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Member Benefits—Did You Know?

Career Resources

Look No Further than IEEE DataPort™ to Manage Your Data.

Engineers and researchers are often faced with the challenge of finding a central location to store, access, or share their research with the larger global technical community. IEEE offers IEEE DataPort as a solution to this challenge by providing users a web-based data platform to manage their datasets in one trusted location. Uploading datasets on IEEE DataPort can

generate citations for one's research, allows users to collaborate with other data owners, and link manuscripts.

IEEE DataPort standard dataset uploads are currently free for all and for a limited time Open Access datasets can be uploaded at no cost using the promotion code OPENACCESS1 at checkout.

For more information visit <https://www.ieee-dataport.org/>

From the OES BEACON Editors

Harumi Sugimatsu and Robert Wernli

Welcome to the December 2019 issue of the Beacon. The latest changes to all our committees and volunteers can be found on the inside of the front and back covers. One change you may notice is the removal of email addresses, which had to be done due to a significant financial phishing attack using our emails. So, please maintain your contact list.

Again, we'd like to thank all of the contributors to our quarterly newsletter. As you can see by the content, this is your newsletter, and we try to cover all aspects of the society activities from our workshops, symposia and conferences to what our individual members, chapters and committees are up to. And, don't forget, all issues of the Beacon are available on the OES website.

Of particular interest in this issue is the report From the President where the results of our recent 5-year review are discussed along with the future goals of OES. Also included are the reports on our latest OCEANS 2019 Seattle conference that covers the conference in general and also the results of the Student Poster Competition, along with the winning paper.

The Journal EIC again provides recently released papers that are available to our members and our VP for Technical Activities provides the latest on our technical committee activities. In addition, a year-end report is provided by our outgoing VP for Professional Activities. And, continuing our technology committee reports, we have reports from the Polar Oceans TC and also the Ocean Observation and Environmental Sustainability TC. There is also a report by the Ocean Sustainable Energy Systems (OSES) Technology Committee on the OSES conference held last July in Brest, France. There are 12 technology committees as shown on the inside of the back cover of this issue ... get involved and enhance your career.

There is plenty going on in our chapters as reported in the articles from Providence, Seattle, Malaysia and Canadian Atlantic. Our student chapters are busy as reported by the OES University of Zagreb Student Branch Chapter when they attended OCEANS 2019 Marseille and the IEEE/OES chapter in Ecuador during a student tour of the Ecuadorian coast. In addition, OCEANS 2020 Singapore provides an excellent overview of why you should attend the Singapore conference next April.

The Beacon continues to report on member activities in the robotic field. This issue includes a report on the OES support to the RoboSub competition held each year in San Diego. OES provides judging support and gives one of the teams the OES Innovation Award that includes a cash prize.

We also take pride in our members. Be sure to see the latest articles on Member Highlights, Member Awards and "Who's Who in the OES." In addition, we have excellent reports on the



Your Beacon EIC busy in her office.



Your Co-EIC, and his wife, Bev, promoting his books at the San Diego Festival of Books.

2019 WIE International Leadership Summit and also from three student branch chapter representatives funded by OES to attend OCEANS.

Of particular interest in this issue is the result of our ExCom elections and a thank you to our outgoing AdCom and ExCom officers. And, last but not least, the results of the annual OES awards honors those recipients. Congratulations to all involved.

There is a wealth of other information and articles in this issue that we hope you enjoy. And, as always, we'll close by inviting you to participate in your society. Submit articles and material for the Beacon. Or ... volunteer for other society activities as a participant or an elected officer. It's your society and it is here to help you reach your professional goals. Enjoy.

From the President

Christian de Moustier, OES President

2019 has been a busy year for the Oceanic Engineering Society (OES), culminating with the Society's 5-year review by the IEEE Society and Council Review Committee (SCRC). This is a comprehensive review that involves a self-assessment with a detailed questionnaire, a face-to-face meeting at the end of November 2019 with the IEEE volunteers who serve on the SCRC, and a final report with comments and recommendations by the SCRC. This review provides a good opportunity to share with you the highlights of our Society.

OES has about 1800 members distributed geographically over all 10 IEEE Regions. For perspective, IEEE has over 422,000 members and comprises 39 technical Societies and 7 technical Councils [1–3].

OES is governed by an Administrative Committee (AdCom) of 18 members elected by the entire OES voting membership, and an Executive Committee (ExCom) of 10 officers drawn from and elected by the AdCom. Together, members of the AdCom and ExCom represent 9 of the 10 IEEE Regions, which is an accomplishment given the size of our membership.

In response to comments made by the SCRC at its previous quinquennial review of the Society in 2014, OES has developed a 10-year strategic plan that was adopted by formal vote of the AdCom in September 2016. Now 3 years later, I am pleased to report that OES has implemented most of the elements of its near-term operational plan that emphasized outreach, conferences, and partnerships.

The OES promotion and outreach activities have been augmented by a social media initiative started in 2018 and continuing into 2020. This initiative has contributed to a renewed interest in OES and a quantifiable increase in networking among OES members on Facebook, Twitter, and LinkedIn. As part of the initiative, the online magazine Earthzine (earthzine.org), launched in 2005 by Paul E. Racette in support of the erstwhile IEEE Committee on Earth Observation, has transitioned to a volunteer-run OES online open-access publication for communicating developments and community interests pertaining to studying the Earth and its many bodies of water.

Thanks to a particularly effective Editorial Team for the quarterly OES Beacon newsletter, you are getting more news on the activities of OES Chapters and Student Branch Chapters, and on Student competitions. More frequent updates on Society activities are now posted on the newly redesigned and upgraded OES website (ieeooes.org).

In conjunction with the social media initiative, Earthzine, Beacon and the IEEE Journal of Oceanic Engineering (JOE) are



Christian de Moustier

PHOTO CREDIT: STANLEY CHAMBERLAIN

cooperating to create more opportunities and build a wider audience for OES members to share their scientific and engineering results and advances. Meanwhile, OES-sponsored and co-sponsored conferences, workshops, and symposia continue to provide essential face-to-face networking opportunities.

The growth in OES-sponsored events has led us to restructure OES operations with new lines of responsibility. The OCEANS conferences continue to be managed in an equal partnership with the Marine Technology Society (MTS), but within OES, they are now under a single line of responsibility headed by

the OES Vice President (VP) for OCEANS. In addition, all OCEANS conferences are now hosted on a dedicated website (oceansconference.org) where you can preview future venues and find opportunities to get involved.

The portfolio of all other OES-sponsored and co-sponsored conferences, workshops, and symposia is now under a single line of responsibility headed by the VP for Workshops & Symposia. The portfolio includes well-established events (e.g. AUV, CWTM, UComms, UT [4]) and a growing number of events emanating from the OES Technology Committees and the Chapters. The 3-year AUV initiative started in 2017 by the AUV Technology Committee has been very successful with workshops and student competitions. It is now expanding into South America with competitions and workshops planned for 2020 in partnership with the international *Breaking the Surface* field workshop (bts.fer.hr).

Under the leadership of the VP for Technical Activities, the OES Technology Committees have been restructured and consolidated from 18 to 12, and they have been given competitive incentive funding to develop new initiatives, workshops, symposia, Advanced Study Institutes, etc. The VP for Technical Activities has also been given oversight of OES Chapters with competitive incentive funding for Chapters to develop local projects such as student competitions, workshops, Distinguished Lecture events, etc.

The OES student scholarship program has been converted into a competitive incentive program to support OES Student Branch Chapters and foster student-run events (e.g. AUV competitions).

A new OES Young Professional Boost program (YP-Boost) recruits YPs interested in getting involved in the leadership of OES. The program provides them with travel funds to attend AdCom meetings at OCEANS conferences while also serving as judges in the Student Poster Competition and in other capacities. In October 2018, Fausto Ferreira and Shyam Madhusudhana, 2 YP-Boost

members, were appointed by the AdCom to serve the remaining terms of seating AdCom members who had relinquished their seat upon being elected to ExCom Offices.

At the conclusion of the 2019 quinquennial review, OES will develop an updated implementation plan for the next 3 years.

OES needs your participation to help run the Society, so consider running for election to the AdCom in 2020, and as voting members of OES, you will elect 6 new AdCom members to serve a 3-year term (2021–2023).

References

- [1] <https://www.ieee.org/about/today/at-a-glance.html>
- [2] https://www.ieee.org/content/dam/ieee-org/ieee/web/org/about/organization_summary.pdf
- [3] <https://ta.ieee.org/preview-operations>
- [4] Autonomous Underwater Vehicle (AUV), Current Waves and Turbulence Measurements (CWTM) Underwater Communications and Networking (UCOMMS), Undersea Technology Symposium (UT)

VPTA Report—Funding for Technical Activities

Malcolm Heron, OES Vice President for Technical Activities



At each OCEANS event (twice a year) we hold a meeting for Technology Committee chairs, and another for Chapter Chairs. Of course we do not expect that the team of chairs (I do not know the collective term for chairs) to be at every OCEANS, so we make the invitations wide to include folk who can deputise for the chair—or indeed anyone who wants to see what is going on. At the TCC meet-

ing in Seattle we discussed the proposal to create a web page for each TC. Go to www.ieeeoes.org/technical-activities/technology-committee/ to see the existing page links from the

Autonomous Maritime Systems TC, the Polar Oceans TC, and the Standards TC. The idea is two-fold. One aspect is to have a list of the executive group for the TC on the web site. This will be the reference group for the chair of the TC and will make succession planning easier. The second aspect is to have a place to record events led by the TC and to promote future events. Workshops and symposia run by the TCs is a major growth area for OES. You can see some of the results of this in the section in this issue of Beacon for Technology Committee activities.

The next thing on the job-list for Shyam (TC Coordinator) and yours truly, is to encourage OES members to affiliate with one or more of the TCs. If you want to be a part of these activities please contact the relevant Technology Committee Chair, or Shyam.

The ball is at your feet ...

VPPA Report—How Much Is Too Much?

Jim Collins, OES VP for Professional Activities



The IEEE and its thirty-nine technical societies offer a comprehensive variety of technical and professional resources to members. How is it possible for a small society like the Oceanic Engineering Society (OES) to offer its 1744 members the quantity and quality of benefits of a large society like the Computer Society with 42,285 members?

According to the October 2019 IEEE Membership Development

Report the IEEE is the host organization of 39 technical societies ranging in size from 563 members to 42,285, respectively the Professional Communication Society and the Computer

Society. With a total of 312,527 society memberships this gives an average of 8013 memberships per society. The median number of memberships is about 4800. With 1744 members the Oceanic Engineering Society is the 6th from the low end of society memberships.

In terms of annual technical activity, OES offers:

- Two major OCEANS Conferences
- Two Offshore Technical Conferences
- Four issues of the OES Journal
- Several workshops and symposia
- Student autonomous marine vehicle competitions
- Student paper competitions at OCEANS conferences
- A Distinguished Lecturer (DL) program

None of these activities depend on the existence of significant membership in a specific location. We have meetings at

many locations where there may or may not be Chapters or even many members. DL's can deliver presentations to Sections or other groups and do not need to depend on Chapters for their audience. Attendees may typically be from many of the world's developed countries or perhaps a local area.

In terms of membership and geographic activity, the IEEE offers a Region and Section structure around the world to give additional local service to members above that offered through the technical structure described above. This includes the following activities that do not require a technical focus such as:

- Women in Engineering
- Young Professionals
- Sections
- Membership and Chapters

- Student Activities and Student Branch Chapters
- Web and Social Media
- The OES Beacon
- Earthzine
- eNewsletter
- Professional Activities Committees for Engineers

I suggest that, as a very active society, the OES may be in danger of over extending its membership resources. Much larger IEEE societies than OES offer a similar quality and quantity of technical and membership services. They have a membership quantity better able to support this activity. So, how does OES do all of the above? Through a lot of effort by its members who are always looking for others to share the load. We appreciate any suggestions and especially additional volunteers?

From the Journal Editor's Desk: IEEE Journal of Engineering Early Access Papers

Mandar Chitre, Journal Editor-in Chief

Congratulations to the authors of our most recently approved papers for the IEEE JOE. The following papers were published as Early Access papers online on IEEE Xplore and will appear in regular issues soon. You'll find these papers now:

- P. Zhou; C. Yang; S. Wu; Y. Zhu, "Designated Area Persistent Monitoring Strategies for Hybrid Underwater Profilers".
- M.F. Auvinen; D.R. Barclay; M.E.W. Coffin, "Performance of a Passive Acoustic Linear Array in a Tidal Channel".
- W. Maleika; P. Forczmański, "Adaptive Modeling and Compression of Bathymetric Data With Variable Density".
- K. Mizuno; K. Terayama; S. Tabeta; S. Sakamoto; Y. Matsumoto; Y. Sugimoto; T. Ogawa; K. Sugimoto; H. Fukami; M. Sakagami; M. Deki; K. Kawakubo, "Development of an Efficient Coral-Coverage Estimation Method Using a Towed Optical Camera Array System [Speedy Sea Scanner (SSS)] and Deep-Learning-Based Segmentation: A Sea Trial at the Kujuku-Shima Islands".
- J. Yu; T. Wang; Z. Wu; M. Tan, "Design of a Miniature Underwater Angle-of-Attack Sensor and Its Application to a Self-Propelled Robotic Fish".
- R.-Y. Yang; H.-J. Tang; C.-C. Huang, "Numerical Modeling of the Mooring System Failure of an Aquaculture Net Cage System Under Waves and Currents".
- M. Razzanelli; S. Casini; M. Innocenti; L. Pollini, "Development of a Hybrid Simulator for Underwater Vehicles With Manipulators".
- S. Zhao; Z. Wang; K. He; Z. Nie; H. Liu; N. Ding, "Investigation on Stochastic Model Refinement for Precise Underwater Positioning".



- E. Westman; M. Kaess, "Degeneracy-Aware Imaging Sonar Simultaneous Localization and Mapping".
- F.D. Lagor; K. Ide; D. A. Paley, "Non-Gaussian Estimation of a Potential Flow by an Actuated Lagrangian Sensor Steered to Separating Boundaries by Augmented Observability".
- E.K. Jørgensen; T.I. Fossen; T.H. Bryne; I. Schjølberg, "Underwater Position and Attitude Estimation Using Acoustic, Inertial, and Depth Measurements".
- K.T. Hjelmervik; H. Berg; T. S. Sæstad, "Predicting False Alarm Rates for High-Resolution

Antisubmarine Warfare Sonars in a Cluttering Environment Prone to False Alarm Rate Inflation".

- A. Agarwal; M. Agrawal; A. Kumar, "Higher-Order-Statistics-Based Direction-of-Arrival Estimation of Multiple Wideband Sources With Single Acoustic Vector Sensor".
- A.M. Young; N.R. Atkins; C.J. Clark; G. Germain, "An Unsteady Pressure Probe for the Measurement of Flow Unsteadiness in Tidal Channels".
- P. Cardenas; E.A. de Barros, "Estimation of AUV Hydrodynamic Coefficients Using Analytical and System Identification Approaches".
- H. Gazzah; S.M. Jesus, "Closed-Form Estimation of Normal Modes From a Partially Sampled Water Column".
- G. Li; H.P. Hildre; H. Zhang, "Toward Time-Optimal Trajectory Planning for Autonomous Ship Maneuvering in Close-Range Encounters".
- T.I. Lønmo; A. Austeng; R.E. Hansen, "Improving Swath Sonar Water Column Imagery and Bathymetry With Adaptive Beamforming".
- A.L. Virovlyansky; A. Kazarova; L. Lyubavin, "Matched Field Processing in Phase Space".

OES Society Awards

Photos by Stan Chamberlain

The OES Society Awards Ceremony was held during the Wednesday Plenary at OCEANS 2019 Seattle. We are honored to introduce the following 2019 OES award recipients. Congratulations!

2019 Distinguished Technical Achievement Award: William Kirkwood

William (Bill) Kirkwood was presented the Distinguished Technical Achievement (DTA) award for excellence in research and development of underwater vehicles, and associated technologies.

Bill's experience in the Oceanic Engineering Society started in the 1990's as a member, then in 2003 he started the Autonomous Underwater Vehicles tutorial series and became an OES Administrative Board Member (ADCOM) in 2008 and became a Senior Member in 2010. Bill has served as Assistant to the Treasurer for 4 years and then as OES Treasurer for 4 years from 2013 to 2017. Bill also Co-Chaired OCEANS' 16 Monterey, which brought the largest number of abstracts submissions to date and one the highest attendance records at an OCEANS conference. Bill served as Chair of the Unmanned Maritime Vehicles (UMV) and Submersibles Technical Committee and supported AUV Symposia from 2008 until 2018. Bill stepped down to the role of Co-Chair in 2018 moving Dr. Hanumat Singh into the leading role. He also Chaired the Technical Committee on Innovative Technology, a startup proposition for new growth. Bill moved the Innovative Technology committee into the UMV committee

and reformed the committee to Autonomous Maritime Systems, bringing Aerial, Surface and Subsurface platforms as well as supporting equipment under one umbrella. Currently Bill is focusing on new initiatives, working with the Office of Naval Research and a number of institutions around the globe to bring more innovation to autonomous systems and comparative competitions around the globe through the creation of an advisory body.

Currently the Senior Research and Design Engineer for the Monterey Bay Aquarium Research Institute (MBARI), Bill has been focused on the applied research and development of next generation technologies for the advancement of ocean science. Creating technical solutions to ocean problems has been the core of his work for almost 35 years.

Bill's primary expertise is in subsea robotic vehicles and instrumentation. As project manager and mechanical designer, Bill lead the development of the ROV Tiburon platform. Later, Bill was the MBARI project manager on the Dorado class AUV co-developed with Sea Grant at the Massachusetts Institute of Technology. Bluefin Robotics Inc., a small to medium sized underwater robotics company, spun out from this effort and commercialized the resulting vehicle system, which is now a division of General Dynamics Mission Systems. Bill patented and licensed the distinctive blue ringtail used on the Bluefin 21 AUV's. Bill further developed AUVs as project manager and lead designer for MBARI's mapping AUV, which operates 9 acoustic devices simultaneously and is still in high demand as one of the premier mapping systems for science in the world. Bill's more recent work has centered on instrumentation for multidisciplinary biogeochemistry research. Bill's efforts have created a plug and play 4000 meter rated laser Raman instrument and precision positioning systems for in situ optical spectroscopy. Bill was also Co-PI and project lead on the Free Ocean CO₂ Enrichment (FOCE) experiments studying the impacts of ocean acidification (OA). The FOCE system is a combination robot and instrument performing in situ closed looped control of pH resulting from the anthropogenic release of CO₂. The control loop is based on predictive models of atmospheric CO₂ and allows scientists to "dial" in a future pH to observe the potential impacts of higher pH and the resulting lowering of oxygen. Several FOCE systems have been built and deployed around the globe, including the Mediterranean, The Great Barrier Reef, Casey Station Antarctica, Frame Straight and of course Monterey Bay. One FOCE system performed regular operations at 900 meters in Monterey Bay for 17 months and year long coral studies on the Great Barrier Reef. Future deployments are in process for Stonybrook University's inland water way and in the coral reefs of Panama at Bocas Del Toro.

As part IEEE-OES, Bill has published extensively with OES as well as other peer reviewed journals and magazines. Bill provided content and served as a technical and editorial reviewer for



William Kirkwood receives the Distinguished Technical Achievement Award from OES president Christian de Moustier.

the MATE textbook “Underwater Robotics: Science, Design & Fabrication” published in 2010. Bill has several other book chapters on development of deep-sea sensors and optical instrumentation. As an adjunct professor at Santa Clara University, Bill teaches classes in ocean engineering as well as mentoring student projects in robotics and instrumentation and has served as an advisor to graduate students on marine related projects. Additionally, Bill continues consulting and provides design, manufacturing and management services for a number of aquaculture firms, universities and scientists with limited access to engineering. Bill was also awarded the Lifetime Achievement Award at the 2018 Autonomous Underwater Vehicles Symposium.

2019 Distinguished Service Award: Marinna Martini

Marinna Martini is presented the Distinguished Service Award (DSA) for contributions to the governance of the Society as an elected member of the Administrative Committee (2007–2012; 2014–2016 and 2019–2021) and Executive Committees, for service as Secretary (2015–2018).

Marinna Martini is the lead engineer for sediment transport instrumentation and field operations at the U.S. Geological Survey in Woods Hole, MA, USA. She provides technical services to USGS scientists in support of physical oceanographic and sediment transport studies. This work includes systems design of moorings, bottom landers and data loggers, software development, project management and leadership (for example: <http://soundwaves.usgs.gov/2011/11/fieldwork2.html>). At the national level she served on steering committees to develop USGS technical capabilities and helped to run workshops. Internationally she has contributed to field work and scientific meetings. Her credentials include an M.S. from the University of New Hampshire, (ocean engineering, instrumentation), a B.S. from the United States Merchant Marine Academy, (marine & systems engineering), professional engineering licensure in the state of Massachusetts, and a U.S. Coast Guard Merchant Marine License, 3rd Assistant Engineer, unlimited horsepower.



Marinna Martini receives the Distinguished Service Award from OES president Christian de Moustier.

2019 Company/Institution Award: Xylem (formerly Aanderaa)

Xylem (formerly Aanderaa) is presented the Company/Institution Award for its enduring and continued contributions to the goals of the Society in advancing ocean research science and technology.

Xylem (formerly Aanderaa) is a leading global water technology company with approximately 17,000 employees in 50 countries, with operations in more than 150 countries. Aanderaa Data Instruments AS, a Xylem brand, headquartered in Bergen, Norway, designs, manufactures and delivers sensors, instruments and systems for measuring and monitoring in demanding environments.

Aanderaa is known for its ability to develop uncompromising state-of-the-art instrumentation that is both reliable and robust for long term observations of the marine environment. Their most important markets are universities and research institutions, oil and gas industries, aquaculture, coastal and harbour operators, road and traffic administration and construction business. They are a market leader in several of market segments. More information is available on www.aanderaa.com



Jon Fajans and Matt Previte receives the OES Company/Institution Award on behalf of Xylem.

2019 Presidential Award: Mohd Rizal Arshad

Mohd Rizal Arshad is presented the Presidential Award for developing the IEEE OES Malaysian Chapter, helping with OTC Asia and running USYS (Underwater SYStems Technologies) series of conferences with IEEE and OES and forging collaborations among ocean researchers in the region.

He will receive the award at the OES ExCom meeting in Singapore because of his schedule.

Mohd Rizal Arshad organised USYS conf in 2006 (Penang), 2008 (Bali), 2010 (Cyberjaya), 2012 (Malacca), 2014 (Shah Alam), 2016 (Kuala Lumpur), 2017 (Penang) and 2018 (Wuhan) with his colleagues. For IEEE USYS2020 it will be organised in Xi'an, China. Rizal and his colleagues have also organised annual National Technical Seminar on Underwater System and Technology (NUSYS) since 2007 until now. This year NUSYS2020 will be held in Dec 2019. A

number of ROV competitions were also organised with the Malaysian Ministry of Education for High School Students. For the past two years, they have initiated the Malaysian AUV (MAUV) Competitions among the undergraduate students. For the regional collaborations, he has worked closely with friends in ITB, Bandung Indonesia and NUS, Singapore. The most recent one was to assist in the establishment of IEEE OES Wuhan Chapter and forging research cooperation with Indian counterparts. As it is, with his all ongoing activities, we are happy that his efforts have got OES recognition.



James Lynch

2019 Emeritus Award: James Lynch

James Lynch is presented the Emeritus Award for his outstanding service to the Society as elected member of Executive Committees as Editor-in-Chief (1999–2004) of the OES Journal.

Dr. James Lynch obtained his B.S. in Physics from the Stevens Institute of Technology in 1972 and his Ph.D. in Physics

from the University of Texas at Austin in 1978. He then worked for three years at the Applied Research Laboratories of the University of Texas at Austin (ARL/UT) from 1978 to 1981, after which he joined the scientific staff at the Woods Hole Oceanographic Institution (WHOI). He worked at WHOI until his retirement in 2017, and currently holds the position of Senior Scientist Emeritus. His research specialty areas are ocean acoustics and acoustical oceanography. He also greatly enjoys occasional forays into physical oceanography, marine geology, and marine biology. Dr. Lynch is a Fellow of the Acoustical Society of America (ASA), a Fellow of

the Institute of Electrical and Electronics Engineers (IEEE), former Editor-in-Chief of the IEEE Journal of Oceanic Engineering, and current Editor-in-Chief of the Journal of the Acoustical Society of America. He is also the 2009 winner of the Walter Munk Award. His primary hobby is amateur astronomy, and he is the current president of the Cape Cod Astronomical Society.

Women in Ocean Technology Panel at the Halifax WIE International Leadership Summit 2019

Ishtar Al-Tahir and Mae L. Seto, OES Canadian Atlantic Chapter

The Society supported a Women in Ocean Technology Panel as part of the Halifax 2019 Women in Engineering International Leadership Summit (WIE ILS 2019 Halifax), October 18-20, 2019. This was the first time a WIE ILS event was hosted in Halifax, Canada. The Canadian Atlantic Chapter was a participant with Dr. Mae Seto, Chapter vice-chair, presenting a breakout session and sitting on the panel. Attendees and speakers came from all over Canada and as far away as the United Kingdom. The event attracted industry, research, STEM promotion, academia, government, business, entrepreneurial and humanitarian leaders. The three Summit themes were: Leadership and Empowerment; Entrepreneurship and Emerging Technologies; and Humanitarian Initiatives.

Multiple businesses in ocean tech and ocean engineering were present at the Summit. As well, ocean tech and engineering researchers from universities, government, and start-ups were present. This included the Ocean Frontiers Institute, Irving Shipbuilding Research Chair, Centre for Ocean Ventures and Entrepreneurship (COVE), Gibbs and Cox Naval Architects and Marine Engineering, Dalhousie University Ocean Tech Research Chair, Dept. of Fisheries and Oceans, and the Royal Canadian Navy. The IEEE WIE ILS capitalized on this as ‘oceans’ was a leading topic on the second day.

The oceans-related breakout sessions and keynote touched on timely oceans topics that were addressed by recognized professionals in the respective areas. To name a few:

- Lunch and Keynote: *An Ocean of Information: Challenges and Opportunities of a Data-rich Seascape* (A. Waite, Associate VP Research (Ocean), Dalhousie University, and Scientific Director, Ocean Frontier Institute)
- *Sink or swim: shark conservation in Atlantic Canada* (H. Bowby—Research Scientist, Dept. of Fisheries and Oceans)
- *The Fate of Plastics in the Marine Environment: An Incomplete Lifecycle* (K. Beady, M.Sc. Candidate, University of New Brunswick)
- *From ocean tech to med tech—a journey from a technology start-up perspective* (F. Broeil, CEO Motryx)
- *Marine Robots: A Manifestation of Industry 4.0 in the Ocean* (M.L. Seto, Associate Professor in Mechanical Engineering and the Irving Shipbuilding Research Chair, Dalhousie University)
- *Working toward impactful climate change mitigation and adaptation in the marine sector* (S. Molloy, President, Glas Ocean Electric)

There were many opportunities to learn from, and network with, experts in oceans through these keynote speakers, breakout

sessions, and especially the Women in Ocean Technology panel. This panel spoke about their journeys and experiences through the marine and oceans sector. They acted as mentors for the audience that day. There was discussion that revolved around topics like the panel members' trainings, the experiences they learned the most from, their path into the ocean

sector, and Canada's role and contributions as a leader in oceans and oceans tech.

IEEE WIE ILS 2019 Halifax brought together professionals from all over and provided learning opportunities in current ocean engineering, research, operations and entrepreneurship. The event was quite successful on all fronts.



IEEE WIE ILS Ocean Technology Panel (L to R: Dr. Anya Waite (Associate VP Research (Ocean), Dalhousie University, and Scientific Director, Ocean Frontier Institute; Dr. Mae Seto (Associate Professor in Mechanical Engineering, and the Irving Shipbuilding Research Chair, Dalhousie University; Maggie Nate (Survivability Engineer, Gibbs & Cox); LCdr Sarah Roberge (Sr. Staff Officer, MARLANT, Fleet Engineering Readiness); and Anna Naylor (Manager of Learning and Development, COVE, also panel moderator).

Chapter News

Submit Chapter News to Beacon Co-Editors and OES Chapter Coordinator

Providence Chapter—A Social Event and Two Technical Meetings

Reported by David Leslie and Sandy Williams

An Afternoon of Sailing, August 3, 2019

The Liberté is a magnificent 3-masted schooner which plies the beautiful waters of Cape Cod and the Chesapeake Bay. During the summer it ties up at the Clam Shack, just inside the mouth of the harbor in Falmouth, MA. The vessel has a length of 74 feet overall (65 feet on deck), with a beam of 18.5 feet. This staysail schooner carries 1700 sq.ft. of sail, spread over six sails and can cruise under diesel power at 8.5 knots.

The IEEE Providence Section, in cooperation with the OES Chapter, chartered the Liberté for a 3-hr afternoon sail. The plan was to sail within the general area of Nantucket and Vineyard Sounds, but the course taken is decided by the captain and depends on the wind and tides encountered on the day of the event. In 2018 our cruise was cancelled at the discretion of the captain because of foul weather. This year the sea state was moderate and winds were brisk from the southwest. From Falmouth we sailed south across to Martha's Vineyard and viewed the harbors of Vineyard Haven and Oaks Bluff from the sea. There was ample time on board for conversation with old and new friends from the OE chapter and the broader



The schooner Liberté.



Harold Belson (IEEE) at the helm.

Providence section. A total of 17 IEEE members and 21 guests were on board. All hands were accounted for when we tied up back in Falmouth.

Dr. Chris Chapman, August 19, 2019

Large, underwater earthquakes generate many types of waves—elastic P and S body waves, surface Rayleigh and Love waves or



Professor Chapman lecturing on the physics of waves from a tsunami and his personal experiences of the Boxing Day 2004 Sumatra earthquake. The figure shows the distribution of deaths in Sri Lanka from the ensuing tsunami.

normal modes, acoustic waves in the ocean (T phase) and ocean gravity waves (tsunami). The latter are often the most devastating and cause the greatest loss of life. On Boxing Day, December 26, 2004, a magnitude (Mw) 9.1–9.3 megathrust earthquake occurred with an epicenter off the west coast of northern Sumatra, Indonesia. It was the third-largest earthquake in recorded history, lasted 9 minutes, and released as much strain energy as all other earthquakes combined over the previous 15 years. The associated tsunami propagated across the Indian Ocean where communities surrounding its coasts were greatly affected. Major disruptions occurred in Indonesia, Sri Lanka, India and Thailand. The tsunami killed an estimated 227,898 people in 14 countries. At the time of the earthquake Chris Chapman was vacationing with his wife on the coast of Sri Lanka.

Chris Chapman is the Emeritus Honorary Professor of Theoretical Seismology at the University of Cambridge, UK. He has held academic positions at the University of Alberta, the University of Toronto and Cambridge University. He has conducted research at Scripps Institution of Oceanography and has worked as a Scientific Advisor for Schlumberger Cambridge Research. He is the author of the textbook “Fundamentals of Seismic Wave Propagation” (CUP, 2004). Our OES chapter hosted Professor Chapman at the University of Massachusetts, Dartmouth, to hear his presentation on the physics of waves from an underwater earthquake and his personal experiences of the tsunami from the Boxing Day 2004 Sumatra earthquake. Professor Chapman presented data from all the types of waves emanating from this event. He described the basic physical features of the excitation and propagation of the tsunami together with the properties that made this tsunami so devastating, and he explained how the other waves can be used to issue tsunami warnings. Professor Chapman was kind enough to break away from his New England sailing vacation to make this presentation, which was attended by 7 IEEE members and 11 guests.

Dr. Rupp Carriveau, October 16, 2019

The Wind Engineering, Energy and Environment Research Institute (WindEEE RI) was established in 2011 in order to

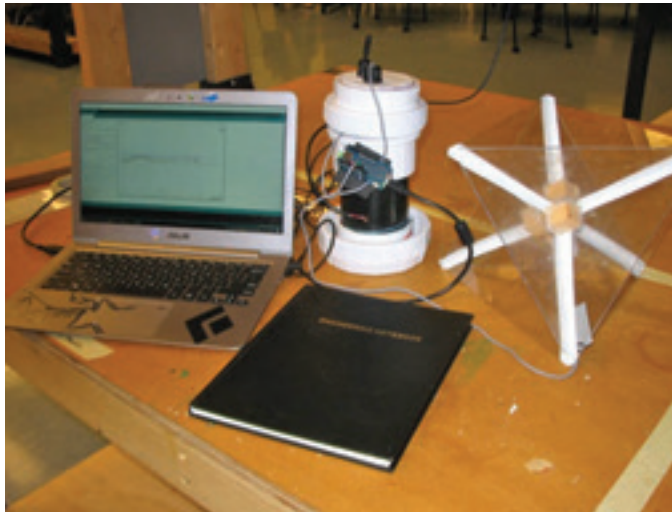


Dr. Rupp Carriveau presents a lecture at WHOI to the IEEE Providence OES Chapter on the WindEEE testing facility.

pursue novel opportunities in wind research at Western University, Canada, related to the emergence of the world’s first three-dimensional testing chamber, the WindEEE Dome. The Institute has promoted innovative research and extensive collaborations nationally and internationally. The areas of research at WindEEE target the three EEE’s: wind Engineering, Energy and Environment. Main topics of research relate to: impact of non-synoptic wind systems (such as tornadoes and downbursts) on buildings and structures, optimization of wind farms and wind turbines, physical modelling of flow over rough surfaces, urban canopies, complex topography and forestry, outdoor and indoor air quality, and wind driven rain and snow.

Dr. Rupp Carriveau is the Director of the Environmental Energy Institute and a Director of the Turbulence and Energy Lab at the University of Windsor in Ontario Canada. He is Chair of the IEEE Ocean Energy Technology Committee. His research activities focus on energy systems futures, and include collaborative research that makes use of the WindEEE facility.

Multipurpose floating platforms are now being considered for renewable offshore energy generation, energy storage, desalination, agriculture, aquaculture, and habitation. While lessons can be learned from the oil and gas industry, design constraints of these platforms make direct comparison difficult. A generic model offshore platform is currently being tested in WindEEE; a unique hexagonally domed facility capable of producing scaled tornadic, downburst, and highly sheared wind profiles. In his presentation, Dr. Carriveau discussed observations from early analysis of the data and challenges encountered during scaling, measurement, and mooring of the experiment. Initial results indicate that the extreme wind cases of tornado and downburst produced very significant motion for the platform. The lecture at WHOI was attended by 6 IEEE members and 3 guests. Coincidentally, and as if to further demonstrate the relevance of wind research, Cape Cod was struck by a “Bomb Cyclone” late on the evening of this meeting, as atmospheric pressure fell by 43 millibars within 24 hours. There was widespread flooding, downed trees and power outages.



Typical Student Project.

Seattle Chapter

Reported by Skip Denny

Student Marine Technology Spring Mixer

In May, the University of Washington's Ocean Technology class students requested members of the OES and MTS local chapters to provide review and comment on the students' year-long projects. After the presentations, the students provided a pot-luck dinner and a networking mixer. This has become an annual event since the Ocean Tech class began a couple of years ago. Students are required to build and document a simple sensor that gets deployed in the water, and an evaluation of its merits is presented to the invited professionals. The sensors range from simple temperature/conductivity cells, to acoustic tracking, and to optical AUV docking systems and software. Input from the professionals has made for an evolutionary sophistication of the individual projects as well as networking contacts for jobs and graduate direction.

OES Seattle Section Support for OCEANS Conference

The main thrust of the chapter members for the bulk of the year has been participation in the preparation and execution of the OCEANS 2019 conference held in Seattle on 27–31 October. Member participation ranged from the Local Organizing Committee (which had meetings starting at once per month in January to weekly intervals for the 6 weeks prior to the conference) and its various subcommittees, serving to review posters and papers, and a variety of volunteer activities during the conference. This level of tasking left little time for the regular chapter meetings—indeed we had to decline an offer of a talk by a Distinguished Lecturer due to overloaded schedules. An offshoot of conference participation was new linkages with other, somewhat geographically close, chapters to look at future joint meetings and collaboration. Work with chapters in Portland, Oregon and Vancouver, British Columbia has been done in the past for other related societies, e.g., Acoustical Society of America local chapters.

Canadian Atlantic Chapter

Underwater Communications: From Theory to Experimentations

Reported by Mae Seto and Christopher Whitt

On December 5th, 2018, a talk was given on underwater acoustic communications at Dalhousie University by Dr. Jean Francois Bousquet. This talk was co-sponsored by the SP-MTT chapter. This talk focused on the physical layer design that enables underwater communication networks and systems as well as the effects of the acoustic channel.

Talk on Marine Robots

Reported by Ferial El-Hawary and Mae Seto

On December 12th, 2018, a talk titled *Marine Robots: A Manifestation on the 4th Industrial Revolution in the Ocean Environment* was given at Dalhousie University by Dr. Mae Seto. This talk was focused on the exciting research in marine robotics at the Dalhousie University Oceans Hub. A tour was also given of the new EMERA IDEA building at Dalhousie University.

Electrical and Computer Engineering Graduate Conference

Reported by Ferial El-Hawary

On April 9th, 2019, the OES chapter supported the annual electrical and computer engineering graduate conference. There were approximately 100 attendees with many of the OES student members in attendance.

Underwater Communications Talk

Reported by Mae Seto and Christopher Whitt

On April 15, 2019, Dr. Martin Siderius gave a technical talk titled *Underwater Communications: Challenges of the Acoustic Propagation Channel*. The talk included a primer on underwater acoustic propagation and its impact on underwater communications and navigations. As well, modelling techniques were presented that gain insight into the underwater communications channel and how to work within its limitations. The talk was held at Dalhousie University and was attended by approximately 25 members and guests.



Martin Siderius discussing Underwater Acoustic Communications.



Brandon Southall discussing the effects of noise on marine mammals.

Talk on Auditory and Behavioral effects of noise in marine mammals

Reported by Mae Seto and Christopher Whitt

On April 30, 2019, the Chapter organized a talk and networking event with world-renowned researcher Dr. Brendon Southall on Auditory and Behavioral effects of noise in marine mammals. Marine mammals use sound for many critical life functions. Human sound in their environment can interfere with communications, affect their hearing, influence behavior and cause non-auditory physiological effects. Recent work on both auditory and behavioral effects of noise was presented. As well, Dr. Southall discussed how the results from this work is integrated into defining noise exposure criteria and applied in regulatory decision-making and mitigation of noise impact on marine mammals.

The talk was hosted by the Centre for Ocean Ventures and Entrepreneurship (COVE) in Dartmouth, Nova Scotia, Canada, and attend by around 50 people.

Talk on Passive Acoustics for Ocean Observations

Reported by Mae Seto and Christopher Whitt

On October 15, 2019, Christopher Whitt gave a talk on Passive Acoustics for Ocean Observations, sponsored by the Chapter and in coordination with the Dalhousie University Oceanography Department's Seminar Series. Passive acoustic monitoring is a powerful tool to study the ocean with. Long-term underwater acoustic recordings capture the distribution of human activity and marine life and provide insight into changes in physical oceanography. Directed measurements help to understand the impact of activities ranging from geophysical surveys, shipping traffic to marine construction. Several recent projects were discussed as case studies to showcase the state-of-the-art. The talk was attended by about 40 people, including Chapter members, graduate students and several guests.

Malaysia Chapter

Visit Northwestern Polytechnical University, Xi'an China

Reported by Khalid Isa and Mohd Rizal Arshad

On 14–17 August, 2019, the IEEE Ocean Engineering Society (OES) Malaysia Chapter organized a visit to Northwestern Polytechnical University (NPU), Xi'an, China. The main activity was to discuss the collaboration between IEEE OES Malaysia Chapter and NPU for organizing the 2020 IEEE 9th Interna-



Photo Session with the Dean and Deputy Dean of School of Photo Session with the postgraduate students during Marine Science and Technology, NPU.



Photo Session with the postgraduate students during Marine Science and Technology, NPU the visit to Unmanned Underwater Lab, NPU.

tional Conference on Underwater System Technology: Theory and Applications (IEEE USYS 2020) in Xi'an, China. Others activities included a session meeting for research collaboration and an Unmanned Underwater Vehicle lab visit. There are many opportunities given by NPU to IEEE OES Malaysia Chapter. The discussion unleashes the expertise of professionals in a friendly discussion and the potential for collaboration between NPU and IEEE OES Malaysia.

IEEE OES Malaysia Chapter Invited Talk at the School of Marine Science and Technology, NPU

Reported by Khalid Isa

On 16 August, 2019, the School of Marine Science and Technology, Northwestern Polytechnical University (NPU), Xi'an, China organized an Invited Talk Session to the postgraduate students. The first invited talk was given by Ts. Dr. Khalid Isa, Chair of IEEE OES Malaysia. He gave a talk about IEEE OES at a glance and autonomous underwater glider. The second talk was provided by Prof. Ir. Dr. Mohd Rizal Arshad. Prof. Rizal presented a talk regarding acoustic technology. It was an excellent platform for the invited speakers, staff and postgraduate students to discuss and share their insights on the trends, issues, possible solutions to prevailing concerns in the field of Ocean Engineering. The talk attracted more than 30 students and staff.



Photo Shoot Session after the Invited Talk Session.



Talk by Ts. Dr. Khalid Isa, UTHM @ Chair of IEEE OES Malaysia Chapter.



Briefing Session.



Talk by Prof. Ir. Dr. Mohd Rizal Arshad, USM @ Past Chair of IEEE OES Malaysia Chapter.



Practical Session.

TEDSAT: STEM Educational Program

Reported by Herdawatie Abdul Kadir

On Thursday, Oct 17th, 2019, a Science, Technology, Engineering and Mathematics (STEM) Programme was held at Universiti Tun Hussein Onn Malaysia (UTHM), Johor. This program is an effort for intensifying efforts to bridge the gap between science, technology, engineering and mathematics achievement

in major examinations between urban and rural schools. It involved four selected secondary schools with a total of 47 participants. The participants are exposed to basic electronic & electric circuit experiments, and finally, learn to program the Arduino robots. The participants have shown extending interest in and understanding of STEM. Each participant was awarded a certificate of attendance and souvenirs.

Technology Committee Reports

Submit TC reports to VPTA and Technology Committee Coordinator with CC to Beacon Co-Editors

Polar Oceans Technology Committee; Linking the poles

Arctic and Northern Ocean Forum 2019

Andreas Marouchos, Polar Oceans Technology Committee Chair

Following on from 2019's ASOF-Fest event in Hobart, the Polar Oceans Technology Committee along with the Remote Sensing and Autonomous Systems TC and the GeoScience and Remote Sensing Society hosted a sister event called the Arctic and Northern Ocean Forum (ANOF) this past September. The aim of these events is to bring together science and technology related to polar research and promote the cross-pollination of researchers between Arctic and Antarctic regions. The event was chaired by Mikko Strahlendorff (Director, Finnish Meteorological Institute) along with Rene Garello (Junior Past President, OES) and Adriano Camps (Past President, GRSS) and was hosted by the Finnish Meteorological Institute in Helsinki, Finland, from September 2nd to the 4th. It was a co-financially sponsored event between OES and GRSS and administratively ran via the IEEE France OES chapter. The forum consisted of a number of talks covering topics from autonomous vehicles to remote sensing as well as a few breakout sessions for attendees to discuss the future of polar technologies and approaches for OES and the Polar Oceans Technology Committee in helping



ANOF2019 attendees during one of the tea breaks—Sergio Ramirez Moreno—ETITC (Left), Jhon Anderson Hurtado—ETITC (Centre), Andreas Marouchos—CSIRO (Right).

increase engagement in the polar technology area. Special thanks to all the speakers, to Mal Heron for leading us through the event, and to all our colleagues at FMI who were so very welcoming during our visit.



ANOF2019 Breakout Session discussing future of polar technologies.

Antarctic and Southern Ocean Forum 2020

Following on from the ANOF event, we will be in the Southern Hemisphere in 2020 with a repeat of our Antarctic and Southern Ocean Forum to be hosted once again in Hobart, Australia, from August 10th–12th. This year's meeting will be co-sponsored by GRSS and run in tandem with the Scientific Committee of Antarctic Research (SCAR) meeting, which is also taking place in Hobart. This will allow the ASOF event to capture more of the science activities surrounding Antarctic research, and provide more opportunities for overseas participants to join the event. More info on the event can be found on the forum website at (<https://asof2020.ieee.org/>) including deadlines for abstract submission.

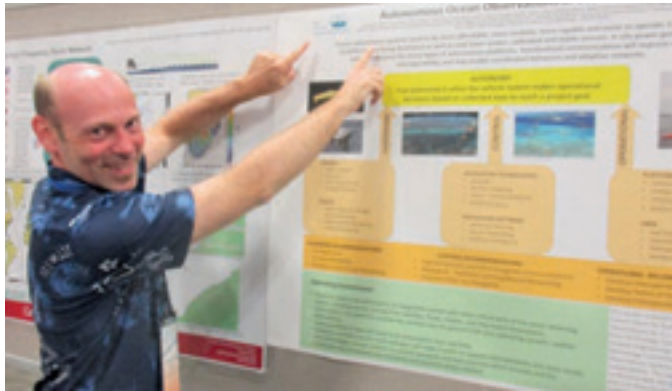
OES Participation in OceanObs'19 16–20 September 2019

Mal Heron, Jay Pearlman and Christopher Whitt

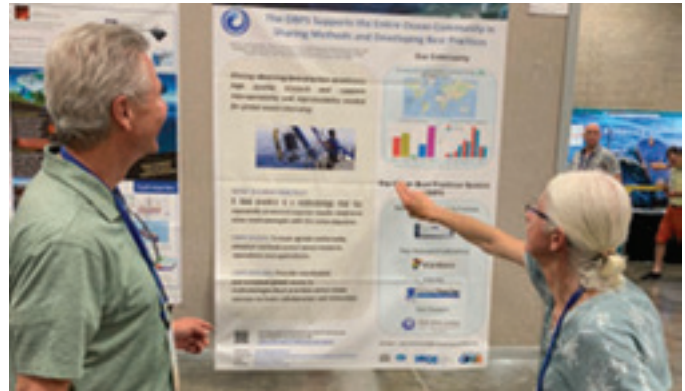
At the end of each decade, the ocean community comes together to look to the future. Where we were, where we are, where we are going in the next 10 years? The discussions are broad ranging, from observations to applications, from sci-

ence to engineering to end users of our ocean data and information.

Setting the foundation for these discussions were more than a hundred “community white papers” that provided both background



Christopher Witt points out the importance of the word 'Autonomous'.



Francoise Pearlman discussing Best Practices with Tom Kearney.

and future vision. OES members participated in a significant number of these and took the lead in two—one on best practices and standards, and another on autonomous vehicles. These were massive efforts, with 58 authors on one and 25 on the other, and with challenges in converging perspectives. Christopher Whitt led the paper on autonomous vehicles and the photo shows how proud he is of the abstract that cuts across nearly all of the Technology Committees in OES. The other photo shows Francoise Pearlman explaining the details of Best Practices. From the topics of these papers, breakout discussion subjects were selected for informal discussions of key issues and opportunities for the coming decade.

A vision for the decade does not appear in a day or even months. The convergence of recommendations from the panels, breakout groups and special sessions is the first step. There will be a series of meetings with the first public meeting at the American Geophysical Union Fall Meeting in San Francisco in December 2019. This is followed by the OceanObs Research Coordination Network (RCN) meeting on February 16th in San Diego, just prior to the Ocean Sciences Meeting. The RCN meeting will provide an open forum for discussing the specifics that provide a foundation to develop the vision.

These were big efforts for the OES members involved, but their active involvement keeps OES technologies head-

ing in the direction that we think the community wants. Those who may be interested in attending the future meetings, please contact Jay Pearlman who is the chair of the Ocean Observing and Environment Sustainability Technology Committee.

There was a conference statement at the end of the meeting. (see http://www.oceanobs19.net/wp-content/uploads/2019/09/OO19-Conference-Statement_online.pdf). The statement is too long for this article but two points are worth noting:

- Harness the creativity of the academic research and engineering communities, and work in partnership with the private and public sectors to evolve sensors and platforms, better integrate observations, revolutionize information products about the ocean...; and
- Use best practices, standards, formats, vocabularies, and the highest ethics in the collection and use of ocean data

References

- [1] Whitt, C., (2019) Future Vision for Autonomous Ocean Observations. *Front.Mar.Sci.*, submitted.
- [2] Pearlman, J, et al., a(2019) Evolving and Sustaining Ocean Best Practices and Standards for the Next Decade. *Front. Mar. Sci.* 6:277. doi: 10.3389/fmars.2019.00277

SUMMER SCHOOL

6-15 July 2020

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Maritime Informatics and Big Data Analytics

MaritimeInformatics2020



summer-schools.aegean.gr/MaritimeInformatics2020

The first edition of the International Maritime Informatics & Big Data Summer School will provide a number of introductory lectures covering the main topics related to Maritime Informatics. It shall host a diverse multinational group of up to 50 students and a lineup of internationally recognised speakers, during an eight-day programme that will allow participants to gain a deeper knowledge and understanding of maritime informatics. Complementary to the lectures, a number of experiments and demonstrations will take place at sea using state of the art maritime robotic systems.

The goal is to provide a unique multidisciplinary week of learning and doing maritime informatics.

Find out more at <https://summer-schools.aegean.gr/MaritimeInformatics2020> or contact us at MaritimeInformatics2020@aegean.gr

Registration – Fees: €500 for registrations until Apr. 1, 2020 / €400 for students of the University of the Aegean, IEEE members, Fusion Society / 550 after Apr. 1, 2020

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OSSES 2019 BREST FRANCE, July 10–12 2019 at IMT Atlantique “Energy Systems with Sea in their DNA”

René Garelo (IMT Atlantique/OES), Life Fellow

Context

The OSSES conference series addresses offshore energy systems—with major emphasis on the word “systems”. Offshore wind has dominated the arena of energy harvesting offshore—and it has done a superb job of showing just how rich the energy resources are offshore and how inexpensively these energy resources can be exploited. Expectations on cost reduction for all offshore energy systems are now driving innovations like never before. This is probably more true for offshore wind than for any other offshore energy form. In the past, the presence of subsidies has meant that the offshore wind technology developers could take what was essentially a design for onshore wind turbines, scale it up, marinise the nacelle and then support the turbine on a tower that looks as much as possible like the towers supporting onshore machines.

The paradigm of trying to take energy systems developed for application on land and port them into the marine environment is now being challenged fatally. Logic calls for machines to be optimised to the environment for which they intended and not simply to emulate machines that have been optimised for a very different environment. Perhaps surprisingly, it will be system cost that actually drives the innovation in future.



Yann-Hervé De Roeck addressing the attendees during his plenary talk.



Daniel Laird during his plenary talk.

OSSES2019 focused especially on systems that are designed with marine DNA already in their blood. This includes floating platforms for both wind turbines and PV collectors, hybrid systems that cater for the collection of energy in multiple forms, the integration of energy storage with electricity generation and various energy harvesting approaches that simply have no equivalent on land.

OSSES2019 was a significant agent of change—helping the community to observe that the future of offshore energy is not simply a linear extrapolation of the past.

Meeting

The meeting held in Brest, France, on July 10 to 12, 2019, gathered about 70 international participants from around the world, ranging from academia to industry or agencies. The event was sponsored by the IEEE Oceanic Engineering Society (OES) with the support of France Energies Marines, the French Institute for Energy Transition dedicated to Marine Renewable Energies. The OES French chapter was running the local arrangements and the overall technical aspects of the workshops were handled by the Ocean Sustainable Energy Systems (OSSES) Technology Committee. The workshop was organized around 45 oral presentations and 5 plenary talks. It reviewed the latest advances in storage models, energy generation and integration of renewables with storage. A YouTube rendition of the meeting can be seen at: <https://www.youtube.com/watch?v=B5YooMXa5Mg>

The technical management of the sessions were supervised by the OSSES “team”, Tonio Sant, Seamus Garvey, Rupp Cariveau and Jochen Bard. 12 sessions were organized, with two half-days of parallel sessions. The sessions were divided in the following main themes:

- OFFSHORE PLATFORMS AND STORAGE MODEL TESTS
- IMPLEMENTATION OF NEW WIND AND STORAGE
- SUSTAINABILITY IN OFFSHORE ENGINEERING
- ADVANCEMENTS IN STORAGE—PART 1
- GENERATION—WAVE ENERGY
- INTEGRATING RENEWABLES WITH STORAGE—PART 1, WIND



Rodica Loisel from University of Nantes.



A view of the attendees.



During the gala dinner in the Bay of Brest.

- *INTEGRATING RENEWABLES WITH STORAGE—PART 2*
- *ADVANCED GENERATION AND STORAGE*
- *ADVANCEMENTS IN STORAGE—PART 2*
- *CAES (Compressed Air Energy Storage)*
- *DESALINATION AND NAVIGATION*
- *GENERATION—TIDAL*

Plenary Talks

The following plenary talks presented the visions and developments of global programs and R&D works:

Funding the Innovation: What is in for Our Ocean?

Andreea Strachinescu

Head of Unit, Directorate-General for Maritime Affairs and Fisheries, European Commission

An Overview of Offshore Renewable Energy Development in France

Yann-Hervé De Roeck

General Manager, French Energies Marines

Wind Energy Development in the U.S.

Daniel Laird

Director, National Wind Technology Center, National Renewable Energy Laboratory, USA



"Aperitif" time.

Wave Energy at Crossroads

Gregorio Iglesias Rodriguez

Professor at MaREI, University College Cork

Requirements of a Low-Carbon Energy Infrastructure

Axel Laval

Energy Asset Manager, Crown Estate, UK

ECEGC 2019 was successfully held in Dalhousie University.

See you again in 2020 too.



OTC ASIA 2020

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About OTC Asia

The biennial Offshore Technology Conference Asia (OTC Asia) is where energy professionals meet to exchange ideas and opinions to advance scientific and technical knowledge for offshore resources and environmental matters.

OTC Asia aim to:

- Meet the demand for technical information to support the growth of the offshore energy industry in Asia.
- Provide opportunities for industry professionals and their employers to share their applied technologies and best practices with other producing areas in the world.
- To create opportunities to institute and strengthen intersociety collaboration and cooperation with member societies based in Asia.

For more info., please visit the URL: <http://2020.otcasia.org/welcome>

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International Symposium on Underwater Technology 2021 March 1 - 4, 2021

IIS Conference Hall "Haricot", Tokyo, Japan
Advanced Underwater Technology for the Ocean

The University of Tokyo is delighted to welcome international experts for the International Symposium on Underwater Technology (UT21). One of the most pleasant months in Japan will host the highly successful symposium, which is organized by the IEEE OES, IEEE OES Japan Chapter, the University of Tokyo's Institute of Industrial Science (IIS), and Earthquake Research Institute (ERI). The symposium will provide you with a thematic umbrella under which attendees will discuss the problems and potential long term solutions that concern not only the Pacific Rim countries, but the world in general.

TOPICS

The symposium consists of keynote talks, double-track technical sessions, a student poster session and a technical tour on the first day.

It will feature advanced underwater technology and scientific use of submarine cables & related technologies. Suggested topics are listed below.

1. Environmental Monitoring
2. Marine Robotics
3. Marine Mineral Resources
4. Renewable Energy
5. Marine Construction
6. Observatory and Disaster Mitigation
7. Fishery Engineering
8. Acoustics and Communications
9. Sensors

ABSTRACT SUBMISSION

On-line submission page will be available in March 2020. Please bookmark the conference website and check for updates: <http://www.ut2021.org>

IMPORTANT DATES

Deadline for Abstract Submission: **September 18, 2020**
Notification of Acceptance: **October 16, 2020**
Deadline for Paper Submission: **December 11, 2020**
Deadline for Early Registration: **January 21, 2021**
Symposium Dates: **March 1 - 4, 2021**

FOR INQUIRIES

Contact: info@ut2021.org

<http://www.ut2021.org>

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Katsuyoshi Kawaguchi, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Chang-Kyu Rheem, IIS, The University of Tokyo
Masanao Shinohara, ERI, The University of Tokyo

Technical Committee Co-Chairs:

Weilin Hou, United States Naval Research Laboratory
Toshihiro Maki, IIS, The University of Tokyo
Blair Thornton, IIS, The University of Tokyo /University of Southampton

Secretariat

Harumi Sugimatsu, IIS, The University of Tokyo



OCEANS
CONFERENCE & EXPOSITION



**SAVE THE
DATE**

OCEANS 2020 Singapore

April 6 - 9, 2020

singapore20.oceansconference.org



OCEANS 2020 Gulf Coast

October 19 - 22, 2020

gulfcoast20.oceansconference.org

OCEANS 2021 Portugal

May 24 - 27, 2021



OCEANS 2021 San Diego

September 20 - 23, 2021

sandiego21.oceansconference.org

The 'Little Red Dot' All Set to Host OCEANS 2020 Conference

Website: <https://singapore20.oceansconference.org>

Venugopalan Pallayil, General Chair, OCEANS 2020 Singapore

Singapore, the Little Red Dot, with an area of 725 square km is home to 5.6 million people. One of the busiest ports in the world, Singapore connects over 600 ports in 120 countries with 130,000 vessel calls annually. This heavy-shipping scenario brings up a unique set of complicated operational constraints. On the other hand, we now live in a world that has realized the importance of upholding the sanctity of its oceans. Maintaining a balance between crucial market flow and ocean conservation is a complex problem that demands attention. It may arguably be the most pressing issue at hand. The relevance and significance of holding a conference like **OCEANS** in Singapore hence needs no further justification.

After a gap of 14 years, **the Garden City** is set to host **OCEANS Conference** during **6–9 April 2020**. Our theme for OCEANS 2020 Singapore is “**Green Ports: In Harmony with Oceans**”, which reflects the need to address preserving our ocean environment through the use of smart marine engineering and technological solutions. This instance stands out in particular as OCEANS celebrates its successful legacy on its 50th anniversary. The conference is expected to attract over 600 delegates, 350 to 400 technical presentations and 40 odd exhibitors from marine and freshwater related industries. Apart from regular presentations by researchers from many different fields of oceans science and technologies, there will also be special sessions on emerging research and technologies organised by experts in those areas. Special sessions on Marine Archeology and Marine Plastic Pollution are being planned to be organized for the first time in an OCEANS conference. Another feature of the conference will be sessions and topics focused on local needs and scenarios. We are also looking forward to organizing some exciting keynote sessions by world renowned institutions like Ocean Infinity, Schmidt Oceans Institute and possibly by National Geographic. The exhibitors will be given opportunities to demo their products in a lake next to the conference center. The student poster competition will also be held as usual.

The Venue: The conference venue, **Marina Bay Sands Expo and Convention Centre** is an iconic venue hosting a 150 m long infinity swimming pool on top of the world's largest cantilever platform and also a 340 m long SkyPark. This venue is an integrated resort with hotels, shopping malls, convention centers and the world's largest atrium casino. There are also 'celebrity chef' restaurants, museums, floating crystal pavilions and arts-science exhibits. It is worth watching this video, <https://www.youtube.com/watch?v=gjz1ebDIYc>, or the video from National Geographic, <https://www.youtube.com/watch?v=uX9fTuv9xc8>, to understand how this amazing facility was built. Words are not adequate to describe this unique facility and you have to see and experience it to believe it.



Marina Bay Sands (conference venue) and the lotus shaped 'ArtScience' Museum.



The infinity pool on top of Marina Bay Sands with city view.

Technical Visits: The Local Organising Committee is planning to arrange guided tours to a couple of facilities in Singapore. One such facility is the Marina Barrage, a dam built across 350 m wide Marina channel to keep the seawater out. The facility serves three purposes: a source of freshwater supply, flood control mechanism and also a recreational facility. Find out more about it during your technical tour to the facility.

Another technical tour is planned to the Technology Centre for Offshore & Marine Singapore (TCOMS), which is Singapore's first R&D Facility for Industry. It hosts the next generation Deepwater Ocean Basin facility equipped with state-of-the-art wave and current generation systems that can simulate harsh marine environments including those in ultra-deep waters.

Getting around: The venue is about a 15 to 20 minutes drive from the airport or about 40 minutes by the train (MRT or Mass Rapid Transport). The train takes you right into the venue. Plenty of transport options, including buses or taxis, are available. Singapore has a very good and reliable public transport system and hence moving around the city center is easy.

Attractions: Attending a conference is not just about participation in the technical programme and exhibition. It also provides the delegates over the world an opportunity to explore, understand and experience the unique cultures of the country where the conference is being held. One of the safest countries in the world, Singapore is also the best example of how people of different religious faiths can co-exist in peace and harmony. We hope to showcase a cultural show during Gala Dinner that would be a blend of local cultures. A Garden City state with lush green vegetation in an urban setting, good transportation system, world class airport, mouthwatering international cuisine and ease of communication in English language all make it very special for visitors. There are a variety of food available to match everyone's taste and make sure you do not miss the essential ones. Ask your LOC members or PCO on those 'must try' food items.

Tourist Attractions: There are many tourist attractions in Singapore and to list all of them here is not practical. Night

Safari is a very unique attraction where you get to see the animals at night. Singapore Zoo, Gardens by the Bay, Botanical Gardens and National Orchid Garden, Universal Studios, Sentosa Island, China Town, Little India Market, Singapore-Flyer, Clarke Quay boat ride, etc., are some of the attractions to name a few. Time permits, you should catch a glimpse of Changi



Changi Jewel, showing the indoor waterfall and laser show.



Cable car, gondola lift providing aerial link between Sentosa Island and Mount Faber.



Night Safari, up and close with the animals.



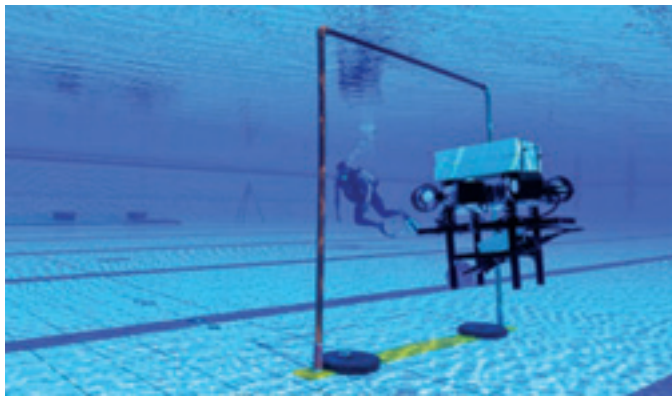
Clarke-Quay by night.



National Museum, Singapore.



SAUVC2019



Jewel, which is a newly built shopping complex at the airport featuring the world's highest indoor waterfall. The 1-Altitude rooftop gallery and bar, standing at 282 meters and with 360-degree view, is the highest alfresco bar in the world.

Being an Easter Weekend, this is also a great opportunity for visiting many neighbouring countries such as Malaysia, Thai-

land, Vietnam, Cambodia and Indonesia, to name a few, which are all 2 to 3 hrs by flight from Singapore.

The Singapore AUV Challenge (SAUVC): The OES Singapore Chapter has been organizing an international student Autonomous Underwater Vehicle (AUV) competition since 2013. The 2020 edition of this competition will be held in conjunction with the OCEANS conference. The competition date will be 3–6 April 2020. More details on this competition can be found at www.sauvc.org. Check out the related Facebook page as well. We have so far received interest from more than 70 international teams for the year 2020 competition. We are also organizing talks under the distinguished lecturer program by OES (DL-fest) alongside this competition. It will feature prominent speakers who are experts in the field of marine engineering. So, if you plan your trip a couple of days early, you can catch the excitement of this unique competition and interact with the next generation underwater roboticists.

We look forward to welcoming you all to Singapore for an exciting conference. Please visit the conference website <https://singapore20.oceansconference.org> for more details.

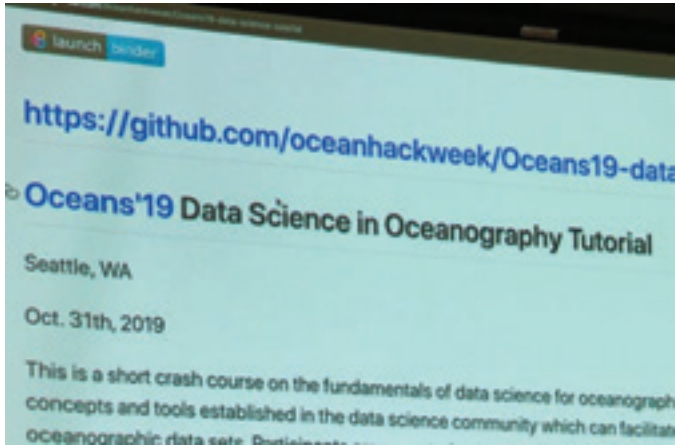
OCEANS 2019 Seattle—A Success

Fritz Stahr, Ph.D., Chair, OCEANS 2019 Seattle

More than 1700 people attended OCEANS 2019 Seattle, October 27th through 31st, at the Washington State Convention Center and the new Hyatt Regency in downtown Seattle. The area's unique history of forward-thinking ocean research, technology development, federal agency and Navy presence, and focus on the Blue Economy combined to make this a great place to host OCEANS this fall. Co-sponsored by the Marine Technology Society and IEEE Oceanic Engineering Society, this year's meeting was themed "Blue Sky. Blue Sea. Blue Tech." The conference attracted professionals and students from 38 countries representing industry, academia, and the public sector to exchange information and ideas on developing next-genera-

tion technologies to work in the oceans for science, resource extraction, and remediation.

The local organizing committee, in partnership with the societies and the conference event planner, presented new features at OCEANS 2019 Seattle including: a Technical Program track for exhibitors in both oral and poster formats; a Start-Up Pavilion in the Exhibit Hall so innovators could catch the eyes of established makers and service providers; and, moving the tutorials, workshops, and demonstrations to Thursday. All met with significant success, engaging many people and companies in ways new to them and valuable to all. Successful activities from prior OCEANS continued—lunches in the Exhibit Hall



Over 200 people attended tutorials, workshops, and technical demonstrations on Thursday.



Sometimes the shirt says it all—thanks AI for reminding us!



Barbara Fletcher, long-time IEEE-OES member, catches up with Stephanie and Ted Brockett, long-time MTS members.



We enjoyed tunes from a VJ in the MoPOP Sky Church at the Gala.



Students and young professionals enjoying the reception.



OCEANS Gala attendees found certain exhibits at MoPOP irresistible!

where over 120 entities displayed the latest in research and observational tools for the marine environment. The Innovation Theater space in the Exhibit Hall—a feature introduced in 2018—was available to companies as well as the societies to bring special activities right to the heart of the space. As a special feature, local research institutions and private researchers

gathered a small fleet of research vessels at Seattle's waterfront marina for tours on Monday . . . a classic fall day with bright blue skies and cool, crisp air.

Some of the popular features of the conference continued, including the Office of Naval Research and Integrated Ocean Observing Systems sponsored Student Poster Competition (see



The Canadian student contingent starting the week together.



Technical sessions and panels were well attended.



Some of our Federal Strategic Vision Town Hall panelists with organizer Zdenka Willis.



Co-convenor of the Town Hall on Marine Debris, René Garelo, discussing some results.



Members of the new committee on Resident Marine Robotics.



Lisa Vollbrecht inspiring us with her plenary talk on technology in the aquaculture business.

article elsewhere in this edition), several special Town Halls on key topics such as marine debris and plastics, and a Gala reception at an iconic location—the Frank Gehry-designed Museum of Popular Culture (MoPOP) at The Seattle Center.

The local organizing committee particularly focused on students and young professionals, with several programs aimed to foster their participation beyond the traditional poster competition and student reception. The Canadian government sponsored a group of young women to attend the conference, and several exhibitors volunteered to lead small groups of students around the exhibit floor to introduce them to colleagues and the technology shown there. Further, a number of students participated in the relatively new General Poster session offered as part of the main Technical Program, as well as presenting papers.

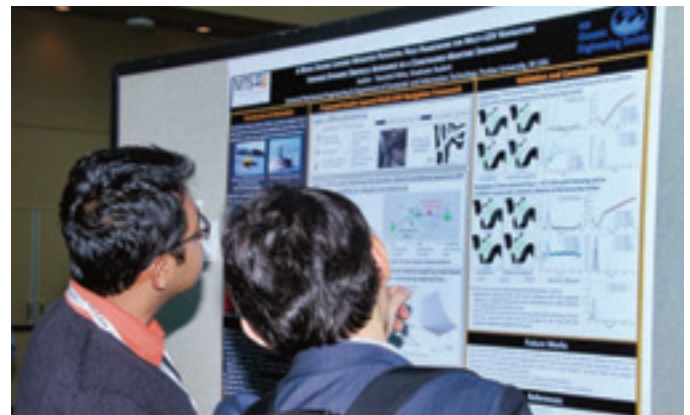
The plenaries held first thing each morning offered a selection of new things, from Stockton Rush on building a new submarine from carbon fiber, to Lisa Vollbrecht on why



The Student Poster Competition participants at the awards ceremony.



Members of the BOEM team, a conference Patron—thanks!



The posters were easily found and well attended.



Plenary panelists from the University of Washington discussed offshore technology to reduce risk of earthquake damage.



The University of Washington's new research ship, RV Rachel Carson, available for tours at Bell Harbor Marina downtown on Monday.



OceanGate's Cyclops-1 submarine Bell Harbor Marina for viewing and tours.

we all should help design new technology for aquaculture, to a panel of scientists and engineers from the University of Washington on how the area offshore the Pacific Northwest

is being instrumented to give us warning for the next major earthquake coming from the Cascadia subduction zone. The various society awards programs followed those each day before the first coffee break and the thrice-daily paper presentations started up.

As usual, the Technical Program featured content across the board of topics for marine technology, from best practices in deploying instruments to best techniques for analyzing data, from key considerations for vehicle design to key attributes of vehicle guidance and control systems, and from results of open-ocean deployments to results of model and lab experiments. The local organizing committee put considerable effort into improving the quality of the program by stringent review of abstracts and challenging authors to make original contributions. Based on some of the immediate feedback from attendees, those efforts paid off in high-quality talks during our 67 sessions presenting over 230 papers, and six panel sessions. We thank all those who contributed to this meeting and encourage any who have not done so to contribute at future OCEANS—it's well worth the effort.

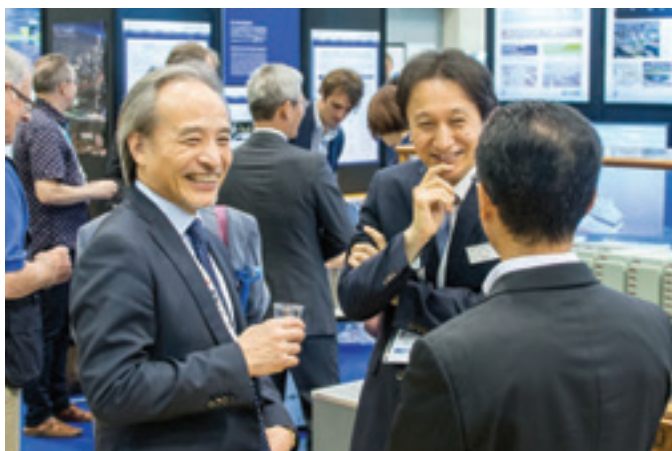
In closing this year's major conference activity for the two societies, I would like to especially thank all members of the local organizing committee who put in countless hours to make this event successful. Without them, this could never happen.

All photos are courtesy of Rick A. Smith, www.rickspix.biz, volunteer photographer for the OCEANS 2019 Seattle LOC.

A Blast from the Past! . . . It's All About Networking

Bob Wernli—Beacon Co-Editor-in-Chief, Photos by Stan Chamberlain

What are the OCEANS conferences all about? Networking!! The majority of us need to build our personal networks for us to achieve our professional goals. How do you do that? With networking at events like our OCEANS conferences. Whether a student or professional, networking at our receptions, dinners, technical programs, exhibits, tours, etc., will help build the ladder that you will use to climb to higher places.



OCEANS 2018 Kobe—Exhibitor Reception.



OCEANS 2018 Kobe—Exhibitor Reception.



OCEANS 2017 Anchorage—Student Reception.



OCEANS 2017 Aberdeen Reception.



OCEANS 2013 San Diego Student Reception.



OCEANS 2012 Hampton Roads.

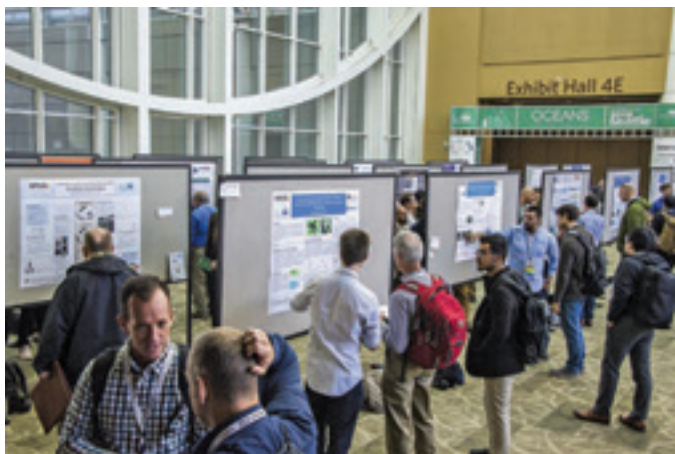
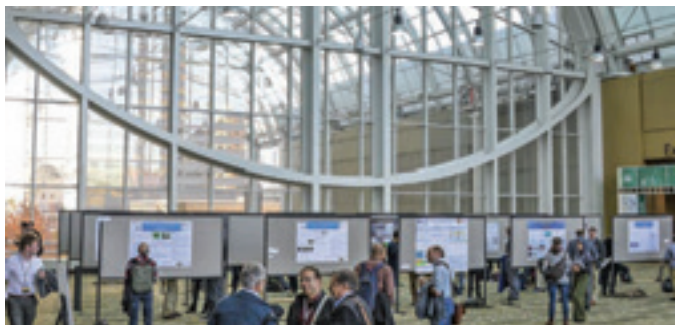
The Student Poster Competition at OCEANS 2019 Seattle

***Shyam Madhusudhana, OES Student Poster Competition Chair,
Photos by Stan Chamberlain***

The Student Poster Competition (SPC) is a flagship event of the MTS/OES OCEANS conferences in which students (both undergraduate and graduate) from colleges and universities around the world participate. Col. Norman Miller had created and implemented the first SPC in 1989 during the OCEANS conference in Seattle, Washington, and it has been a feature of OCEANS conferences ever since. It was befitting that the 30th anniversary of SPC had returned to Seattle. During each conference, typically about twenty students are selected from the pool of aspiring applicants, based on their submitted abstracts, to present a poster describing their work. The selected students' travel, accommodation and conference registration are fully supported by the conference. In addition, monetary prizes are also awarded to the top three best presenters among the selected participants.

The second of this year's SPCs was held during OCEANS 2019 Seattle at the Washington State Convention Center from the 27th to the 31st of October. The SPC program was funded by a grant from the Office of Naval Research (ONR), and we offer our sincere gratitude for their continued support. Preparations in the run-up to the event were ably managed by the local organizing committee (LOC), and in particular by Miles Logsdon who was the SPC chair on the LOC. Out of the 20 applicants that were shortlisted, four candidates had to withdraw due to different reasons, and we had 16 students presenting their work at the event.

The students put up their posters at designated slots on the Skybridge on October 28th. In this edition of the SPC, we had a total of 18 volunteers that offered to serve as judges. We understand that this commitment was an imposition on the



The poster sessions were well attended.



SPC participants. A representative from ONR handed out the awards and certificates.



Some of the judges. At left extreme is the LOC SPC Chair, Miles Logsdon.

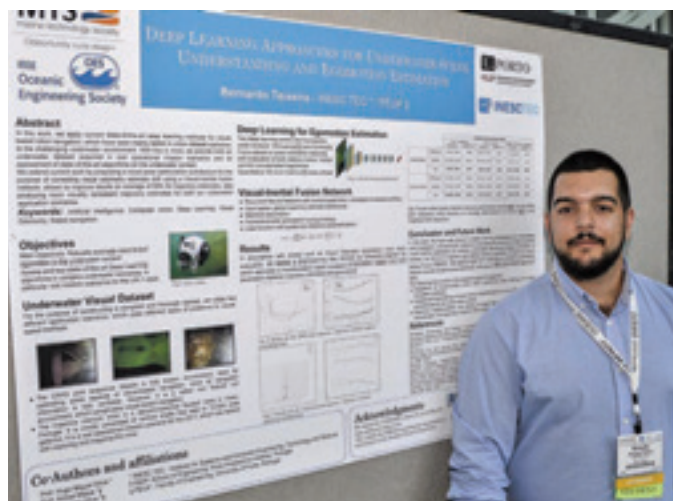
judges' conference schedules, and we deeply appreciate their dedication to encouraging the next generation of ocean scientists and engineers. To ease the load on students as well as the judges, the judging process was restricted to four short sessions spread over two days.

The participants and the judges were all gathered at the main stage on the morning of November 30th. Each participating student was awarded a Certificate of Attendance, and the judges' efforts were acknowledged by presenting each of them a Certificate of Appreciation. The three top-ranked posters were announced and prizes were awarded.

The full list of 16 participants (including the prize winners) together with their affiliation, poster title and an abstract of their poster are given below.

First Prize, Norman Miller Award (Certificate & \$3000 prize)

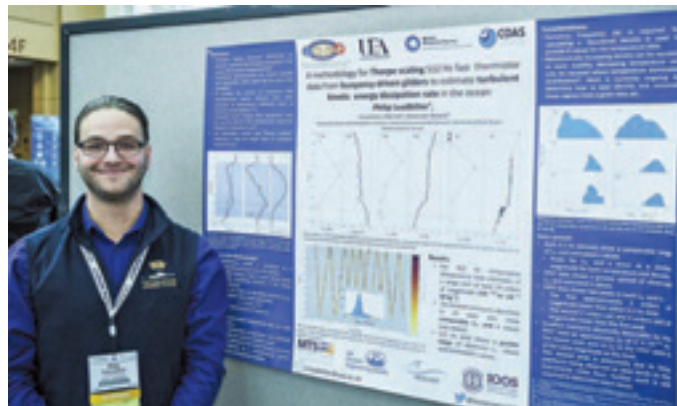
Bernardo Teixeira, INESC TEC, Portugal
Deep Learning Approaches Assessment for Underwater Scene Understanding and Egomotion Estimation



Abstract—This paper address the use of deep learning approaches for visual based navigation in confined underwater environments. State-of-the-art algorithms have shown the tremendous potential deep learning architectures can have for visual navigation implementations, though they are still mostly outperformed by classical feature-based techniques. In this work, we apply current state-of-the-art deep learning methods for visual-based robot navigation to the more challenging underwater environment, providing both an underwater visual dataset acquired in real operational mission scenarios and an assessment of state-of-the-art algorithms on the underwater context. We extend current work by proposing a novel pose optimization architecture for the purpose of correcting visual odometry estimate drift using a Visual-Inertial fusion network, consisted of a neural network architecture anchored on an Inertial supervision learning scheme. Our Visual-Inertial Fusion Network was shown to improve results an average of 50% for trajectory estimates, also producing more visually consistent trajectory estimates for both our underwater application scenarios.

Second Prize (Certificate and \$2000 prize)

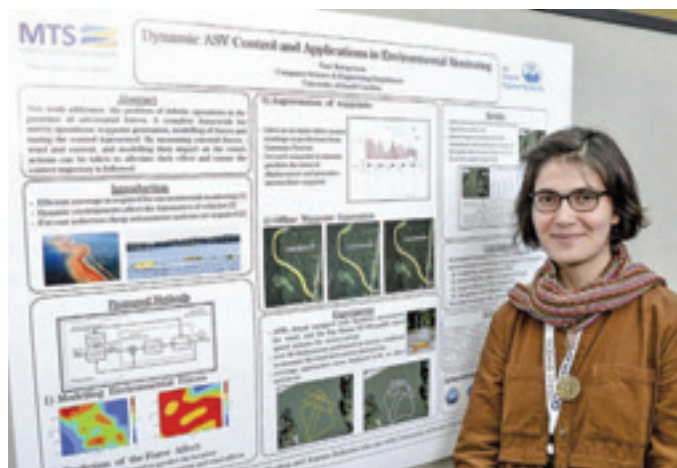
Philip Leadbitter, University of East Anglia, United Kingdom
A methodology for Thorpe scaling 512 Hz fast thermistor data from buoyancy-driven gliders to estimate turbulent kinetic energy dissipation rates in the ocean



Abstract—A Kongsberg Seaglider with a microstructure package was deployed in the Faroe-Shetland Channel in 2017 as part of the 4th Marine Autonomous Systems in Support of Marine Observations (MASSMO4). Using the FP07 fast thermistor (512 Hz), the standard Seaglider thermistor (0.2 Hz) and potential density calculated from Seaglider conductivity-temperature-salinity (0.2 Hz) a comparison of the Thorpe Scale method has been made. Through this method turbulent kinetic energy (TKE) dissipation rates are inferred from the length-scale of a turbulent overturn. Comparison of the three physical quantities show that overturns with a comparable length-scale also have a comparable TKE dissipation rate. The range of estimated TKE dissipation rates from the 0.2 Hz data is also comparable to those inferred using the same method applied to potential density calculated from a ship mounted CTD.

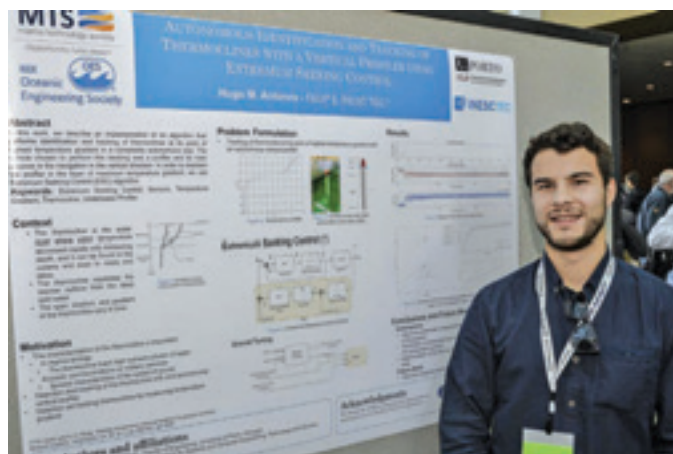
Third Prize (Certificate and \$1000 prize)

Nare Karapetyan, University of South Carolina, USA
Dynamic Autonomous Surface Vehicle Control and Applications in Environmental Monitoring



Abstract—This paper addresses the problem of robotic operations in the presence of adversarial forces. We present a complete framework for survey operations: waypoint generation, modelling of forces and tuning the control. In many applications of environmental monitoring, search and exploration, and bathymetric mapping, the vehicle has to traverse in straight lines parallel to each other, ensuring there are no gaps and no redundant coverage. During operations with an Autonomous Surface Vehicle (ASV) however, the presence of wind and/or currents produces external forces acting on the vehicle which quite often divert it from its intended path. Similar issues have been encountered during aerial or underwater operations. By measuring these phenomena, wind and current, and modelling their impact on the vessel, actions can be taken to alleviate their effect and ensure the correct trajectory is followed.

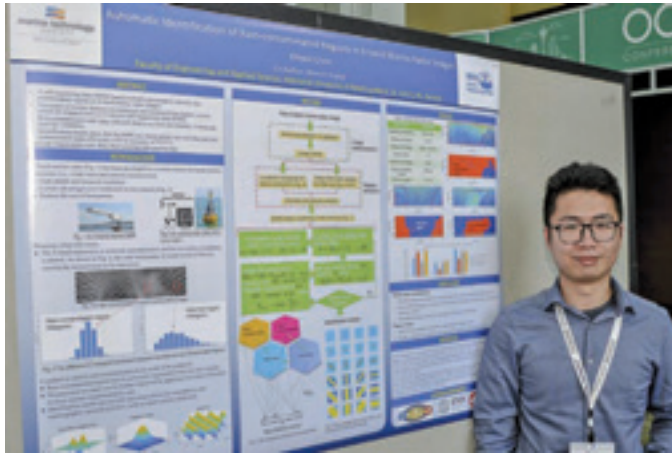
Hugo Antunes, University of Porto, Portugal
Autonomous Identification and Tracking of Thermoclines with a Vertical Profiler using Extremum Seeking Control



Abstract—The thermocline is a relatively narrow vertical region that separates the mixed layer at the surface from the deep-water layer. In this region, the gradient of temperature with respect to depth is higher than in the rest of the water column. The characteristics of the thermocline have strong impact in marine biology, since it may trap high-nutrient organisms, and it also affects sound propagation, with direct impact on underwater acoustic communications and military operations. Under adaptive sampling, Autonomous Underwater Vehicles are practical tools for efficient ocean observation. In this work, we describe an implementation of an Extremum Seeking Controller that performs identification and tracking of thermoclines at its point of highest temperature gradient in a completely autonomous way. The vehicle chosen to perform this tracking was an autonomous vertical profiler, and the algorithms were validated using both real and simulated data.

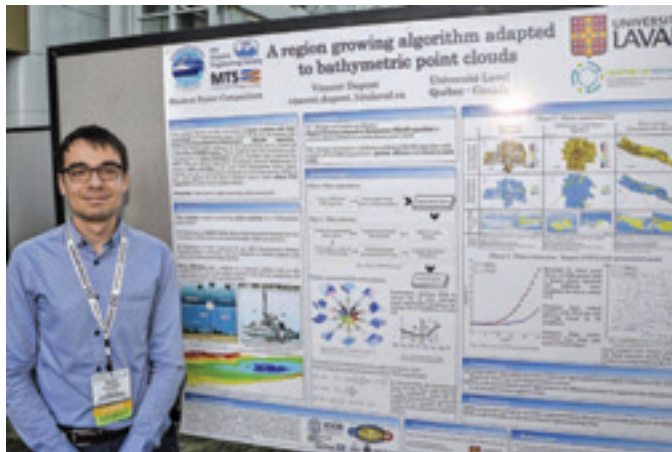
Xinwei Chen, Memorial University of Newfoundland, Canada
Automatic Identification of Rain-contaminated Regions in X-band Marine Radar Images

Abstract—A self-organizing map (SOM) based method for identifying rain-contaminated regions in X-band marine radar



images is proposed. The difference of texture and pixel intensity distribution between rain-contaminated and rain-free echoes is first exploited. A Gabor filter bank is designed to filter marine radar images and generate texture features. Bin values extracted from the localized histogram can represent pixel intensity features. Both types of features extracted from each pixel are combined into a feature vector and trained using an unsupervised neural network, SOM, which clusters pixels into rain-free and rain-contaminated types. Images collected from a shipborne marine radar in a sea trial off the east coast of Canada under rain conditions are utilized to validate the proposed method. Identification results generated from clustering show that the rain-contaminated pixels are effectively detected.

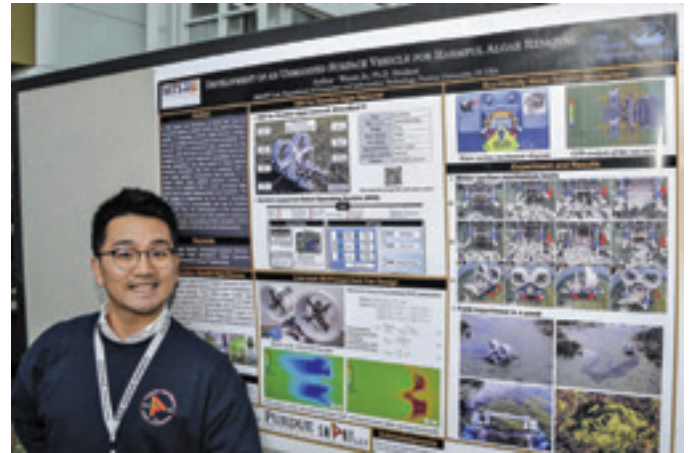
Vincent Dupont, Université Laval, Canada
A region growing algorithm adapted to bathymetric point clouds



Abstract—This project focuses on the extraction of plane surfaces and their uncertainty in a bathymetric point cloud. To do so, we propose the Region-Growing-Adapted-to-Bathymetry (RGAB) algorithm. Knowing where plane surfaces on the seafloor are is needed in calibration of MBES system. These surfaces are also involved in the computation of error estimators used to validate data acquired by ASV. With the RGAB algorithm, we propose several adaptations to classic region growing to be used with bathymetric point cloud. Indeed, we use a more

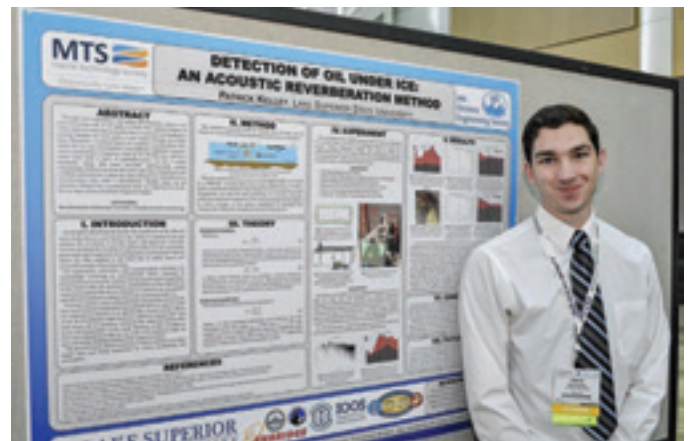
robust PCA approach to extract local normal vectors and a raster-based analysis on the bathymetric DTM to get seed regions for all plane surfaces.

Wonse Jo, Purdue University, USA
Development of an Unmanned Surface Vehicle for Harmful Algae Removal



Abstract—In this paper, we introduce a small and low-cost unmanned surface vehicle (USV), the SMARTBoat 5, capable of removing harmful algal blooms (HABs), which are a rising environmental issue worldwide. The developed USV is a hovercraft type, operated by two propellers with duct fans; it is able to freely move even in shallow water and to approach shorelines. For eco-friendly, immediate, and safe control of algae, the USV is equipped with a novel water suction mechanism that enables it to actively collect algae without physical contact. In addition, it is equipped with a mesh net-based algae filter system that is easily disassembled and replaced. The USV system is supported by the Robot Operating System (ROS) for expandability and use in diverse applications. The performance of the proposed water suction mechanism and USV platform overall are validated through computational fluid simulation (CFD) and experiments in both lab and real environments.

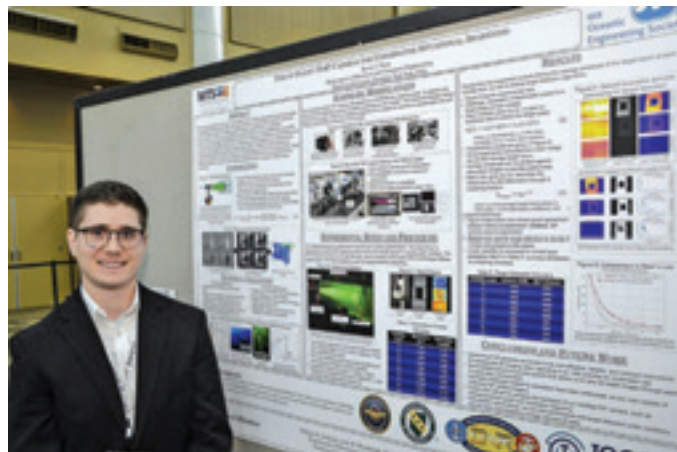
Patrick Kelley, Lake Superior State University, USA
Detection of Oil Under Ice: An Acoustic Reverberation Method



Abstract—Through new exploration and aging infrastructure, there is an ever-increasing risk of oil spills or leaks into natural bodies of water, but presently there is no low-cost method to actively monitor for such spills under ice cover, particularly not any method giving rapid coverage of a large area. Therefore, a method based on acoustic reverberation time under the ice was investigated. A broadband, impulsive acoustic source generating a frequency band of 10–90 kHz was used in a water tank with a layer of naturally-grown ice for a scaled feasibility study of this method; this band provided appropriately short wavelengths, scaled for the small tank environment. Reflections from the tank walls were minimized, and a diffuse environment within the tank allowed for extraction of a reverberation time with a hydrophone. Results show an oil presence changed the reverberation time as compared to an oil-free ice layer across all diffuse frequency bands.

Kevin Mack, Clarkson University, USA

Time-of-Flight (ToF) Cameras for Underwater Situational Awareness

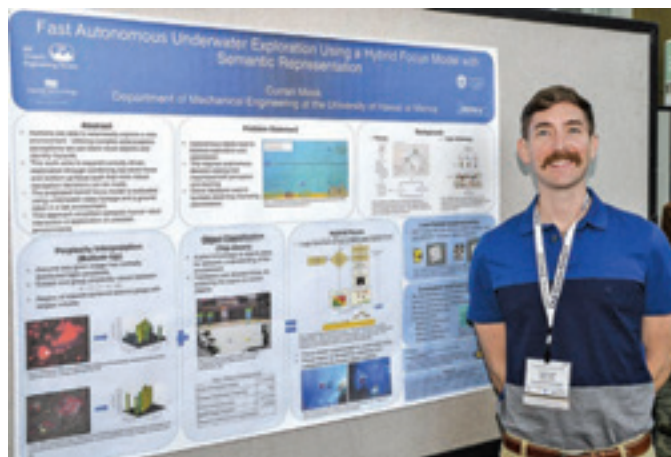


Abstract—Recently developed commercial Time-of-Flight(ToF) cameras have been used to accurately and reliably measure scene depth with high resolution in applications such as automotive LiDAR. There is a desire to adapt this technology for applications in underwater environments. In this work, we establish a methodology for using modified commercial ToF cameras in turbid water. We express the need for hardware and software modifications to the camera and demonstrate initial results in the efficacy of the camera in an underwater test scenario. We include ToF camera imagery taken under a variety of water conditions to understand the performance limitations of this technology as a function of water clarity. Target detection results from preliminary laboratory test tank experiments are presented for two different classifiers, each of which achieves high accuracy for a certain range of water conditions.

Curran Meek, University of Hawaii at Manoa, USA

Fast Autonomous Underwater Exploration using a Hybrid Focus Model with Semantic Representation

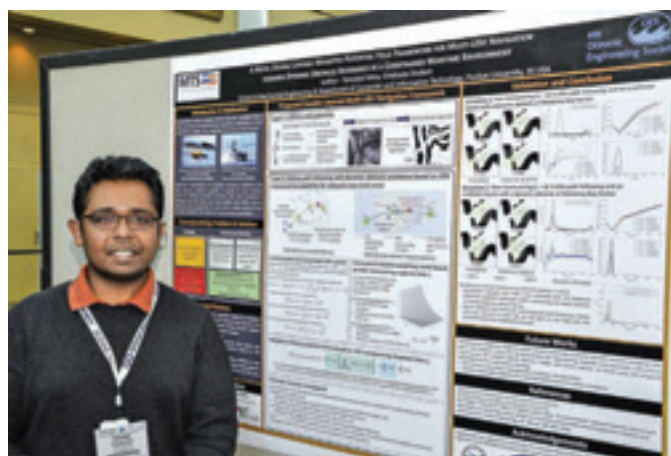
Abstract—By combining complex exteroceptive perceptions, humans are able to seamlessly explore a new environment, build



up their knowledge base, and “easily” identify novel objects or imminent hazards. This work aims at employing a similar intelligent cognition and exploration system for unmanned marine robots. The proposed system semantically discriminates the visual inputs of the robot’s environment by combining task-directed and stimulation-based focus to encode artificial “attention”, to enhance exploration decision making. Additionally, the hybrid focus model can use the semantic descriptors to label a target object (e.g., a certain type of coral) with metric information (e.g., geographical locations of the coral) from a range-and-bearing sensor, allowing a metric map to be generated with semantic labels of the desired types of objects. These maps can help simplify human and robot interaction by providing a clear semantic interpretation of the robots observations. The proposed system is implemented and tested on an indoor robot and with underwater images.

Tamzidul Mina, Purdue University, USA

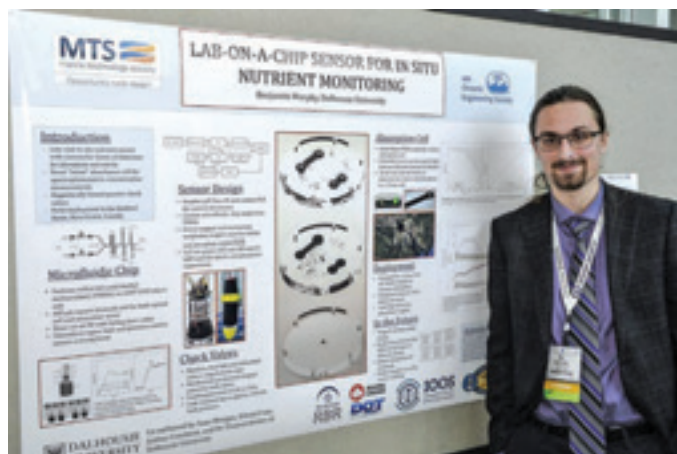
A Novel Double Layered Weighted Potential Field Framework for Multi-USV Navigation towards Dynamic Obstacle Avoidance in a Constrained Maritime Environment



Abstract—Motion planning of multiple unmanned surface vehicles (USVs) towards increased autonomy and wider coverage of the maritime environment is a pertinent requirement. Given the numerous types of USVs currently available with a wide spectrum of maneuvering capabilities, we present a generalized

multi-USV navigation framework adaptable to specific USV maneuvering response capabilities for dynamic obstacle avoidance. The present paper integrates an optimal path planning with safety distance constrained A* algorithm and a proposed adaptively weighted potential field based path following approach with collision avoidance based on USV maneuvering response times. The system allows USVs with fast maneuvering abilities to react late and slow USVs to react sooner to oncoming moving obstacles gradually such that a smooth path is followed by the USV group with reduced cross track error. Simulation results validate reduced cross track error for slow and fast maneuvering response time multi-USV teams.

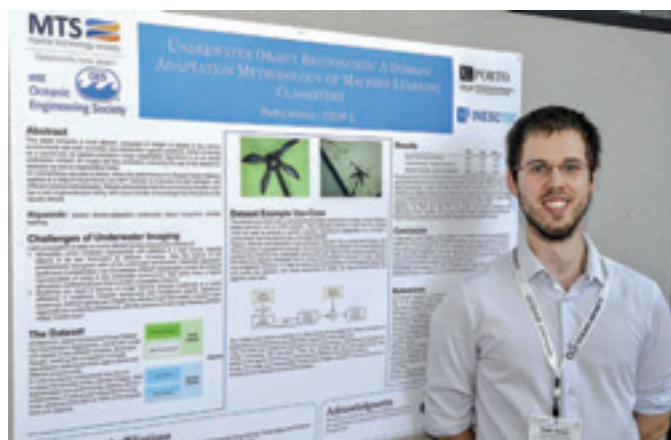
Benjamin Murphy, Dalhousie University, Canada
Lab-on-a-chip sensor for in situ nutrient monitoring



Abstract—Presented here is a low-cost in situ nutrient sensor based on lab-on-a-chip (LOC) technologies. A microfluidic chip with integrated check valves and a novel absorbance cell forms the backbone of the sensor. Using spectrophotometry to measure concentrations of nitrite and phosphate in liquid samples, effective limits of detection (LOD) of 30 nM and 100 nM are achieved for nitrite and phosphate respectively using a 10 mm optical path. The sensor was deployed in the Bedford Basin in Halifax, Canada for 12 hours for in situ phosphate measurement and analysis.

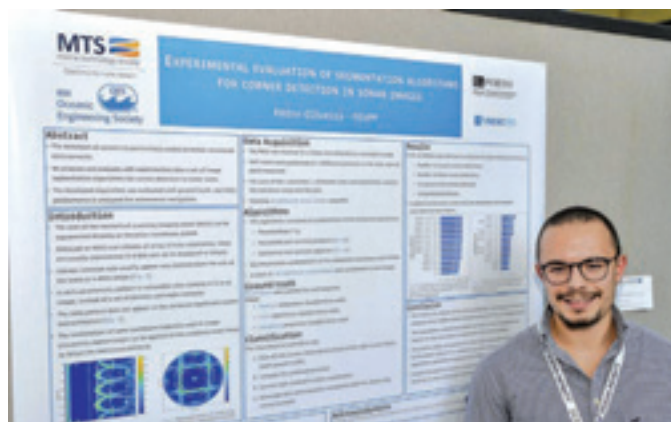
António Oliva Afonso, University of Porto, Portugal
Underwater Object Recognition: A Domain-Adaption Methodology of Machine Learning Classifiers

Abstract—This paper presents a novel dataset, composed of images of objects in two distinct environments and both controlled and uncontrolled capture conditions, aimed at serving as a benchmark for domain-adaptation image classification algorithms in an air versus underwater context. All images are fully annotated, extending the use of the dataset for detection as well as segmentation tasks. An exemplifying use-case is tested, where the performance of a Support Vector Machine applied to a Bag-of-Visual-Words and SIFT features is evaluated on both domains, with different training methodologies. Results demonstrate that the conventional classifier used has a lack of general-



ization ability, with a poor transfer of knowledge from the aerial to the aquatic domain.

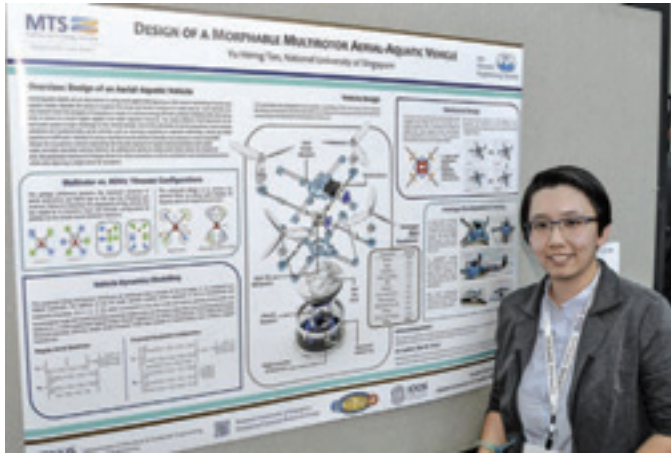
Pedro Oliveira, University of Porto, Portugal
Experimental evaluation of segmentation algorithms for corner detection in sonar images



Abstract—Corners usually appear very distinct from the rest of the scene in a mechanical scanning imaging sonar (MSIS) image, generally characterized by sharp intensities. The detection of corners is particularly useful in human-structured environments such as tanks because the knowledge on their location provides a way to compute the vehicle position. The combination of some basic operations typically used for image segmentation have great potential to detect and localize corners in sonar images automatically. This article proposes and evaluates with experimental data a set of image segmentation algorithms for corner detection in sonar scans. The developed algorithms are evaluated with ground truth, and their performance is analyzed following a few relevant metrics for autonomous navigation.

Yu Herng Tan, National University of Singapore, Singapore
Design of a Morphable Multirotor Aerial-Aquatic Vehicle

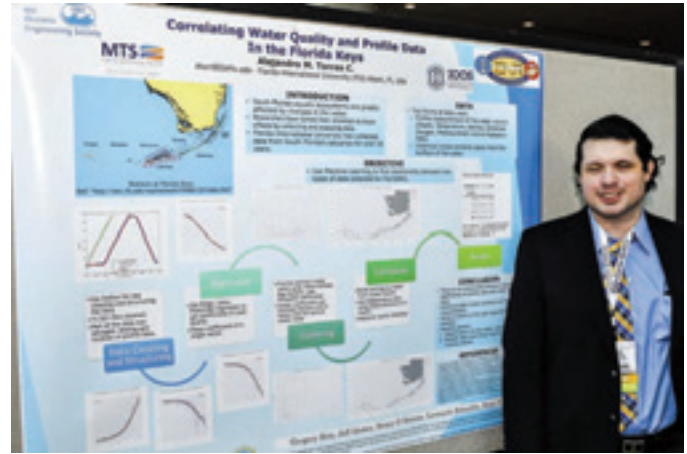
Abstract—The design of any aerial-aquatic vehicle faces the unique challenge of vastly different fluid dynamics of air and water. Due to the demands of aerial propulsion, most existing solutions are fundamentally aerial vehicles with an auxiliary capability to operate underwater. Instead of using standard aerial platforms directly, we propose a novel morphable design for a multirotor-based



vehicle inspired by the thruster layouts of regular aerial quadrotors and underwater remotely operated vehicles (ROVs). By adding the ability to rotate each motor about its respective arm, the proposed mechanical linkage allows for direct actuation in all six translation and rotational directions. The proposed concept is demonstrated in a proof of concept prototype and the details of the design and physical implementation are shown in this paper.

Alejandro Torres, Florida International University, USA
Correlating Water Quality and Profile Data in the Florida Keys

Abstract—Aquatic ecosystems present complex structures susceptible to changes that can cause adverse effects in the water.



These problems have turned the attention of researchers to understand them, and possibly take action to prevent further damages. This interest led to the accumulation of large amounts of data with limited personnel and resources to analyze it. An example of this is the collection of data in South Florida for 25 years by Florida International University. By making use of a depth profile and surface water quality data sets collected in the same location at the same time, a methodology is proposed to correlate these two data sets. By using Machine Learning, we represented depth profiles with coefficients followed by clustering analysis. Similarly, a water surface chemical dataset was clustered using k-means. We then used statistical methods to test the connection between these two data sets.

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Deep Learning Approaches Assessment for Underwater Scene Understanding and Egomotion Estimation

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Abstract—This paper address the use of deep learning approaches for visual based navigation in confined underwater environments. State-of-the-art algorithms have shown the tremendous potential deep learning architectures can have for visual navigation implementations, though they are still mostly outperformed by classical feature-based techniques.

In this work, we apply current state-of-the-art deep learning methods for visual-based robot navigation to the more challenging underwater environment, providing both an underwater visual dataset acquired in real operational mission scenarios and an assessment of state-of-the-art algorithms on the underwater context. We extend current work by proposing a novel pose optimization architecture for the purpose of correcting visual odometry estimate drift using a Visual-Inertial fusion network, consisted of a neural network architecture anchored on an Inertial supervision learning scheme.

Our Visual-Inertial Fusion Network was shown to improve results an average of 50% for trajectory estimates, also producing more visually consistent trajectory estimates for both our underwater application scenarios.

Index Terms—Artificial intelligence, Computer vision, Deep learning, Visual Odometry, Robot navigation

I. INTRODUCTION

Deep Learning has become the "Holy Grail" approach for visual based classification tasks. Most of the renown novel methods for computer vision classification tasks [1][2][3][4] are based on deep learning architectures (e.g. neural network approaches) and deep learning is becoming ubiquitous in most of today's Computer Vision applications.

Based on the significant improvements on accuracy and performance obtained in visual detection and classification tasks, novel deep learning approaches for other applications such as camera pose estimation and visual motion estimation (i.e. Visual Odometry (VO)), started to surface, laying the groundwork for the acquisition of robust reliable data that can be used to feed visual SLAM systems. Motion estimation for visual based navigation applications is one of the key challenges in Computer Vision that is undergoing extensive research in the field of Robotics research, but also in the context of autonomous driving applications. This is partly due to the development and proliferation of more powerful and



Fig. 1. UX-1 Robot photo at Kaatjala Mine courtesy of UNEXTMIN project

cheaper GPU alternatives, which has prompted the surge of data-driven methods such as deep learning to also tackle VO tasks. In recent years, learning based VO has been drawing significant attention, as it can combine powerful feature representation capability with increased robustness especially in more complex scenarios.

One of most complex scenarios is the underwater environment, where visual based navigation methods tend to fail or have lackluster performance due to the lack of appropriate lighting conditions, water turbidity, backscattering effect, lack of image texture and vignetting effect. In this work, we benchmarked deep learning egomotion estimation methods performance in underwater motion estimation scenarios using indoor pool image sequences but also real operation mission scenarios from the UNEXTMIN UX-1¹ [5] robot. The dataset was acquired while the robot was in operation exploring and mapping flooded caved mines.

Our contribution in this paper is twofold: (i) assessment and evaluation of deep learning motion estimation frameworks

¹<https://www.unexmin.eu/>

on the underwater context; (ii) a novel Visual-Inertial Fusion Network that manages to improve around **50%** upon global trajectory estimate errors

The remaining of the paper has the following organization: Section II contains a review of relevant work in the deep learning for computer vision research field, with the focus placed on VO tasks. In section III, we describe the different dataset scenarios. In section V we describe the design of the novel Visual-Inertial Fusion Network approach. Experimental Results and training methodology are presented and discussed in section VI. Lastly, in section VII, some conclusions are drawn from the obtained results and future research directions in the scope of this work are laid out.

II. RELATED WORK

Usually, VO taxonomy divides geometric based Visual Odometry methods into feature-based or direct/dense methods for VO estimation. Both approaches have made great success in the past decade [6]. However, they still face many challenging issues, in particular when being deployed in large scale robotic applications and facing complex environment application scenarios.

In recent years, deep learning methods have risen to predominance by showing good capability for cognitive and perceptual tasks in computer vision applications, whether at analyzing unknown features, capturing image depth or even perceiving egomotion between image frames. Thus, the development of learning-based applications aimed at improving visual-based robotic navigation has had a significant surge as of late.

We start our related work with a brief review of Visual Odometry implementations running on top of deep learning architectures by analyzing key contributions and nuances between different deep VO estimation methods, further dividing the state-of-the-art into depth, global pose and egomotion estimation.

A. Depth Estimation

Depth estimation methods take advantage of camera displacement or difference in the apparent position of an object viewed along two different lines of sight to estimate depth.

Early work by Eigen *et al* [7] proposed a supervised method for depth estimation with a ground-truth depth map and a scale-invariant error as a cost function for training. The work was further extended by further integrating convolution neural networks improving accuracy and efficiency on both segmentation tasks and depth estimation. CNN-SLAM [8] is a proposed monocular SLAM system that relies on convolutional neural networks solely to estimate depth, recovering pose and graph optimization from conventional feature-based SLAM. This approach demonstrated that deep learning architectures can also work hand-in-hand with vision-based systems, improving upon overall robustness and accuracy of said algorithms.

Unsupervised schemes have recently emerged, also posing as viable alternatives. Garg's idea [9] was to use CNN's to predict the depth map for the left input image, reconstructing

the left image from the right image and using the photometric reconstruction error (eq. 1) between the original left image I and the new synthesized left image I' in the training phase of the algorithm.

$$E = \sum \|I - I'\|^2 \quad (1)$$

SfMLearner [10] is a solution that established an influential framework for Deep Learning for Visual Odometry research. It uses a monocular image sequence in order to estimate depth and pose simultaneously in an end-to-end unsupervised manner, through enforcing geometric constraints between image pairs in the view synthesis process. SfMlearner++ [11] improved upon the results in both depth and pose estimation by using the Essential matrix, obtained using Nistér's Five Point Algorithm [12], to enforce epipolar constraints on the loss function, effectively discounting ambiguous pixels.

GeoNet [13] is a similar approach, a jointly unsupervised learning framework for monocular depth, optical flow and egomotion estimation that decouples rigid scene reconstruction and dynamic object motion, making use of this knowledge to further tailor the geometric constraints to the model. Vijayanarasimhan *et al.* [14] presented SfM-Net, innovating through adding motion masks to photometric losses to jointly estimate optimal flow, depth maps and egomotion.

B. Global Pose Estimation

Localization is a crucial component for autonomous systems development, since it enables a robot to determine where it is on an environment, which serves as a precursor to any type of action execution or planning.

The main purpose of data-driven pose estimation is to estimate pose without explicitly modeling the camera motion. PoseNet [15] was the first instance of CNN usage for pose estimation, starting from a supervised scheme with a 6-DoF pose groundtruth. Making use of geometry to design meaningful constraints to the loss function [16] proved to yield significant improvements to method performance and accuracy. This method showed very robust performances in relocalization tasks and was further extended to support both color and depth inputs, improving upon its accuracy in challenging environments, such as night-time.

The application of deep RCNN's architectures to Visual Odometry task have been gaining favor in the past years, as they allow for bypassing the need for almost all blocks in the conventional VO pipeline, allowing for end-to-end pose inference. The Recurrent Neural Network component can be used for exploring either temporal dynamics or spatial analysis of image sequences, thereby reducing the uncertainty of pose estimation and generally improving upon method performance. The introduction of LSTM units to neural network design as showcased in [17] proved to improve results in localization tasks making use of structured correlation in feature space using LSTM units.

TABLE I
RELATED WORK IN DEEP LEARNING FOR COMPUTER VISION
APPLICATIONS

Algorithm	Year	Supervised	Depth	Global Pose	Egomotion
Eigen et al.[7]	2014	✓	✓		
PoseNet[15]	2015	✓		✓	
DeepVO [18]	2017	✓			✓
SfMLearner [10]	2017	no	✓		✓
PoseLSTM [17]	2017	✓		✓	
UnDeepVO [19]	2017	no			✓
CNN-SLAM [8]	2017	✓	✓		
VINET [20]	2017	no			✓
VLocNet [21]	2018	no		✓	✓
GeoNet [13]	2018	no	✓		✓

C. Egomotion Estimation

Building upon the success of absolute pose estimation, the egomotion between consecutive image frames can also be estimated with the use of deep neural architectures inspired by geometric models. The key principle is that for the egomotion estimation task we are interested in capturing the motion undergone by the camera system between consecutive images rather than just determining the position and attitude of the observer. FlowNet [22] and its successive iterations garnered immense attention as a reliable deep learning framework for learning optical flow and paved the way for early egomotion estimators. Wang *et al.* proposed a monocular visual odometry system called DeepVO [18], which trains a RCNN to estimate camera motion in an end-to-end fashion, inferring pose directly from a sequence of raw RGB images in a video clip while bypassing all usual modules in the conventional VO pipeline. The advantage of such approach is to simultaneously factor in both feature extraction and sequential modelling through combining CNN's and RNN's.

As labeling data in large scale significantly hinders the application of supervised learning methods to robotic applications, Li *et al* proposed UnDeepVO [19], a monocular system that uses stereo image pairs in the training phase for scale recovery. After training with unlabeled stereo images, UnDeepVO can simultaneously perform visual odometry and depth estimation with monocular images.

Valada *et al* [21] proposed a novel architecture that encompasses both global pose localization and a relative pose estimation, jointly regressing global pose and odometry and learning inter-task correlations and shared features through parameter sharing. This method is denoted as Deep Auxiliary Learning.

Visual Odometry methods are particularly sensitive to rotation errors, as small early drifts can have a large influence on final trajectory pose estimates. Peretroukhin [23] proposed HydraNet, a deep learning structure aimed at improving attitude estimates, able to be fused with classical visual methods. Through regressing unit quaternions, modeling rotation uncertainty and producing 3D covariances, HydraNet manages to improve visual algorithms at predicting 6-DoF pose estimates.

Another application Deep learning architectures are currently being tested on is sensor fusion. VINet [20] is a proposed framework that fuses pose estimates from DeepVO

[18] with inertial data, showing comparable performance to traditional fusion systems. The same method was also adopted to fuse other kinds of information such as magnetic sensors, GPS, INS or wheel odometry [24] [25]. Sensor fusion can be easily incorporated into deep learning architectures and jointly trained end-to-end with pose regression, thus making a potentially interesting solution for Visual Odometry applications as it can be used for a wide variety of purposes (e.g. recovering absolute scale on monocular camera systems).

In table I, a brief comparison of state-of-the-art methods is presented, detailing the tasks they perform.

III. UNDERWATER VISUAL DATASET

Deep learning methods usually require vast amounts of data in order to properly train its neural architectures. This is particularly true in robotic applications, since autonomous systems can operate in very complex environments, often under extreme conditions. As so, the availability of large scale datasets is crucial for further development of deep learning algorithms and its respective generalization ability, therefore improving upon its robustness when being deployed in full-scale large complex environments.

In the underwater context, there are not many publicly available large datasets and there is none widely regarded as a comprehensive benchmark for method evaluation. In the scope of this work, we also wanted to assess method performance using one of CRAS robotic solutions, namely the UNEXMIN UX-1 robot. With this in mind, we developed a deep visual underwater dataset, an underwater focused dataset collected with the UX-1, tailored for visual odometry method implementation and evaluation, with which we pretend to assess performance of state-of-the-art deep learning architectures for VO estimation in different underwater scenarios. In Fig. 2, we can observe example images of our dataset sequences, that showcase the different environments included in our dataset.

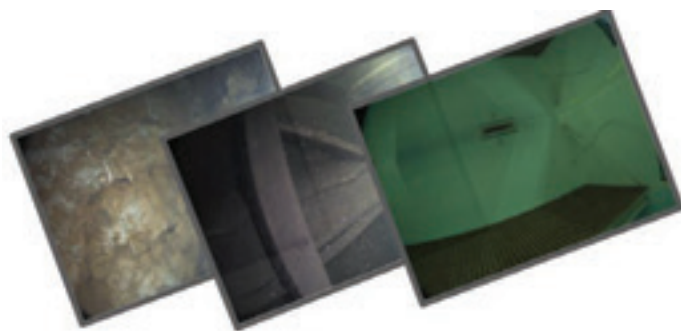


Fig. 2. Dataset image examples

In this section, we are discussing in detail the data acquisition process, specifically describing the UNEXMIN UX-1 robot and all the technology contained within it, while providing related remarks about the image acquisition methodology, specifically the camera setup, the reasoning and assumptions of the process.

A. Data acquisition methodology

As previously mentioned, the dataset was constructed using data acquired with the UX-1 robot. This robot is equipped with a plethora of different sensors, including 5 cameras. In this work, and especially since the UX-1 does not have a great overlay of camera fields-of-view, we are focusing on monocular visual methods, and as so, we choose to analyze the left camera system, with the goal of estimating robot pose in the central reference frame (i.e. pose estimates in the camera system reference frame has to be later transformed to the robot body reference frame). Groundtruth data is generated by the navigation module of the UX-1 software, a filtered calibration of sensor fusion from multiple local sensor sources (IMU, Doppler Velocity Logger, Structured Laser System, etc), progressively refined through multiple operation missions in complex settings and extremely challenging operational conditions.

In the scope of this work, we are working with the underlying assumption that this navigation data corresponds exactly to the real robot pose, which is not easily verifiable in operational mission scenarios. However, it can be asserted, with relative confidence, that this data represents a close approximation of the real robot position and can, therefore, be used as groundtruth for our use case. The groundtruth data file consists of a .txt file where each line contains 8 scalars, representing a timestamp and 6-DoF poses with a 3D translation vector and an orientation quaternion.

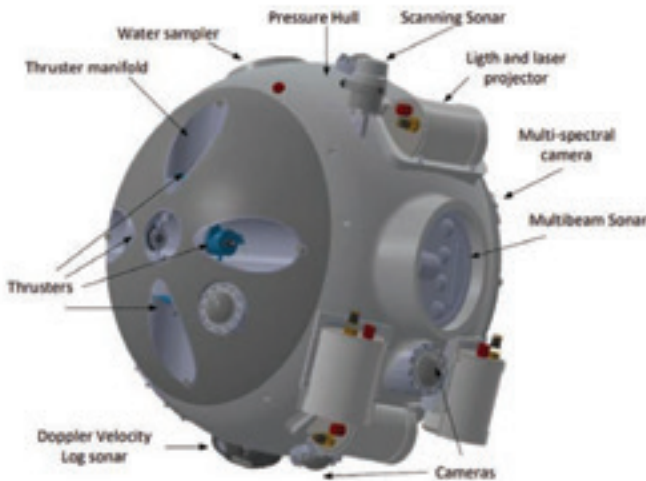


Fig. 3. UNEXMIN UX-1 robot description

B. Dataset Scenarios

For the purpose of constructing a complete and thorough dataset, we utilize two different application scenarios, which pose different types of problems to visual-based methods:

- 1) **The CRAS pool** sequence depicts a fully known environment, ideal for calibrating some aspects of visual-based navigation, since all navigation information is fully verifiable. However, it is a rather non feature

rich environment with lack of appropriate illumination conditions, which complicates visual-based navigation.



Fig. 4. CRAS indoor pool

- 2) **The Urgeirica uranium mine** is a decommissioned flooded mine in Viseu, Portugal. It is mostly composed of vertical shafts that lead to 15-30m wide galleries. It is a real operational mission scenario for the UX-1, which was tasked with exploring and mapping the mine.



Fig. 5. Urgeirica mine entrance

IV. DEEP LEARNING APPROACHES FOR VISUAL-BASED ROBOT NAVIGATION

A. Egomotion Estimation

In the scope of underwater robotics research, and specifically in the context of our work, the most interesting application we are interested in exploring are unsupervised deep learning frameworks for egomotion estimation.

For the purpose of estimating motion dynamics, we are turning our attention to two similar state-of-the-art deep convolutional visual frameworks: SfMLearner [10] and GeoNet [13]. Though both frameworks also estimate monocular depth (and optical flow in the case of GeoNet), we are only focusing on camera motion estimation CNN's.

SfMLearner[10] is an unsupervised learning pipeline for depth and egomotion estimation. The unsupervised objective is fulfilled based on the following intuition: given knowledge of camera self-motion within a sequence of images and the depth of every pixel in those images, we can gain an unsupervised target by performing view synthesis. As mentioned above, we are interested in evaluating Zhou's PoseNet, the SfMLearner framework component responsible for regressing 6-DoF pose estimates. The PoseNet architecture is essentially a temporal convolutional network which processes a sequence of n images

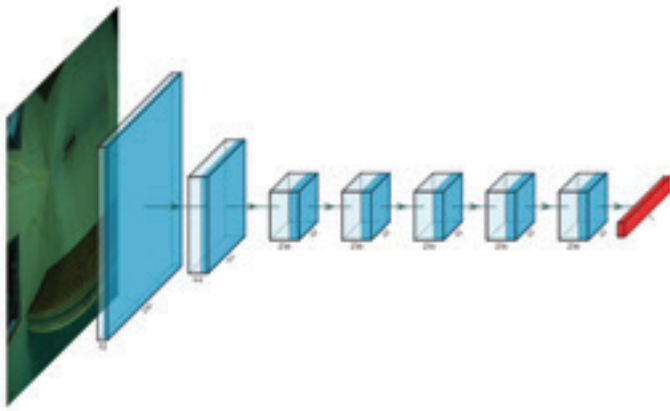


Fig. 6. Representation of the SfMlearner PoseNet, the framework component responsible for regressing 6-DoF pose estimates. It consists of 7 blocks of convolutional layers followed by ReLU activations, outputting a 6-dimensional vector that comprises a 3D translation vector and euler angles orientation representation.

by predicting relative transformation from the center image of the sequence (the image at the central position of the snippet, as shown in Fig. 7) to the other images in the sequence, outputting a $n-1$ transformation vector composed of a 3D translation vector and a Euler angle orientation vector for each transformation.

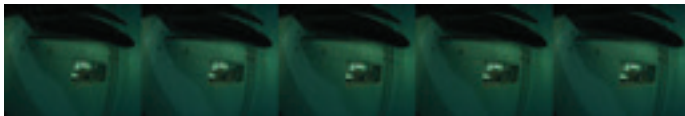


Fig. 7. CRAS pool 5-sequence length snippet:

The network itself is a convolutional regressor model with seven convolutional layers with stride-2 followed by ReLU activations, leading to a final linear convolution that outputs the aforementioned $6 \times (n-1)$ -dimensional channels. On top of this network, an "explainability" mask is used to downweight the loss on image patches undergoing motion external to the camera's motion (e.g. a car or pedestrian moving in the frame).

GeoNet[13] is a jointly trained end-to-end unsupervised learning framework for monocular depth, optical flow and egomotion estimation. Specifically, this framework focuses on extracting geometric relationships in the input data by separately considering static and dynamic elements in the scene. Significant performance gains have been reported, mostly due to increased robustness towards texture ambiguity and occlusions in the scene.

The framework is composed of two stages: the Rigid Structure Reconstructor and the Non-rigid Motion Localizer. The first stage is tasked with understanding the scene layout and structure and it consists of two sub-networks, i.e. the DepthNet and the PoseNet. The second stage concerns itself with dynamic objects in the scene and it is utilized for the purpose of refining imperfect results from the first stage due

to motion external to the camera motion, as well as help deal with high pixel saturation and extreme lighting conditions.

Similarly to SfMlearner, view synthesis at different stages works as a synthetic supervision for the unsupervised learning architecture, with image appearance similarity enforcing geometric and photometric consistency within the loss function.

The most relevant part of the framework in the scope of our work is the Pose Net, which consists of 7 convolutional layers followed by batch normalization and ReLU activation (see Fig. 8). The prediction layers output the 6-DoF camera poses, i.e. translational vectors and orientation Euler angles.

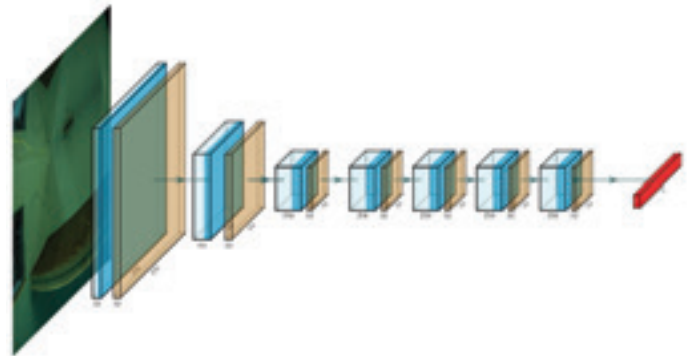


Fig. 8. Representation of the GeoNet PoseNet, the framework component responsible for regressing 6-DoF pose estimates. It consists of 7 blocks of convolutional layers followed by ReLU activations and additional batch normalization layers, outputting a 6-dimensional vector that comprises a 3D translation vector and euler angles orientation representation.

V. VISUAL-INERTIAL FUSION NETWORK

Regardless of the algorithm, traditional monocular VO solutions are unable to observe the scale of the scene and are subject to scale drift and scale ambiguity. This is not different for deep neural architectures, as reported in the previously studied frameworks. The most common approach for pose optimization in the literature is to fuse visual and inertial data as a way to enforce global scale consistency with respect to the groundtruth data and therefore it would make sense to investigate analogous deep learning approaches to perform this task.

In this work, we propose a Recurrent Neural Network architecture anchored in a supervised learning scheme whereby we use filtered IMU readings as a supervision for 6-DoF pose estimate optimization.

The **input space** of this network are the concatenated egomotion predictions of both Sfmler and GeoNet, i.e. global trajectory estimates in the robot central body frame. For this purpose, and due to deep learning architectures requiring large amounts of data to converge to a robust model, we had to run multiple predictions from both frameworks so as to synthesize a dataframe dataset.

The **network** itself consists of stacked LSTM units working with progressively smaller time step lags leading to a multilayer perceptron that regresses the optimized trajectory estimate. The goal is to process the data as a sequence-to-

sequence problem, optimizing the input trajectory estimates to a more globally consistent trajectory.

The **fundamental assumption** driving this architecture is that the output space of the optimized trajectory estimate lie in a manifold much smaller than 6-DoF space. Implicitly constraining the output prediction space to a minimization of the mean square error between visual and inertial data helps to avoid the curse of dimensionality.

For **loss function** design, the intuition was that we needed to make use of the quaternion parametrization to penalize rotation errors in a meaningful way. In this light, we decoupled the translation and rotation components and formulated a loss function that takes the mean squared error for translation and the quaternion distance between estimate and groundtruth in the $SO(3)$ group.

$$loss = \sqrt{\sum (E_x^2 + E_y^2 + E_z^2) + \sum |q_e - q|} \quad (2)$$

where $E_{x...z}$ represents the computation of distance between estimate and groundtruth position. Quaternion distance is computed as the norm of the difference between estimate and groundtruth quaternions. In addition, we constrained the equation to take into account the fact that q and $-q$ encode the same rotation, only considering the smaller of the two possible distances in the loss function calculation.

VI. EXPERIMENTAL RESULTS

A. Training Procedure and Hyperparameter Details

In this section, we focus on the experimental results for egomotion estimation frameworks. In addition, we will show the impact of the Visual-Inertial Fusion Network so as to optimize the trajectory estimate and correct inherent VO drift on the data generated by the previously studied egomotion estimation frameworks. SfMLearner and Geonet share the data preprocessing step whereby the input image sequence is split into 5 sequence length snippets (see Fig. 7). In conjunction with camera intrinsic calibration and image timestamps, the 416x128 snippets were fed to the frameworks and the neural networks were trained using tensorflow[26] running on a CUDA enabled Nvidia GTX 1080. It is also worth noting that a post-processing step was implemented in order to recover full concatenated trajectory from the 5-snippet length predicts, so as to analyze also the global trajectory errors. Some context finetuning was performed, empirically adapting the network to penalize heavier errors in rotation as large global trajectory errors were being introduced due to early rotation errors unaligning the pose estimates with the groundtruth, thus accumulating significant drift. For the Visual-Inertial Fusion Network on the other hand, and given that there was no prior knowledge about how to tune a pose optimization network, we adopted a grid-search learning scheme to sweep multiple combinations of hyperparameters and return the one that converges to smaller loss values. This is only feasible in a short timeframe because we are working with low dimensional data (i.e. dataframes instead of high resolution imagery) but

for this application, it is perfectly suited for finding an optimal solution for hyperparameter tuning.

B. Results

Results on our dataset are presented in two different forms. First, we evaluate in a similar fashion to how both authors presented them, by computing estimate errors within the previously mentioned 5-frame sequences, with scale correction optimization and alignment with groundtruth data, so as to resolve scale ambiguity and minimize the impact of early drift accumulation errors.

TABLE II
ABSOLUTE TRAJECTORY ERROR (ATE) EVALUATION

	KITTI seq 09	KITTI seq 10	CRAS Pool	Urgeirica Mine
SfMLearner	0.016 ± 0.009	0.013 ± 0.009	0.016 ± 0.006	0.028 ± 0.086
GeoNet	0.012 ± 0.007	0.012 ± 0.009	0.012 ± 0.006	0.026 ± 0.081

In the remaining of this section, we will present and discuss the results considering the full concatenated trajectory, thereby escaping the snippet representation and recomputing errors with respect to translation for all sequence trajectories under analysis. For the sake of coherent representation we will present the trajectories after the application of a post-processing step denoted as Umeyama alignment [27], commonly used in VO quantitative trajectory error metrics. It consists of a least-squares estimation of transformation parameters translation, rotation and scale between estimates and groundtruth pose data.

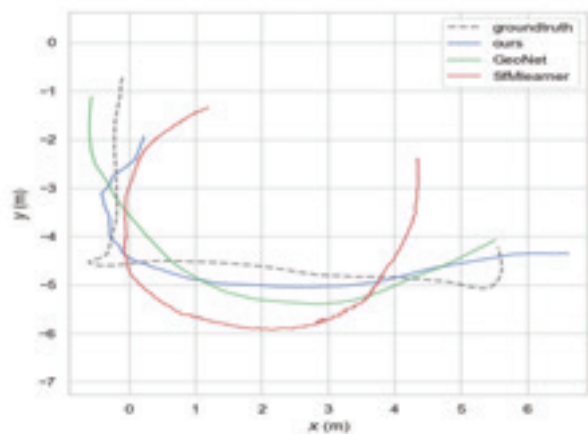


Fig. 9. Results for the CRAS pool sequence: trajectory estimates against groundtruth data

As it can be observed in table III, our Visual-Inertial Fusion Network was able to synthesize the best results for global trajectory estimation with or without any type of preprocessing step. It performs on average around **40%** better for the CRAS pool sequence while showing an average improvement of around **55%** in the urgeiria mine sequence. It is important to note, however, that both SfMLearner and GeoNet are unsupervised frameworks, and the devised solution leverages a supervised learning scheme.

TABLE III
RESULT COMPILATION FOR ABSOLUTE POSE ERROR W.R.T. TRANSLATION

		Absolute Pose Error (APE)					
		"raw" comparison		scale-corrected		SIM(3) Umeyama alignment	
		Avg.Error	RMSE (m)	Avg.Error	RMSE (m)	Avg.Error	RMSE (m)
CRAS POOL	SfMlearner	3.301±2.049	3.996	2.755±1.573	3.049	0.731±0.440	0.905
	GeoNet	28.739±14.613	29.912	20.846±6.687	20.087	5.345±1.112	5.475
	ours	2.329±1.781	2.877	1.380±1.259	1.380	0.570±1.005	0.637
Urgeirica Mine	SfMlearner	52.709±1.199	52.461	20.354±3.366	19.129	0.7208±0.584	1.158
	GeoNet	55.392±2.728	56.096	22.043±1.041	22.475	0.839±0.543	1.077
	ours	46.269±2.928	47.973	4.177±0.219	4.227	0.168±0.106	0.212

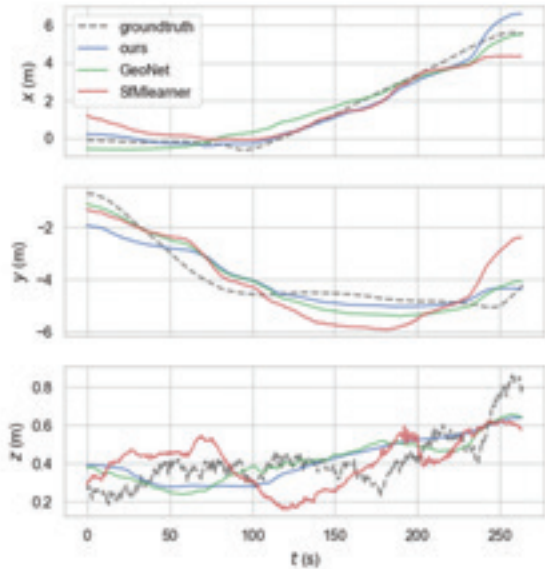


Fig. 10. Results for the CRAS pool sequence: trajectory estimates against groundtruth data decoupled by translational component

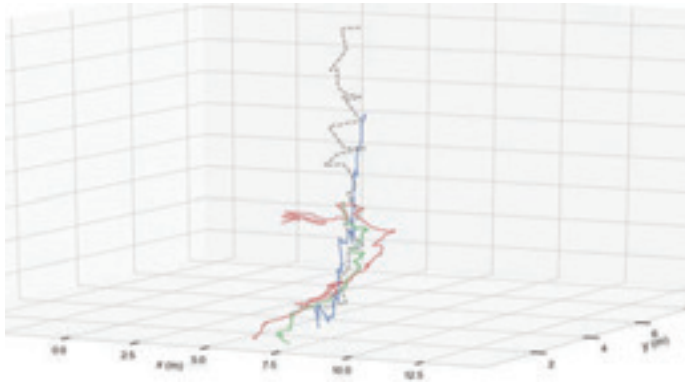


Fig. 11. Results for Urgeirica Mine sequence: computed trajectory estimates against groundtruth data

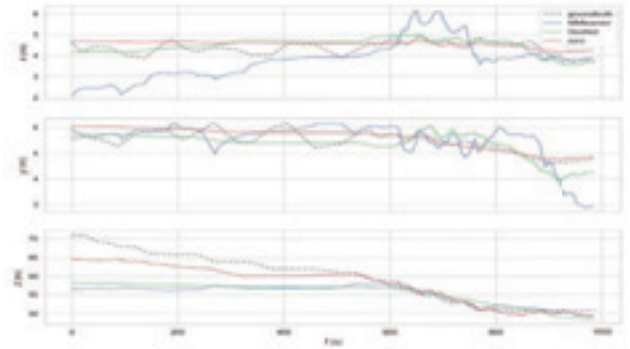


Fig. 12. Results for Urgeirica Mine sequence: trajectory estimates against groundtruth data decoupled by translational component

C. Discussion

The performance of state-of-the-art deep learning methods for egomotion estimation can be analyzed through different perspectives, leading to the following conclusions:

- First of all, as it can be observed in table II, we were able to produce similar results to those presented in the literature only for our CRAS pool sequence. It is still a good indication that it was possible to achieve such results in the underwater context, however, it is important to note that it was only true for our fully known structured environment. Real mission operational scenarios like the urgeirica mine sequence pose greater challenges to visual-based motion estimation algorithms and that is reflected on higher magnitude error rates.
- Secondly, it is possible to observe that both networks performs fairly better at regressing translational displacement than rotational movement. Rotation, and in particular pure rotations, are not handled well in any of the studied methods.
- In accordance to the expectations, and in agreement with both authors result presentation, pose estimates only present persuasive results with a post-processing step. The need for scale correction is a consequence of the use of monocular camera setups, but some type of groundtruth alignment algorithm is also required.

- Though relative motion estimates seem at first glance to show potential due to small average error rates, their concatenation onto the full trajectory reveals that the drift accumulation results in poor trajectory shape mimicking. In conclusion, there is still room for improvement when it concerns to global pose estimation derived from unsupervised egomotion estimation frameworks.
- We introduced a visual-inertial fusion network, anchored on a recurrent neural network architecture with an inertial supervision learning scheme. It was shown to improve results an average of **50%** for trajectory estimates, also producing more visually consistent trajectory estimates for both our application scenarios. This approach can later be integrated with egomotion estimation frameworks in an end-to-end fashion, leading to more accurate and reliable robot trajectory estimates.

VII. CONCLUSION

A. Summary

In this paper, the focus was placed on deep learning approaches for visual-based robot navigation, with particular interest on evaluating the potential for learning-based visual method application on complex underwater operational mission scenarios.

Firstly, a review of state-of-the-art deep learning approaches for Visual Odometry applications was conducted, detailing the progress in performance and accuracy deep learning methods have managed to achieve in recent years, as well as its shortcomings. It was concluded that there was close to no information about the performance of deep learning methods for VO estimation in underwater context scenarios, and would therefore be particularly interesting and relevant to assess the performance of some of the most renown state-of-the-art algorithms in operational mission underwater scenarios.

The next step was to construct a comprehensive dataset encompassing different texture environments and providing different types of challenges to visual-based pose and/or motion estimation. As reported in III, this was achieved through the use of data acquired with the UX-1 robot, and presents three novel image sequences that all pose different challenges to visual-based VO estimation.

In order to access the performance of learning-based visual methods on our dataset image sequence, we focused on two different tasks: absolute relocalization and egomotion estimation. We came to the conclusion that relocalization algorithms have an overall good performance across different scenarios, but lack generalization ability when exposed to more than one different mapping during training. It is reasonable to assume that we could achieve good performance from the application of this methods in real robotic solutions, though real time testing was not performed and thus validation is still required.

As for egomotion estimation, the results were not as accurate and reliable as expected. Relative motion estimates of state-of-the-art algorithms show small errors in translation yet rotations still pose some challenges these methods are not able to overcome. Analyzing concatenated trajectories, we

can easily observe that pure rotations and accumulated drifts lead to failures in pose estimation, thus making the algorithm unable to provide consistent and reliable estimates, as required by real robotic systems.

In section V, we again address the issue of the aforementioned poor performance of egomotion estimation methods, presenting a possible solutions for obtaining the global pose optimization objective. The proposed solution consists of a Visual-Inertial Fusion Network, aimed at improving global pose estimates through an inertial supervision learning scheme. This supervised architecture proved to significantly improve results on global pose estimation, with around **50%** better error rates.

In this work, real-time implementation of deep learning algorithms was not addressed, mainly because the UX-1 does not possess any type of GPU hardware, therefore rendering any conclusion from on board implementations non-viable. In addition, and although the robot possesses multiple cameras, visual stereo implementations are significantly hard to design for this particular robot, due to non-overlapping camera fields-of-view.

B. Future Work

The following future work in this research scope is suggested:

- Integration of visual-inertial fusion within end-to-end deep learning for robot navigation pipelines. Further study of inertial integration without losing the unsupervised learning objective.
- Assessment and testing of visual stereo implementations on top of deep learning architectures for the underwater context. This work focused on monocular camera setups mostly due to the UX-1 design constraints, yet it would be interesting to investigate the performance of deep learning architectures also for the stereo use case.
- Real-time implementation and testing of deep learning architectures for both relocalization and egomotion tasks for the underwater context. The low budget recommended option would be using a Nvidia Jetson Nano and TensorRT for fast inference implementation.

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Student Poster Competition (SPC): We offer an opportunity for students to present their research and interact with researchers and professionals during OCEANS 2020 Singapore. The SPC is open to all undergraduate and graduate students enrolled, at least half time, in any community college, college, or university worldwide. Submitted abstracts will be evaluated by a panel of experts, and about 15-20 abstracts will be selected for the competition. Students accepted to the SPC are required to submit a full paper, and prepare a poster to be displayed and evaluated at the conference (April 7-9, 2020). Financial support including conference registration, travel and accommodation, is provided to all students selected for the SPC.

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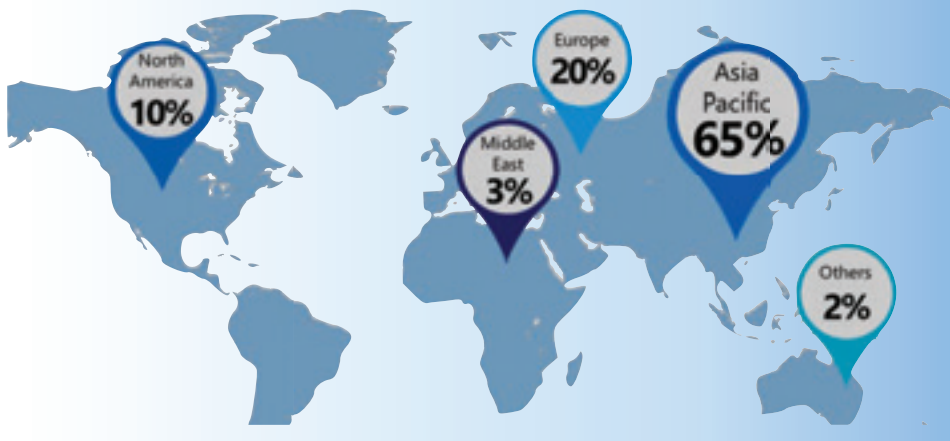


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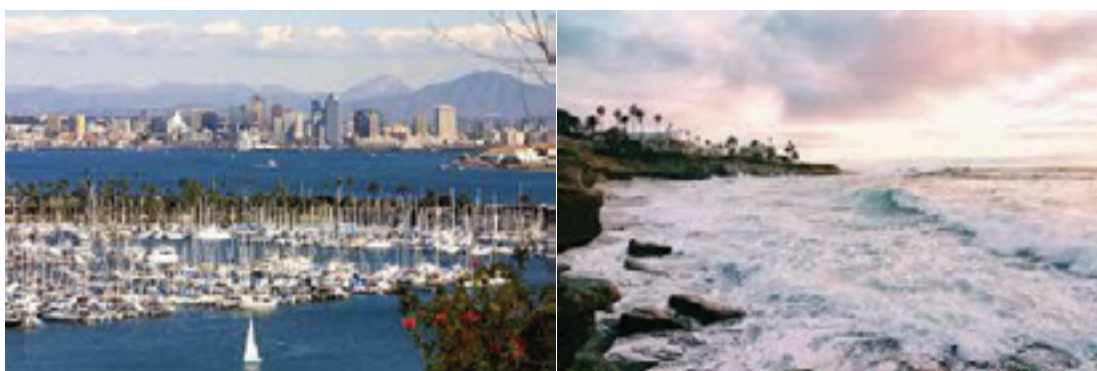
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The OCEANS 2021 San Diego committee invites you to beautiful San Diego to participate in the world's most prestigious, comprehensive, and diverse conference and exposition regarding our most critical resource—the oceans. Coordinated with the kickoff of the United Nations “Decade of Ocean Science (2021-2030), this will be the 8th time the OCEANS conference has come to San Diego, a venue that has consistently provided the largest and most successful OCEANS conferences ever.

OCEANS 2021 San Diego will expand significantly in scope, bringing together key international industry and government stakeholders, focusing on investment plans/strategies during the upcoming five years as well as emerging technologies, new science and research initiatives, and the latest in commercial products.

The theme for OCEANS 2021 San Diego is **“Sustaining our Oceans . . . Sustaining our Future,”** reflecting on the critical nature and importance of our industry and its sustaining technologies. New Technical tracks will include Artificial Intelligence (AI), the great challenge of Data Management, Arctic and Antarctic exploration, and will present emerging technologies for ocean stewardship, food supply production and management, national defense, energy production, and overall management of the oceans and waterways. Assuring a successful conference will be committee members from the highly successful 2013 and 2003 San Diego OCEANS conferences along with new, influential and highly capable technical, academic and business leaders. Your OCEANS committee is working diligently to bring together influential buyers, investors, stakeholders, industry experts, and innovators from government agencies, industry, and academia.

We look forward to welcoming you to San Diego.



Alan Kenny
Conference Chair



Robert Wernli
Conference Co-Chair

Who's who in the OES

Jenhwa Guo, National Taiwan University (NTU)

Jenhwa Guo was born in Taipei in 1958. He is a professor at the Department of Engineering Science and Ocean Engineering, National Taiwan University (NTU). In 1982, he took an M.S. degree in oceanography from NTU. He received his Ph.D. in mechanical engineering from the University of Minnesota, Twin Cities, U.S.A. in 1991. His thesis was on robotic exoskeletons. In 1992, when he was hired to teach at NTU, he had a brief conversation with the Conference Chairman Robert Wernli at the Intervention/ROV '92, held in San Diego, as a result of which he decided to join the IEEE/OES. In the same year, he participated in a short course on AUV system design, held at NTU and run by Professor Tamaki Ura of the University of Tokyo. He has since become one of Taiwan's pioneers in AUV/ROV research. In 1998, he began to be involved in conferences outside of Taiwan, including the 1998 IEEE Symposium on Underwater Technology in Tokyo, where he met Harumi Sugimatsu, Lian Lian and others, who have become lifelong friends. In 2008 to 2012, he served as the head of the Marine Exploration Technology Division of the newly established Taiwan Ocean Research Institute, led by Professor Forng-Chen Chiu of NTU. His division was focused on the development of the first deep-sea scientific ROV in Taiwan, and has been involved in numerous unmanned underwater vehicle projects. He was the Secretary General of the 2004 IEEE Symposium on Underwater Technology, and of the 2014 MTS/IEEE OCEANS conference in Taipei. Since 2015, he has co-organized an academic group for the design of a 0.1 MW floating Kuroshio turbine, establishing analytical tools for the turbine design, and developing its mooring systems. In the summer of that year, he visited the laboratory of Professor Ken Takagi of the University of Tokyo to observe the Kuroshio Power Project. Since then, he has been a member of the advisory board on underwater cultural heritage for the Ministry of Culture of Taiwan. This year, he was given a position on the Taiwan Transportation

Safety Board, monitoring an investigating team for marine casualty events. His research interests are the sensing and control of biomimetic underwater robots, the navigation of autonomous vehicle fleets for coastal acoustic tomography, the design of ocean current power generation devices, and the use of AUVs in underwater archaeology.

Jenhwa and his wife, Yuwen, have three children. His daughter works as a financial specialist for a Singaporean company.



Jenhwa and his mother.



Family photo taken when his daughter and older son graduated from college.



Jenhwa, Prof. Chen-Fen Huang (front, fourth from the right) and their coastal acoustic tomography team.

His older son is a chemical engineer for a semiconductor manufacturer. His younger son is a college student who is majoring in statistics. His beloved mother, Yuan, lives in a small town near Taipei. He visits her every week. She is of an age at which she is entirely dedicated to her family and friends. Jenhwa realizes

that his most valuable moments are those spent with the people who live and work with him. Now in his 60s, he can dedicate himself to his greatest passion of ocean research, working with his colleagues and graduate students. He is having the best time of his life!

Member Highlights

Contact the Editors If You Have Items of Interest for the Society

Long Voyage without Seeing the Land
Harumi Sugimatsu, BEACON Newsletter Editor in Chief

We had a voyage for surveying the seabed mineral resources using AUVs and an ROV this summer for almost three weeks from 28 August to 19 September. On the way to going to the south east from Moji port that belongs to Kyushu island (the south part of Japan), on 30 August, we passed very near the Soufugan, which is a unique rock standing up to approximately 100 m height from the sea surface. Many birds are living at the rock, but no humans.

We then passed the Minamitorishima Island, 1860 kilometers southeast of Tokyo on September 1st. The island has a triangular shape and is very flat. So, if a typhoon hits the island, people should evacuate to a safe place.

During the AUVs and ROV survey that was conducted from 3 to 12 September, there were no islands; we saw just the blue oceans. The next day, on September 13th, we were on the long way back to Moji port. No islands until September 16th, when we saw the Ogasawara Islands (Bonin Islands). Islands are

famous for whale/dolphin watching. Much of nature's beauty is there, however, all we were able to see was the islands from a distance...

Totally, we saw only three islands during our voyage. We were in the small world, but it moved with ship trajectories. Such days in the ship are like the whole world is reflected into. Very dense days. Voyage, travel, reflects the person's life itself. What is next, I am now imaging.



Soufugan with many birds, but no humans.



Minamitorishima Island, 1860 km from Tokyo.



Ogasawara Islands.

OES Thanks Outgoing AdCom Members

Photos by Stan Chamberlain

Each year at the North American OCEANS conference, this year it was OCEANS 2019 Seattle, the OES thanks the outgoing members of the Administrative Committee for their time and support as volunteers. This year we thanked the following for their service to the society:

Administrative Committee:

- Lian Lian—2017–2019
- Shyam Madhusudhana—2017–2019

Incoming Executive Committee Members

Also at OCEANS 2019 Seattle was the election of officers to fill the upcoming openings on the Executive Committee. Those elected to continue in their present positions include:

- VP for Workshop & Symposia—Philippe Courmontagne
- Journal Editor-in Chief—Mandar Chitre

Newly elected officers include:

- VP of Professional Activities—Brandy Armstrong



Lian Lian and Shyam at the AdCom meeting in OCEANS 2019 Seattle (L to R).

Congratulations and thanks to all of our outgoing, continuing and newly elected officers.



Group photo after the AdCom meeting in Seattle.

Welcome New and Reinstated Members

Argentina

Maria Celeste Cebedio

Australia

Timothy Cain
Stephanie Ward

Austria

Thomas Benjamin Knesl

Brazil

Euclides Lourenco Chuma

Canada

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Chris Williams
Rick Williams
Brandon Wui
George A Zdasiuk

Student Members, Don't Miss Out On Your Opportunity to Attend OCEANS

Three Enterprising Students Found a Way to Attend OCEANS 2018 Charleston, All Travel Expenses Paid

***Brandy Armstrong, OES Student Activities Chair
Laura Hode, Uchenna Nwankwo and Courtney Bouchard, The University
of Southern Mississippi Chapter***

The Student Branch Chapter (SBC) support program is designed to provide financial support to SBC chairs or representatives to attend the OCEANS conference. This allows students to become involved in the society, network at the conference and participate in and promote student activities. To participate, the SBC should provide the student activities chair (Brandy Armstrong, brandy.armstrong.us@ieee.org) the name and contact information of the SBC chair or representative who is nominated to attend the next OCEANS conference. The financial support for travel to OCEANS and for technology initiatives will be based on the available funds and the activity of the SBCs.

Normally only one student from each chapter is approved to attend on the travel grant, but three enterprising students from the University of Southern Mississippi, School of Ocean Science and Engineering planned and budgeted appropriately so that they were all approved for a travel grant to attend OCEANS 2018 in Charleston. Read on to hear their perspectives on why attending OCEANS is a valuable and rewarding experience for students.

Laura Hode

Oceans is a curious word, curious not because it lacks a definition but because it has so many. We recognize 5 oceans, but

since water exchange occurs between them, we also reference a single, global ocean. This ocean permits commerce, sees armed conflict, and is crisscrossed by hundreds of jurisdictions. The science of oceans ranges from bathymetric surveys to meso-scale circulation to ecosystem dynamics and beyond. In terms of environments, oceans extend from the intertidal zone to the abyssal plains, and the concept of oceans is no longer confined strictly to Earth. I mention all of this because I recently attended OCEANS in Charleston, South Carolina. I feel the vagueness of the name does the conference credit. It leaves the door open for companies, agencies, and institutions to showcase a myriad of products, prototypes, and research all tied loosely to that simple word: oceans.

For my part, I wanted to meet people. I am a Ph.D. student at the University of Southern Mississippi, but our campus is at Stennis Space Center, Mississippi. There are lots of NASA personnel, there are lots of navy personnel, and there are a host of secure buildings. You find out very quickly that everyone knows everyone, but if you are new, it is challenging to find a time and location to meet them. As such, OCEANS for me was a chance to meet researchers whose papers I had read, companies whose equipment I maintained, and agencies whose data I used.



Taking a tour of historic Charleston, South Carolina, host city of OCEANS. Left to right: Courtney Bouchard, Laura Hode, Uchenna Nwankwo.



Opening plenary with the co-chairs of OCEANS Charleston: Jeff Payne (left) and John Flynn (right).



Display of the newly unveiled Bluefin-9 Automated Underwater Vehicle from General Dynamics side by side with its model. The Bluefin-9 was one of many underwater vessels being showcased at the conference.

Of course, I was not the only one who wanted to chat with my fellow conference goers. There were old friends meeting up and collaborations being made, and I was a graduate student trying not to awkwardly interrupt. As you attend more conferences and spend longer in your field, you meet at least a portion of everyone, and little by little you acquire your own stories. I love stories. The two things about oceans. They are salty, and they are wet. Naturally, we deploy metal equipment powered by cables and batteries into them. You know, the best possible pairing to salty and wet. When you add people and some very determined marine mammals to that mix, the stories just add up. I love stories because they are a unique icebreaker. No two stories are alike. You remember them, and hopefully, you are remembered.

Since I am in the process of finishing my degree, being remembered can be valuable. Some students do not want to

attend conferences. Preparations take time from their research, and they assert they do not require networking. They know exactly the field in which they want to work and have already met the key people in that field. Consequently, the conference holds no value for them. I respect their certainty, but throughout my life, I have found myself at pivot points. These are events that shifted my life into unexpected directions, and I welcome these new adventures. I had not anticipated attending OCEANS, but I am glad the opportunity presented itself.

I grew up in a land-locked state surrounded by mountains. My father would lay out sleeping bags under the stars whenever there was a meteor shower, and in the crisp early morning air, you could see every star. The universe was awe-inspiring, so I studied astrophysics. My intention was to continue a career in that field, but I got the opportunity to teach in Japan after graduation. My home was in the middle of the Japanese inland sea on a tiny island only accessible by boat. My students and neighbors were the descendants of pirates, and tankers were built and serviced on the island next door. Life there revolved around the sea, and sometimes the sea hit you with a mean right hook. I had never understood the appeal of the ocean, but the wonder of it crept into my bones. As such, I found myself applying to graduate school in marine science. I am not sure when the next pivot point will come or what form it will take, so I recognize the potential of conferences like OCEANS. They provide me with an opportunity to share my discoveries and my awe with others, and I can share in the discoveries and awe of others. We share stories, and perhaps the next adventure begins.

I also owe a debt of gratitude to the conference organizers and to the Institute of Electrical and Electronics Engineers (IEEE) Oceanic Engineering Society. A select number of students were chosen for the student poster completion, but a regular poster session was also opened for the conference. Additionally, efforts were made to introduce students to senior researchers on multiple occasions: the student mixer, the career panel breakfast, and the Women in Engineering panel. We had the chance to meet most of the mentors the first evening of the



Career Panel Breakfast, Wednesday, October 24, 2018. Left to right: Brandy Armstrong (moderator), Fausto Ferreira, John Potter, Nicole LeBoeuf, Matthew Gilligan.

conference at the mixer, but I learned a little more at each event. From a continuing dialogue perspective, this setup was effective. Graduate school is a lesson in frustration. To do it well, you should ask questions for which no answers exist. You struggle, and every so often, it is comforting to be reminded that everyone else struggled too. That way, you can ask more questions and continue the struggle.

Attending OCEANS was a wonderful surprise. At every conference I have attended, I find myself in at least one session that presents the oceans in a light I never considered. For instance, surfers can be citizen scientists who create an objective analysis on how changing the dominant grain size on a beach can be detrimental to ecosystems. Beyond the sessions though, I was able to make connections with those groups everyone seemed to know but I had never had a chance to meet. I got to share one-up stories about destabilized lithium batteries with a company (I will not say which one) and commiserated with other organizations about taking down equipment before hurricanes. We are so happy to keep the equipment intact but sad to lose the data. That is the beauty of OCEANS; it connects us.

Uchenna Nwankwo

OCEANS 2018 conference was a great experience. It provided opportunities to acquire knowledge, network and appreciate the beautiful city of Charleston. As a student, it accorded me the opportunity to discuss with fellow students who are doing amazing research and with other professionals. It was also a fully funded experience by IEEE/OES which shows how much these organizations have the interests of student development at heart.

I observed something unique during the conference. Special sessions were dedicated to students. The first was an opportunity to interact with mentors. I found this experience worthwhile because I got to meet a couple of renowned professionals. Secondly, a breakfast session was organized. During this session, mentors shared their life experiences. Honestly, the session was an eye opener for me. I got to understand that the path to success during a post-graduate program is filled with ups and downs. In the final session dedicated to students, I heard the best talk about climate change in my entire life.

It was amazing how OCEANS 2018 was able to incorporate business and pleasure. Enriching meals were provided. The trip to the aquarium was exceptional. This was so because before then, I had never been to an aquarium. I got an opportunity to gain more knowledge about American history. Though I was not able to visit Fort Sumter, at least I was able to see it from afar. On the day of the tour, the sight of sunset was so beautiful.

The OCEANS 2018 application was a great tool during the conference. However, I was not entirely satisfied with it. There were a couple of talks I got to know about after they had been given. I was not able to attend them because they were under sessions names which did not capture the content of the talk. I felt maybe in future OCEANS conferences, talks should be under adequate session names. I also felt that more opportunities should be given to students to present their research either through presentations or through posters.

I observed that there were not many posters and that poster sessions were not attended when compared to oral presentations and exhibitor sessions. One reason for this was that poster sessions were not indicated on attendee tags. I also observed that poster sessions commenced during lunch. It was challenging for the presenters to get lunch and still be at their posters the same time. In subsequent conferences, more awareness about poster presentations should be made. Also, more room should be given for poster presentations because this will enable students/presenters to get constructive criticisms about their work.

During the career breakfast panel, a question was raised about diversity. This struck a chord in me. I immediately observed that the representation by people of color during the conference was not encouraging. I could not explain this. To the best of my knowledge, the population of people of color in oceanography at both graduate and professional levels is poor. I feel this is something that can be addressed during conferences. I believe with more diversity, scientists can better relate and reach out to all walks of life about salient issues like climate change.

OCEANS 2018 was a great experience. I was positively impacted by it and I look forward to subsequent OCEANS conferences.

Courtney Bouchard

I didn't grow up near an ocean, so for me the ocean was just the small area of beach in Galveston that we would drive 6 hours to visit, make some sand castles, and maybe have an ice cream. Now that I've found myself studying oceanography, I realize that our coasts are so much more than that. This OCEANS 2018 Charleston conference was centered on the theme "Healthy Oceans, Resilient Coasts, Robust Commerce...Strong Nations." After attending OCEANS 2018, I am more inspired about my role as a scientist in helping protect the coasts.

I wanted to attend this conference to hear talks from people with the technical expertise I hoped to gain. And while all the talks and sessions I attended were helpful, I was specifically impressed with the mentor/mentee atmosphere that this conference set up. At one point during the icebreaker I heard a man yell, "Where are the students, I need to talk to some students!" That man turned out to be Sandy Williams from WHOI and from the hour I spent talking to him I learned a great deal about graduate school, career paths, and a little bit about scuba mishaps with current professors of mine. I'm sure I'm not the only graduate student who has felt a little overwhelmed, so it was nice hearing from Sandy and others who have been in this field for a while tell us about how they have navigated academia and career.

The career panel and Women in Engineering panels helped make the conference seem less large and allowed more interaction with mentors and mentees. Some sound advice I received while at these events was from Mark Milligan of Savannah College who said, "The only proper path to take in your career is the one you choose." I made connections with students, businesses, and seasoned academics at the OCEANS conference that I know I'll be using in my career and I will be attending many more OCEANS conferences in the future.

Trip Along the Ecuadorian Coast

Lady Nicole Macas Mendez, Current Chair President of the First IEEE/OES Chapter in Ecuador and an Oceanographic Engineering Student

The coastal profile is an emblematic element of the Ecuadorian national identity. In addition, it is a source of various resources, both tourist and fishing as well as biological; allowing a very important development of shrimp aquaculture. The Ecuadorian coasts are 2860 kilometers long, have their most outstanding point in the Puntilla near Salinas and its easternmost inlet at the mouth of the river Mataje, province of Esmeraldas. Its most important geographical accident is the Gulf of Guayaquil, which is the largest in the Pacific profile of South America, being the city of Guayaquil where the trip began.

The geomorphology of these coasts can be classified into three main types: high cliffs with small bays interspersed in areas of tertiary sedimentary reliefs, such as Pedernales to Manglaralto; medium and low with small cliffs and large rectilinear front beaches, such as those located near Manta; and the low coasts of the deltaic type with fluvial-marine arms and with mangrove-covered islands such as those located in the Gulf of Guayaquil and along the south coast.

Due to the mixing conditions of the waters of the Southern Equatorial stream, which are characterized by being low salt and rich in oxygen with the cold Humboldt stream, loaded with nutritious elements, the high fertility of the Ecuadorian sea and the particular conditions are explained of the oceanic environment of the Galapagos Islands.

Our trip began from the city of Guayaquil, at midnight, where we depart by bus to "Atacames" on a trip of approxi-

mately 9 hours; after resting and eating we go to the beach of "Súa", with calm waters, being a beautiful bay surrounded by mountains where they live waterfowl communities such as frigates, blue footed boobies and seagulls. From there we take a boat to visit the Island of the Birds and the Cave of Love, formed by the force of the waves.

The section we visited between the beaches of "Tonsupa" and "Súa" is 20 kilometers, being mostly a cliff coast up to 50 m high. In addition, the low coasts are sandy, and often covered by mangroves that develop in areas near rivers.

After leaving "Súa" we headed to "Tonsupa" where we could observe the rapid erosion of the coast due to the force of the waves; the cliffs present in the area have a base composed of silty sediments, which causes their fall; although this phenomenon is common on beaches around the world, this area occurs quickly and alarmingly due to the strong events of El Niño and the systematic destruction of mangroves.

After viewing both beaches, we go to "Atacames" to rest and have dinner. The next morning we depart to "Bahía de Caráquez" whose entrance bridge, built over the estuary of the Chone River, is the longest in Ecuador with 1980 meters in length, 13.20 meters in width, also has a bicycle path and pedestrian crossing, thus contributing to the tourism and the comfort of the inhabitants of the area.

In the afternoon we arrived at the port of Manta, the one with the greatest draft in the country, with 13 meters deep where Postpanamax ships can dock. There they guided us on a



visit of a couple of hours through the different facilities that have recently been repowering as the cabotage docks, the fishing fines and the facilities of the international terminals where cruise ships arrive, which were damaged by the earthquake that hit the country in April 2016. This is also a port considered multipurpose; part of the cargo it mobilizes is solid bulk, liquid bulk, machinery and vehicles and also serves the international and artisanal fishing fleet.

After this we continue the trip to the city of “Montañita”, known for being an important center for surfing. On the morning of the third day we continue the trip to “Playa de los Frailes”, considered the best in the country, for its tourist attractions. Belonging to the Machalilla National Park, however, it is an oceanic beach with a strong swell. It is away from the road, its entrance is controlled and it has three kilometers in length of beautiful clear sands. In the northern part there is a path that goes up to the viewpoint where you can observe the area. With typical vegetation of tropical dry forest, from June to September it is possible to observe migratory whales.

On the afternoon of the last day we arrive at “Ayangué” beach, which is a fishing village, located in a bay that is shaped like a horseshoe. It is known for its clear and calm waters, in addition to the coral reefs, that allow the tourists to dive into the waters. Near this beach is the National Center for Aquaculture and Marine Research (CENAIM), belonging to ESPOL, built in the 90s with financial support from the government of Japan. The center’s mission being the improvement and sustainable development of aquaculture and marine biodiversity of Ecuador through scientific research, technological development, training and dissemination. CENAIM also fosters a close link with the productive sector through experimentation services with shrimp and fish, laboratory analysis, training and training of professionals, and the supply of products for sanitary improvement and feeding of aquaculture crops. The link with the academy and community is developed through thesis offer for students from national and international universities, and internships for students from local schools.

We finished the trip on the night of the same day with the arrival in the city of Guayaquil, this being of great importance and very fruitful in terms of knowledge of the most relevant areas of the Ecuadorian coast for those studying in areas related to marine sciences.

The importance of good management of coastal areas was reflected in April 2016 when an earthquake of magnitude 7.8 hit the north coast of the country, leaving a total of 691 dead and 7216 injured in addition to the countless material damage and the situation of vulnerability and poverty in which many families remained.

Therefore, territorial planning based on risk areas along with disaster preparedness towards the population has become fundamental in recent years.

Ecuador is in a highly seismic zone, with cities vulnerable to rising sea levels, so preparing ourselves to be resilient in the face of future catastrophes and imminent climate change is a priority.

We thank IEEE Oceanic Engineering Society (OES) for financing this trip.

Photo Gallery



Location of beaches visited on the trip.



Arriving to the island of the birds.



Bird Island.



Mangrove area in Súa.



Endemic birds of the dry forest.



Bridge to Bahía de Caraquez.



Love Cave.



Fishing pier in the port of Manta.



Esmeraldas estuarine zone.



Súa Beach.



Port of Manta (Author: El Universo newspaper, 2018).



Los Frailes beach.



Tonsupa Beach.



Aquaculture students and part of the OES-IEEE directive.

The University of Zagreb Student Branch Chapter at OCEANS Marseille 2019

Anja Babić, Nadir Kapetanović, Igor Kvasić

The joint IEEE-OES and MTS OCEANS 2019 Conference & Exhibition held from the 17th to 20th of June in Marseille, France, represented the very first OCEANS experience for Anja Babić, Nadir Kapetanović, and Igor Kvasić, PhD students, researchers at the LABUST—Laboratory for Underwater Systems and Technologies, and members of the IEEE OES University of Zagreb Student Branch Chapter.

Nadir Kapetanović presented his paper *Side-Scan Sonar Data-Driven Coverage Path Planning: A Comparison of Approaches* in a poster session, while Igor Kvasić presented the preliminary results of his PhD thesis research in the paper titled *Convolutional Neural Network Architectures for Sonar-Based Diver Detection and Tracking*.

Anja Babić, as the Chair of the SBC, was chosen to be on the panel of judges for the OCEANS 2019 Student Poster Competition. The competition was a tough one, with many candidates presenting diverse research, showing off work more than deserving of a prize.

Participating in the scoring discussion among the judges was particularly interesting, offering useful insight into and various views on both research practices and the presentation- and communication-related aspects of the fields involved. Getting to interact with the students and hear about their work, as well as consider it in greater depth, was a fairly novel and ultimately rewarding experience.

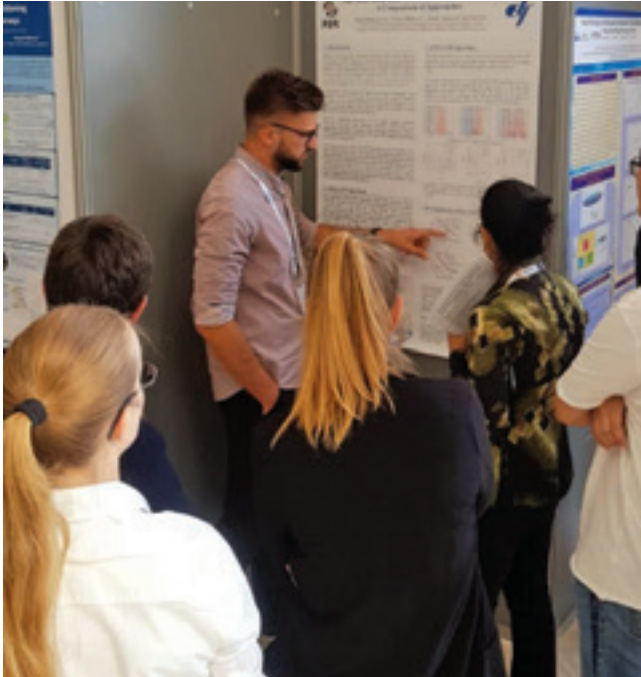
In between lectures and presentations and during the OCEANS social events and meals, Anja, Nadir, and Igor also got to meet up and brainstorm with various international colleagues. This included frequent collaborator Edin Omerdić, PhD, from the University of Limerick, Ireland, who presented a joint research paper between the Universities of Zagreb and Limerick produced through the H2020-TWINNING project EXCELLABUST, titled *Multi-Modal Supervision Interface Concept for Marine Systems*.



IEEE OES UNIZG SBC members (left to right: Igor Kvasić, Anja Babić, and Nadir Kapetanović) at the Exhibit Hall of the IEEE OES/MTS OCEANS 2019 Marseille Conference & Exhibition.



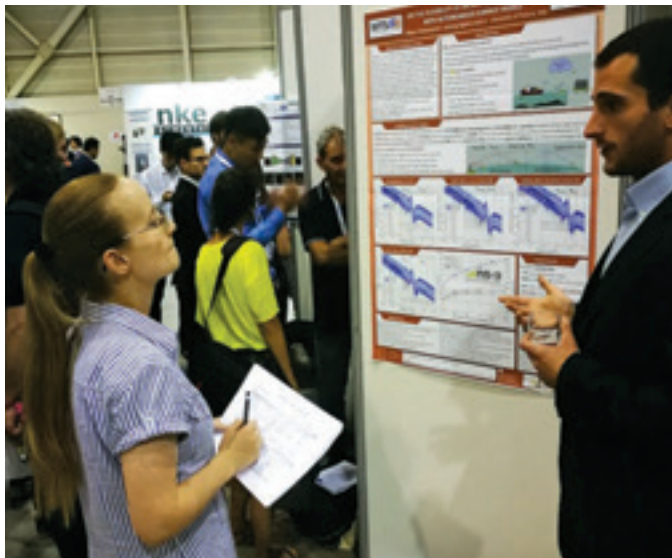
Igor presenting his paper.



Nadir presenting his paper in the poster session.



The ALSEAMAR company stand with the exhibited SEAEXPLORER glider.



Anja busy assessing the quality of posters in the Student Poster Competition.



The SUBSEA TECH stand showing off their modular catamaran vehicle design.



Edin Omerđić presenting the results of joint research.



ixblue company stand with a model of their DriX autonomous surface vehicle.



Nadir and Igor aboard the Janus II workshop.



COMEX ORUS 3D team showing the presentation participants how the 3D model of the inspected object is being generated on-the-go from the visual feedback of a 3-camera system.

While the conference side of OCEANS perhaps resembled events all three students had previous experience with, the exhibition did not, and touring the various company stands and presentations was an amazing opportunity. The many companies whose stands they had a chance to visit included ALSEAMAR with their glider designed to endure an impressive 4 to 8 weeks at sea, and which can be used for oil and gas monitoring, marine environment surveys, and anti-submarine warfare, as well as rapid environmental assessments.

At the stand of SUBSEA TECH, some interesting ideas were exchanged about the catamaran design of surveying autonomous surface vehicles (ASVs), which was something especially relevant and interesting since both Nadir and Anja have experience in the area of bathymetric surveys, and a catamaran design seems very efficient in terms of survey speed and vessel stability for the ASV mounted with a multibeam sonar.

Another interesting design of an ASV was presented by the iXblue company. Their DriX vessel, which is 8m long and has an endurance of more than 10 days, can reach speeds of over 14 knots thanks to its diesel engine and 250l tank.

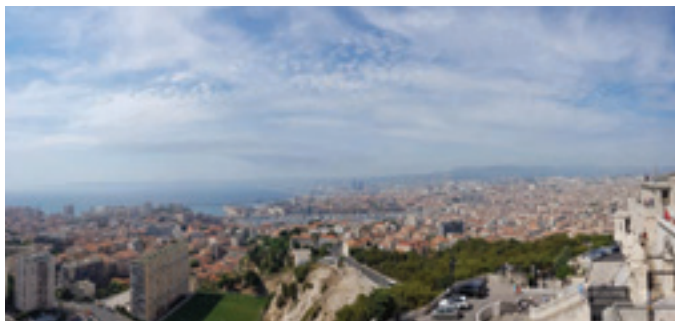
Nido Robotics, sharing their expertise in building innovative underwater vehicles, was one of the more familiar partner companies seen at OCEANS, along with the many component manufacturers such as SubConn and MacArtney displaying their latest product lines. Trittech presented their newest additions to the imaging sonar technologies, which is always an



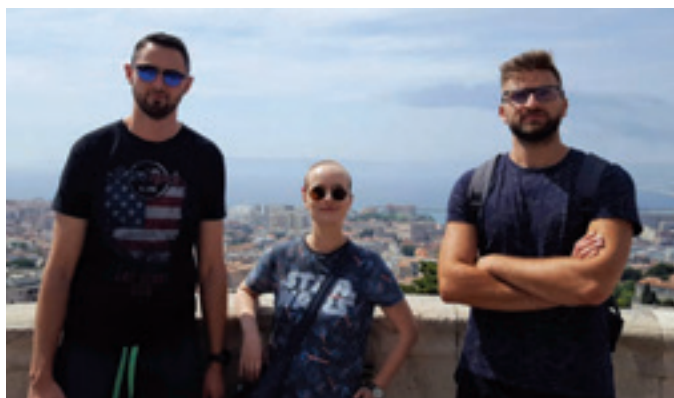
Deployment and retrieval of the APACHE ROV from COMEX's Janus II workshop.



Igor trying out the VR set with a 3D model reconstructed in millimetric accuracy.



Panorama of the Port of Marseille seen from the Notre-Dame de la Garde basilica.



Igor, Anja, and Nadir enjoying their visit to some of the most famous Marseille landmarks.



The Museum of European and Mediterranean Civilizations at sunset, with its unique modern architecture embedded in the heart of the old port and the bridge symbolically connecting it to the 16th century fort of Saint-Jean.

interesting tool in the context of the students' parent laboratory's underwater research topics.

On June 19th, Nadir and Igor participated in the field trip organized by ORUS 3D (daughter company of COMEX) and their company presentation aboard the workshop Janus II. The company team gave a short introduction of their 3D photogrammetric reconstruction technology—being the only ones that are certified by BUREAU VERITAS for millimetric and even sub-millimetric accuracy of the 3D models reconstructed using solely visual information. Their system consists of 3 cameras and an LED lighting system, which is mounted on the APACHE ROV. This system is used for offshore oil and gas inspections, civil engineering inspections, archeological site documentation and 3D reconstruction, as well as marine sciences and military defense.

The object chosen for the workshop presentation happened to be one of Jacques Cousteau's famous observa-

tion stations, which was abandoned in the 90s when it caught fire and sank. After reaching the location just in front of the famous National Park Calanques, where the company tests its equipment and algorithms on underwater objects, the ORUS team deployed the APACHE ROV and started taking recordings of the underwater site. At the same time, in the office aboard the ship, the attendees of the company presentation were introduced to the developed 3D photogrammetric reconstruction pipeline, resulting in the dense point cloud and parts of the 3D model being generated on-the-go.

During the return to the Marseille marina, the presentation participants were given the chance to experience the reconstructed 3D models of the underwater objects in virtual reality (VR).

After the official OCEANS program was over, there was still time to visit some of Marseille's most famous landmarks, including the Notre-Dame de la Garde basilica and the Old Port, to enjoy the atmosphere of the Panier—Marseille's oldest neighborhood, and to view some of the current exhibitions at the MuCEM (Museum Of European And Mediterranean Civilizations).

All in all, OCEANS 2019 in Marseille proved to be an excellent and above all well-rounded experience, with highly relevant scientific talks and posters to be found in the conference part, and impressive and novel technical solutions on display in the exhibition part. The opportunities for networking and idea exchange should also not be understated, as the event schedule offered many. Anja, Igor, and Nadir all managed to find their niches represented, and gained insights that will be helpful in pursuing their respective PhDs, as well as their future work in the field of marine robotics and systems.



The interior of the basilica.

OES Provides the “Innovation Award” at RoboSub Competition

Robert Wernli

IEEE OES supported the 22nd Annual International RoboSub Competition that was held from 29 July to 4 August, 2019, at the TRANSDEC facility at the Naval Information Warfare Center Pacific (NIWC PAC). I was invited by Bill Kirkwood to stand in for him as a judge for the overall competition and also to determine the winner of the OES Innovation Award. Although I spent my career at NIWC PAC (the latest of many names for the navy laboratory on Point Loma in San Diego) and had attended previous RoboSub competitions, I had not had the opportunity to judge the many excellent competitive teams.

RoboSub is an international competition designed to advance the development of Autonomous Underwater Vehicles (AUVs) and develop relationships between young engineers and the organizations developing and using AUV technologies. The competition is open to full-time middle school, high school, undergraduate and graduate students. The competition is organized by RoboNation with funding from the U.S. Office of Naval Research. For this competition there were 54 teams representing Brazil, Canada, China, Egypt, India, Japan, Norway, Poland, Russia, Singapore, Thailand, Turkey and the United States of America and territories. Each year there is an overarching theme for the competition. This year's theme was “Vampire,” which used related “creatures” and “activities” to characterize the tasks that ranged from a simple passing thru a gate to “slaying vampires.”

I have to say that those involved in the judging were very busy during the competition. As part of the “static” judging team, we would interview each team at their tent over a period of several days and evaluate them on a range of items from their uniforms to their vehicle design and documentation. The other team of judges, assisted by navy divers, awarded points to the teams based on how many tasks they successfully completed.

There were many high scores and the capability of the student teams was amazing. The winning teams, and their cash awards, included:

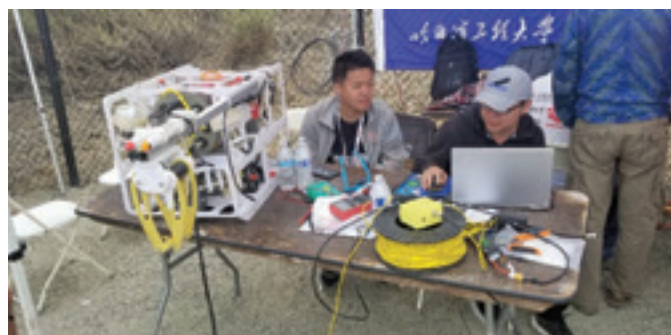
- Harbin Engineering University (China)—\$6,000
- Far Eastern Federal University/Institute for Marine Technology Problems (Russia)—\$4,000
- Arizona State University Polytechnic (USA)—\$3,000
- University of Alberta (Canada)—\$2,000
- Cornell University (USA)—\$1,000

To determine the winner of the OES Innovation Award, I ended up with five top candidates:

- Far Eastern Federal University (Russia) for their unique “torpedo” design
- Project Radian (Temecula, CA, USA) for conducting vision tracking with just three lines of code.

- iHub (Egypt) for their Data Fusion and SLAM
- University of Missouri (USA) for an electronic board that folds into a triangle
- Team Inspiration (San Diego, CA, USA) for their adequately achieved goals: “To Learn, To Share, To Inspire, To Innovate”

And the winner of the Innovation plaque and \$300 from OES is:



*Harbin Engineering University working on their 1st place AUV.
Photo courtesy of Andrew Wilde.*



*Team Inspiration receiving the Innovation Award plaque
from yours truly at the RoboSub Award Event. Photo courtesy
of RoboSub.*

Team Inspiration

Team Inspiration was the only high school and middle school team in the competition and were not only highly scored technically and verbally, but they “were greatly inspirational.” They also conduct a lot of community outreach to spread their love of robotics. More information can be obtained on the team at: <https://team11128.wixsite.com/main>.

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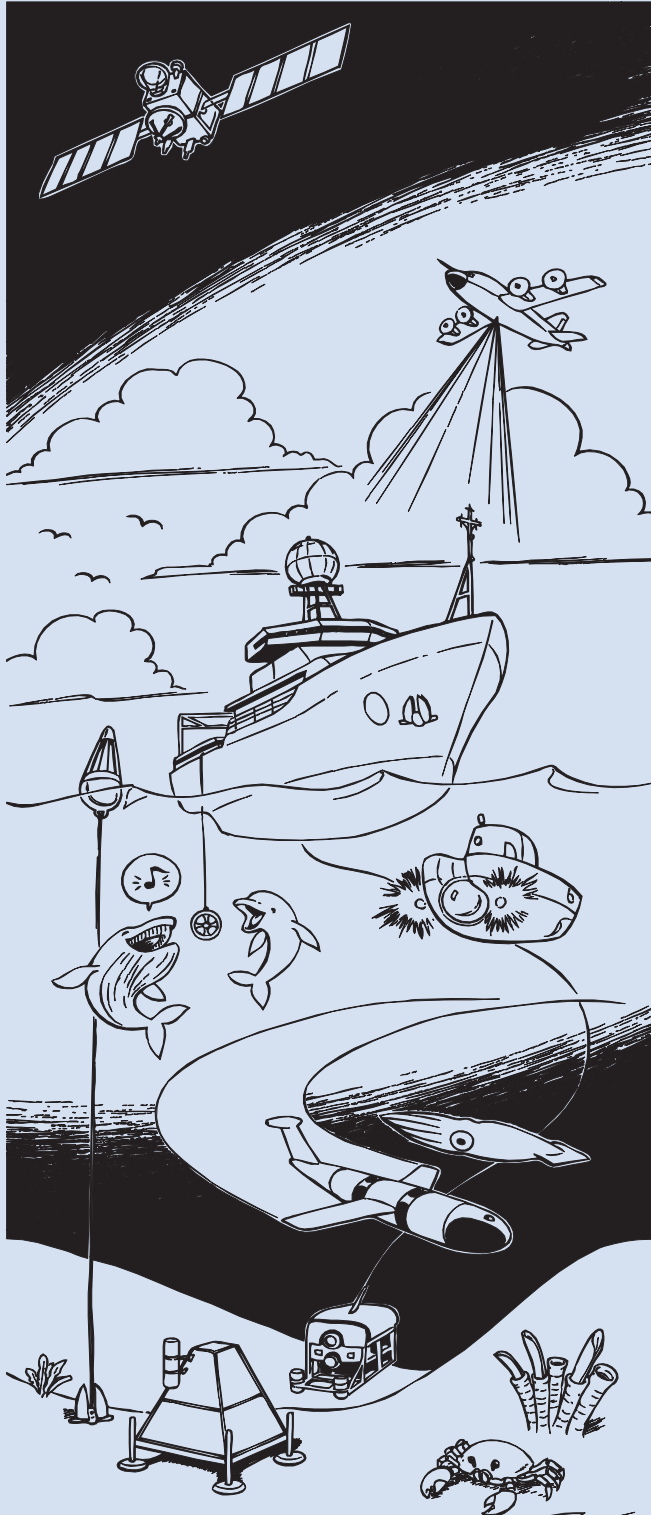
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