned Systems, Distributed Intelligence Systems, Robotics and Automation. He has published more than 400 book chapters, technical journal, referred conference papers, invited papers, including 19 books. He was Editor-in-chief of the Robotics and Automation Magazine, 1996-2005 and since 2006 Editor-in-Chief of the Journal of Intelligent and Robotic Systems. He served as a member of the Robotics and Automation Society Awards Committee and serves as co-chair/chair of the Aerial Robotics and Unmanned Aerial Vehicles Technical Committee. He has served as General, Program, Registration, Local Arrangements Chair in conferences. He was a Distinguished Speaker in the Robotics and Automation Society, IEEE Senior Member, Fellow of the American Association for the Advancement of Science and of the U.K. Institute of Measurement and Control, and Technical Expert of the NATO Science and Technology Organization. He is a Fulbright Scholar. In 2019, he was awarded by IEEE and the Robotics and Automation Society for his 10 years of service as Editor-in-Chief.*

ROS/Neptus Integration Tutorial

Ignacio Torroba, Özer Özkahraman, KTH - Royal Institute of Technology, Sweden

ROS is quickly gaining traction within the AUV community as a readily available middleware that is easy to set up and use. In the larger robotics community, the adoption of ROS and the development of standard robotics software components has led to an accelerated pace of progress over the last several years. In order to gain similar advantages underwater there is a need to connect established AUV open source software to ROS. One such package is Neptus, which has modules for planning, execution and review of AUV missions. Neptus can be used as a high-level, off-board interface to plan missions that are then communicated via IMC to an on-board control system that converts the abstract high-level commands to sequences of more complex control behaviors to be executed by the vehicle. DUNE is an example of one such on-board system with wide support that uses IMC natively. For systems that do not use IMC, there needs to be a conversion from that peer-to-peer messaging paradigm to the ROS publish-subscribe (topic) based paradigm. For example, SMaRC has developed a ROS-based system based on a behavior tree control structure along with simulation environments. The two software systems can communicate through a module that is simultaneously a ROS and IMC node. The result is a way for Neptus to link to ROS in a natural way. This tutorial will describe and demonstrate how the powerful features of the Neptus software can be fully integrated with the SMaRC ROS based system to run behavior tree plans in simulation environments using Gazebo and Simulink that include multiple vehicles, sensor modeling, and vehicle dynamics.

01.10.2019
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Ignacio Torroba
Özer Özkahraman

Ignacio Torroba *earned his Master of Science degree in Robots from the University of Southern Denmark in 2016. He is currently a PhD student at KTH and is working within SMaRC. His focus areas are underwater navigation and SLAM, with special interest in the particular challenges posed by marine environments and the limited sensor capabilities of AUVs.*

Özer Özkahraman *earned his computer engineering bachelor's degree, followed by a Master of Science degree in machine learning in 2017, from KTH. He is currently a PhD student working within the Swedish Maritime Robotics Center, SMaRC, at KTH. His research is primarily focused on multi-agent decision making and coordination. His areas of scientific interests include topics such as decentralised, swarm robotics and exploration.*

2nd OCTOBER
Wed

AUVLib – Sonar data processing for machine learning

Nils Bore, KTH - Royal Institute of Technology, Sweden

In underwater surveys, many different kinds of sonars are used to capture different characteristics of the seafloor. In industrial surveys in particular, large amounts of data are captured and saved for offline processing. Using commercial software, the data can be inspected visually, and processed to produce stitched mosaics or bathymetric maps. In the new era of machine learning, new possibilities open up to further exploit the large amounts of data produced during underwater surveys. In this tutorial, we will introduce the participants to auvlib, an open-source python-based library that facilitates the process of applying machine learning to underwater sonar data. auvlib is able to read many common sonar file formats, and can achieve common tasks such as filtering data, producing bathymetric maps, and visualizing the data. In addition, we will show how to drape bathymetric maps with sidescan data in order to produce correspondences between the sensors that can be used for deep learning. The participants will thus use auvlib to make the full journey from raw sonar data to a trained neural network.

02.10.2019
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Nils Bore

Nils Bore *is a computer vision and state estimation expert working with the SMaRC project at the KTH Royal Institute of Technology. During his PhD in robotics and computer vision, he worked on developing state-of-the-art technologies for the long-term autonomy of service robots as part of the STRANDS project. In the final year of the project, a robot was demonstrated to operate autonomously in the challenging environment of a human work place for half a year. In a series of research articles, Nils applied techniques from machine learning and state estimation on the gathered data, resulting in novel ways of tracking the qualitative evolution of human environments. In his work with underwater vehicles within the SMaRC project, he is now seeking to apply machine learning techniques to novel sensors and environments. Nils is the main person responsible for the development of the software system on the SAM AUV. In that role, he is also investigating software robustness in underwater systems and software-hardware interaction.*

JANUS: The first digital underwater communications standard

Roberto Petroccia, NATO STO Centre for Maritime Research and Experimentation, Italy

For over 70 years, the only underwater (UW) communications standard has been the analogue UW telephone, known as 'Gertrude'. With the rapid rise in the availability and use of autonomous UW assets, there has been a pressing need for a wireless digital UW communications standard that can be used to convey any type of data and support machine-to-machine exchanges. JANUS answers this need and is the result of over 10 years of effort, led by the NATO STO Centre for Maritime Research and Experimentation (CMRE), funded by NATO ACT and involving contributions from many international research centres, modem designers, producers and users. The standard known as JANUS has now been approved by NATO and is to be implemented across naval assets of all 29 NATO nations. But JANUS is not restricted to NATO, indeed not even restricted to military use, but it is open and available to both military and civilian use worldwide. The adoption by NATO navies is just the start. Driven initially by naval demand, we soon expect many UW modems to be offering JANUS as a communication protocol option, and to see its use spread to offshore oil and gas operations, oceanographic surveying, diver support and many other applications. JANUS not only provides an interoperable UW communications protocol for point-to-point communications, but also offers a bootstrapping method for node discovery and the construction of dynamic ad-hoc networks. JANUS also offers the potential to dynamically negotiate and de-conflict operations that may not have been coordinated in prior planning, but which discover each other during operation. This tutorial will describe JANUS and current JANUS-related activities, including at-sea experimentation in support of real-life applications, such as support of Submarine Escape and Rescue (SMER) operations.

03.10.2019
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Roberto Petroccia

Roberto Petroccia *(SM'18) received the Laurea (highest Honors) degree and his PhD from University of Rome "La Sapienza," Italy, in 2006 and 2010, respectively, both in Computer Science. He was a Research Staff member in the same University until 2015. Since 2015, he has been a Research Scientist in the NATO STO Center for Maritime Research and Experimentation, La Spezia, Italy. His research interests include wireless sensor networks, underwater communications, and networking, a field he has contributed to with over fifty papers published in leading venues (h-index 16, i10-index 31, Google Scholar, Apr'19). In the last five years, Dr. Petroccia has participated in more than 20 experimental campaigns at sea where innovative underwater solutions he developed have been extensively tested. Dr. Petroccia has been collaborating with several underwater acoustic modem and vehicle manufacturing companies and research labs to design technologies supporting cooperative underwater networking. He was in the organizing committee of the IEEE UComms 2016 and 2018, and ACM WUWNet 2012 and 2014 conferences. In 2019, he was selected to be part of the OES YP-BOOST programme. Dr. Petroccia is also an invited lecturer of the Master's programme in Ocean Engineering offered by the University of Pisa, Italy, and he has supervised the work of several master's theses and PhD students.*

4th OCTOBER
Fri

Software Defined USBL-Modem (SDM-USBL) - a new product of Evologics

Oleksiy Kebkal, Veronika Kebkal, EvoLogics, Germany

The tutorial contains the explanations to the construction, architecture and application programming interface of the Software Defined USBL-Modem (SDM-USBL) - new product of Evologics GmbH. The tutorial contains a demonstration of application examples and hand-on exersises with real hardware SDM-USBL devices.

*With a Ms in computer science and applied mathematics, **Oleksiy Kebkal i**s 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).*

***Veronika Kebkal** received the MS degree in Applied Mathematics in Moscow State University in 2009 with the Diploma Thesis "Algorithms and Software Development for turbo-coding of S2C-DQPSK signals in underwater acoustic communications". It was the beginning of her scientific activity in the field of underwater acoustic communication. Currently she is working as a software development engineer by Evologics GmbH, particularly in development of the DMAC and network layers (selectable stacks of protocols) for the acoustic modems built upon the Sweep-Spread Carrier technology (S2C-tecnology).*

04.10.2019
Tutorial Introduction
15:00 - 15:30
Hands-on
(divided in 3 groups)
15:30 - 18:30
Tutorial
Oleksiy Kebkal
Veronika Kebkal

DEMONSTRATIONS

1st OCTOBER
Tue

LSTS toolchain: Bridging interoperability challenges

José Pinto, Keila Lima, Manuel Ribeiro, University of Porto - Underwater Systems and Technology Laboratory (LSTS), Portugal

In this tutorial, we will showcase the use of Neptus as an interoperability infrastructure for controlling different unmanned vehicles, irrespective of their underlying software platforms. Neptus is a software tool developed at the University of Porto by the Underwater Systems and Technology Lab (LSTS) to plan, monitor and supervise teams of heterogeneous vehicles, in communication-challenged environments. In this session, we will give a Neptus overview and demonstrate how new vehicles can be integrated and become part of a multi-vehicle system by exposing capabilities and performing the assigned behaviors. You will learn how to add your own autonomous vehicles to Neptus and conduct operations by coordinating vehicles running MAVLink, DUNE and/or MOOS. The tutorial will conclude with a demonstration at sea where vehicles with very different characteristics and control software will be coordinated together using the given approach for an archaeology application.

01.10.2019
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
José Pinto
Keila Lima
Manuel Ribeiro

José Pinto *is a Researcher at the School of Engineering from Porto University. He has received his Diploma Degree in Computer Science from the Faculty of Sciences and a MSc Degree in Computer Engineering at the School of Engineering. He started conducting research in Autonomous Vehicles back in 2005, when he joined the Underwater Systems and Technology Lab. There he has helped developing the LSTS Toolchain composed of Neptus, IMC and DUNE. He has been at sea numerous times operating AUVs / ASVs / ROVs and is currently responsible for onboard autonomy and planning. His areas of interest include multi-vehicle planning and coordination, onboard autonomy, scientific applications of autonomous vehicles and human-robot interaction.*

Keila Lima *is Software Engineer and a AUV operator at LSTS, after being collaborating with the lab during her masters thesis. The thesis referred to the coordination and command of autonomous vehicles using a DSL, Dolphin, integrated in LSTS software toolchain. She has been working in different parts of the toolchain, but mostly on the command and control unit Neptus (developments and operations).*

Manuel Ribeiro *is a Software Development Engineer with a Master's degree in Informatics Engineering with a specialization in Software Engineering from Faculty of Sciences of the University of Lisbon. He works as an AUV operator and a RPAS pilot with building, testing, operating and piloting experience. His Master's thesis*

focused on the development of a language for coordination of multiple autonomous vehicles on a network (NVL: Networked Vehicles Language). He is a researcher at LSTS in the University of Porto since 2013, where he is working on the development of the command and control unit (Neptus) for the operation of different types of unmanned vehicles and has been working on projects related to network cooperation of autonomous vehicles.

ULS-200 Underwater Laser Scanning Demonstration Information

Michael Murray, University of Southampton, UK

In 2007 2G Robotics invented a series of deployable underwater laser line scanners (ULS-100, 200 and 500) to provide the highest resolution, precision and spatial accuracy of a 3D model generated delivering millimetric levels of detail captured within an aquatic environment under the right conditions (www.2grobotics.com).This has provided an unprecedented means within the commercial maritime industry to obtain micro-analytical 3D and 4D time series analyses of submerged assets, by reducing assumptions, risks and costs to stakeholders well beyond other means of recording. However, underwater laser scanning has not been easily adopted or acquired through its historically high cost, specialized level of training to operate and considerable power requirements. Nevertheless, within the past few years these limitations have become greatly reduced or eliminated and a ULS-200 model by 2G Robotics presents a highly effective, small, affordable and versatile option for the marine science researcher. Nevertheless, little is known as to what extent this affordable laser line scanner can do within various highly dynamic aquatic conditions and its potential to become an even more powerful tool for research with the incorporation of machine learning (AI) during the scanning process and for post-processing. In order to better understand these considerations, an in-water demonstration of this system of the ULS-200 will be performed by Michael Murray in a 2m deep pool at BtS by scanning various materials of known sizes and textured surfaces at different ranges. An examination of the data quality will then be assessed through the open source CloudCompare application. Throughout the demonstration a description of its essential components and requirements, and its advantages and disadvantages of use to the marine science researcher will be discussed concluding with considerations of its future potential.

02.10.2019
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
Michael Murray

Michael Murray *currently resides in San Diego, California and is a PhD candidate in Archaeology through the University of Southampton where his study involves exploring the use of cutting-edge digital 3D recording techniques for underwater archaeology and marine exploration. He is an accomplished scientific diver, licensed surface-supplied diving technician, traditional sailboat captain, maritime studies educator, and more recently, 3D laser scanning, photogrammetry, and sonar processing specialist. Since*

2014, he has been examining the archaeological efficacy of underwater laser scanning compared to close range micro-bathymetry sonar and photogrammetry through a generous grant by 2G Robotics and its post-production interpretive potential using Mixed Reality platforms supported by Oculus. His experience in underwater archaeology dates back to 1997 when he accepted an invitation to work as an assistant for Dr. Jerome Lynn Hall of Texas A&M University excavating the Monti Cristi Pipewreck; a rare 17th century Dutch smuggling ship with the 3rd largest documented cache of clay pipes found in the new world located off the north coast of the Dominican Republic. Mr. Murray has had the good fortune throughout his career of participating on several high-profile underwater recording and excavation projects including: a survey of several German and British WWI mine laying submarines in the English Channel in commemoration of the 100th anniversary of the UKs involvement in WWI, the National Geographic sponsored Aucilla River Pre-history project in the Panhandle of Florida looking for evidence of the first Native Americans on the continent, and as one of two lead divers in the 2015 archaeological recording and recovery of artifacts of the CSS Georgia; one of the first Confederate Ironclads built in 1861 during the American Civil War.

EvoLogics

Oleksiy Kebkal, Konstantin Kebkal

EvoLogics will demonstrate the following systems

Demonstration of the basic functionalities of AUV System developed for BONUS SEAMOUNT project – new innovative underwater vehicle system for detection, monitoring and studying submarine groundwater discharge and associated nutrient fluxes.

BONUS SEAMOUNT technology integrates and optimizes sensors in bionic underwater vehicles of versatile character, adaptable to the objectives and characteristics of each mission. AUVs are equipped with innovative NOA DRIVE bionic propulsion system for improved AUV payload capacity and maneuverability. After completing the development the BONUS SEAMOUNT system will be used for simultaneous inspection of the seabed and the water column in order to obtain complex data, relevant for the understanding of the implications of the seabed morphology and geological characteristics on the occurrence of submarine groundwater discharge.

Demonstration of underwater sensor network.

Two underwater multiparameter probes, used as sources of sensor data integrated with underwater acoustic modems, will be requested via underwater acoustic network to transmit recent measurements of several selected water parameters. The sensor data will be delivered via the network using different networking scenarios. The network will represent a set of stationary and mobile underwater acoustic network nodes. The operation of the network will be visualized on a large TV screen at the coastal operation center.

3rd October Thu

Demonstration of one of the special network modes – long baseline positioning mode.
The nodes of the underwater acoustic network will be used for position estimation of unmanned vehicle SONOBOT moving in the coverage zone of the underwater network nodes (baseline nodes). The operation of the vehicle and the network will be visualized on a large TV screen at the coastal operation center.

Demonstration of basic functionalities of the SYMBIOSIS system. - A holistic opto-acoustic non-invasive system to monitor coastal and deep waters for fish stock, and to assess the environmental health by monitoring key pelagic fish species.
Demonstration of the prototype will include separately the operation of its underwater optical part (synchronized underwater flash light and camera operations), as well as its underwater acoustic part (operation of the software defined USBL modules).

03.10.2019
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
Oleksiy Kebkal
Konstantin Kebkal

With a Ms in computer science and applied mathematics, ***Oleksiy Kebkal i****s 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 (Ukraine) in 1995 and his PhD in Electronic Engineering from the Technical University Berlin (Germany) 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.*

4th OCTOBER
Fri

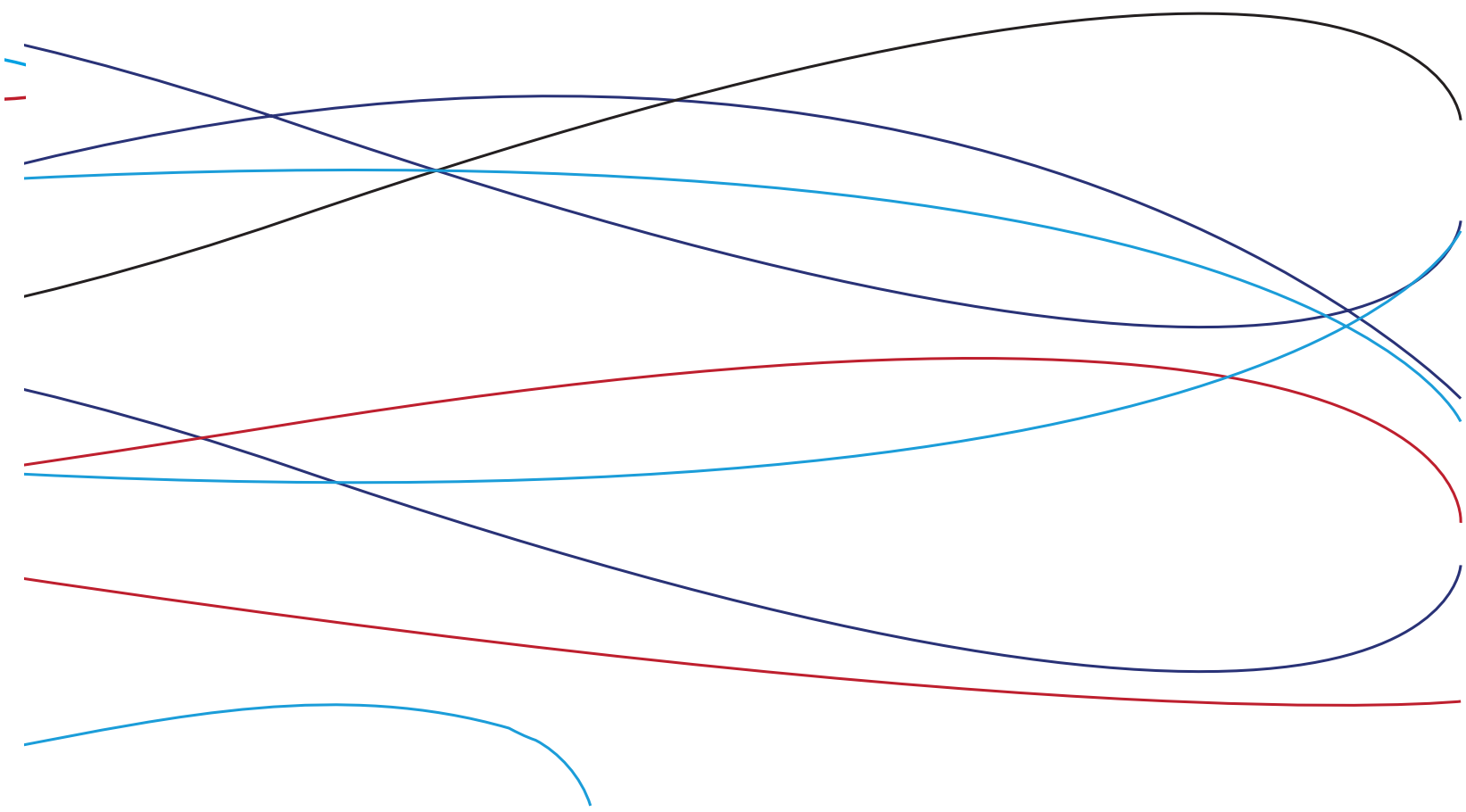
Autonomous underwater manipulation from a floating I-AUV: Simulation and control strategies

Roberto Petroccia, NATO STO Centre for Maritime Research and Experimentation, Italy

For over 70 years, the only underwater (UW) communications standard has been the analogue UW telephone, known as 'Gertrude'. With the rapid rise in the availability and use of autonomous UW assets, there has been a pressing need for a wireless digital UW communications standard that can be used to convey any type of data and support machine-to-machine exchanges. JANUS answers this need and is the result of over 10 years of effort, led by NATO STO Centre for Maritime Research and Experimentation (CMRE), funded by NATO ACT and involving contributions from many international research centres, modem designers, producers and users. The standard known as JANUS has now been approved by NATO and is to be implemented across the naval assets of all 29 NATO nations. But JANUS is not restricted to NATO, indeed not even restricted to military use, but open and available to both military and civilian use worldwide. This demo is combined with the tutorial "JANUS: The first digital underwater communications standard". It will provide more hands-on information to better understand how to implement and use the first digital underwater communications standard, including how JANUS overcomes the barrier of interoperability of current underwater acoustic modems.

04.10.2019
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
Roberto Petroccia

Roberto Petroccia *(SM'18) received the Laurea (highest Honors) degree and his PhD from University of Rome "La Sapienza," Italy, in 2006 and 2010, respectively, both in Computer Science. He was a Research Staff member in the same University until 2015. Since 2015, he has been a Research Scientist in the NATO STO Center for Maritime Research and Experimentation, La Spezia, Italy. His research interests include wireless sensor networks, underwater communications, and networking, a field he has contributed to with over fifty papers published in leading venues (h-index 16, i10-index 31, Google Scholar, Apr'19). In the last five years, Dr. Petroccia has participated in more than 20 experimental campaigns at sea where innovative underwater solutions he developed have been extensively tested. Dr. Petroccia has been collaborating with several underwater acoustic modem and vehicle manufacturing companies and research labs to design technologies supporting cooperative underwater networking. He was in the organizing committee of the IEEE UComms 2016 and 2018, and ACM WUWNet 2012 and 2014 conferences. In 2019, he was selected to be part of the OES YP-BOOST programme. Dr. Petroccia is also an invited lecturer of the Master's programme in Ocean Engineering offered by the University of Pisa, Italy, and he has supervised the work of several master's theses and PhD students.*



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