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Members are encouraged to submit copy highlighting 1) Chapter Events, 2) People & Company News, 3) Student & Young Professional News, 4) Technology Updates, or 5) other material of broad interest to the OES. Please send to Beacon Editor-in-Chief, Harumi Sugimatsu <harumis@iis.u-tokyo.ac.jp>. Word format, 1-1/2 space; Photos (always encouraged): jpg, 300 dpi preferred. Material becomes property of IEEE-OES. Please send e-mail or physical address corrections or updates to the EIC.

IEEE OCEANIC ENGINEERING SOCIETY EXECUTIVE COMMITTEE

EX-OFFICIO ADMINISTRATIVE COMMITTEE

ELECTED ADMINISTRATIVE COMMITTEE

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From the President

Greetings

More news, more often!

Due to the excellent work from the Beacon editorial team, we are now able to address you every three months. As of the time of this writing, I'm in Genova, Italy attending Oceans'15. And many of you have probably met or saw me around.

The conference (so-called "Spring OCEANS") had an incredible success in terms of scientific return and broke the record for abstracts/papers received for the modern era, approaching the numbers we had when only one OCEANS per year was the rule.

It's an indication that bringing the conference to our members and to the potential attendees in a given part of the world is very effective.

In the previous editorial, I was mentioning some of the workshops underway. They are now over and have been very well attended, bringing the "word" of OES into the world of underwater vehicles and sensors, as well as other means of monitoring the main part of the Earth: the oceans. And our presence is on almost every continent of the planet, from Europe with OCEANS, to South America (OTC Brazil) via Asia/Pacific (several AUV related events) and North America (OCEANS'15, DC). Sounds like only Antarctica is left …

And during our Administrative meeting in Genova, we decided to strongly support the Eurathlon event in Europe (http://www.eurathlon.eu/) at the end of the summer. OES will be the main patron for the underwater related activities.

As already said, I am, as President, participating in the IEEE Technical Activity Board (TAB) meetings with all of the other Society or Council Presidents. I have been appointed to the IEEE Conference Committee and I will increase my participation in all the debates on how to better run a conference or workshop. In July, all the leadership of the Society will meet at the IEEE POCO (Panel Of Conference Organizers) in Glasgow, Scotland. This will be a very good opportunity for us to meet and talk with the IEEE professional conference organizers, and to continue our fruitful exchanges.

The critical IEEE review of the Society went very well, and we received the expert returns just a week ago. I will present the

(continued on page 17)

OES Technical Activities

Kenneth G. Foote, IEEE Fellow, OES Vice President for Technical Activities

The core of OES, as well as that of each of the 38 other IEEE member societies, is its technical activities. In the case of OES, these are broadly defined by the mission statement: "The Field of Interest of the Society includes all aspects of science, engineering, and technology that address research, development, and operations pertaining to all bodies of water. This includes the creation of new capabilities and technologies from concept design through prototypes, testing, and operational systems to sense, explore, understand, develop, use, and responsibly manage natural resources." This field thus subsumes the totality of engineering activities in the ocean and freshwater bodies of water too.

In order to represent and promote technical activities, OES maintains a number of technology committees (TCs). Currently there are 18 TCs, although this number fluctuates due to the range of interests represented by active members willing to organize and lead TCs, as well as changing community interests and advances in technology.

For convenience, the TCs are organized into affinity groups. Both the groups and their constituent TCs are listed together with the points of contact.

ACOUSTICS AND SIGNAL PROCESSING
POC Dr. Jean-Pierre Hermand, jhermand@ulb.ac.be
Environmental Acoustics
Ocean Signal and Image Processing
Underwater Acoustics
Underwater Communication, Navigation, and Positioning

GEAR, INSTRUMENTS, AND VEHICLES
POC Dr. William Kirkwood, kiwi@mbari.org
Environmental Technology
Innovative Technology
Underwater Cables and Connectors
Unmanned Maritime Vehicles and Submersibles

DATA AND INFORMATION
POC Dr. Kenneth G. Foote, kfoote@whoi.edu
Information Processing and Data Fusion
Numerical Modeling, Simulation, and Data Visualization
Standards

OBSERVATIONS AND MEASUREMENTS
POC Dr. Malcolm L. Heron, mal.heron37@gmail.com
Airborne/Spaceborne Ocean Remote Sensing
Current, Wave, and Turbulence Measurement
Oceanographic Instrumentation, Navigation, and Positioning
Subsea Optics and Vision

POLICY AND GLOBAL CONCERNS
POC Dr. Jay S. Pearlman, jay.pearlman@ieee.org
Global Earth Observing System of Systems
Ocean Energy
Ocean Policy and Education

Every TC represents an opportunity to promote a particular technical activity within ocean engineering. Exemplary in this regard is the Current, Wave, and Turbulence Measurement TC, which recently held its eleventh quadrennial workshop, the 2015 IEEE/OES Eleventh Current, Waves and Turbulence Measurement (CWTM), in St. Petersburg, Florida, 2-6 March. The statement of scope is the following. "Development of sensors for measuring current, waves and turbulence; use of these sensors to study sediment transport, coastal erosion, wave climate, and currents that affect marine operations; and new technologies to make flow and wave observations such as radar remote sensing, correlation sonar, drifters, and satellite observations are included." There were ninety participants. Contributed papers are being published on the IEEE Xplore Digital Library http://ieeexplore.ieee.org/Xplore/home.jsp.

The Global Earth Observing System of Systems (GEOSS) TC has a much broader remit, with immense scope evident from http://www.oceanicengineering.org/page.cfm/cat/84/Technical-Committees-and-Scope/. Quoting, "The technology domain for the Global Earth Observation System of Systems (GEOSS) Technology Committee is in all aspects of this complex system of sensors, communication devices, storage systems, computational and other hardware elements. These entities are used in concert to improve the monitoring of the state of the Earth, to increase the understanding of Earth processes, and to enhance prediction of the behavior of the Earth system. GEOSS will link millions of established national, regional and international sources and datasets into a single network capable of tracking environmental changes in atmospheric, oceanic, and land-based ecosystems around the world. This system is expected to yield advances in knowledge in many areas of benefit to humankind, including disaster reduction, health, energy, climate, weather, water, and agriculture. The GEOSS Technology Committee will track developments in systems engineering and integration, architecture, and standards related to sensor systems, communications, data processing, data archiving and cataloging, data searching and access, data portrayal, and decision support systems. The GEOSS Technology Committee will interact with the other OES Technology Committees, IEEE Technical Councils and Societies, and select international scientific and technical organizations to recommend solutions to difficult issues related to the GEOSS mission."

The four constituent TCs of the Acoustics and Signal Processing Affinity Group are all very active. The average number of members in each of these TCs is about 25. The level of activity reflects the power and breadth of application of the various methods, including instruments and other tools. Signal processing is fundamental to acoustics, data processing, and data imaging of all sorts, with many challenges in the ocean due to natural variability. It is the concern of the Ocean Signal and Image Processing TC. The TCs concerned with acoustics are similarly active, because of the many practical applications enabled by this remote sensing modality. This recognizes that the ocean is largely transparent to sound, much less so to light, which under very favorable conditions might propagate over distances of order 100 m. At other wavelengths, electromagnetic radiation might not propagate as much as 1 mm, at least in sea water, because of its conductive properties. Exemplary applications include, among many others, inference of physical properties of the ocean environment (Environmental Acoustics TC); mapping of the seafloor and quantification of marine organisms (Underwater Acoustics TC); and use of sound for underwater communication, navigation, and positioning by instruments, vessels, and other vehicles of all sorts (Underwater Communication, Navigation, and Positioning TC)

New instrumentation for oceanographic observations and measurements is addressed by the Oceanographic Instrumentation, Navigation, and Positioning TC. A related subject of special concern to this TC is data acquisition. Data are explicit concerns of two other TCs, in the Data and Information Affinity Group, namely the Information Processing and Data Fusion TC and the Numerical Modeling, Simulation, and Data Visualization TC.

A third member of the Data and Information Affinity Group is the Standards TC. That OES has a dedicated standards activity is a general requirement for all IEEE societies. Of particular note in the present case is the OES Standards Initiative, with Internet presence at http://www.oceanicengineering.org/page.cfm/cat/105/OES-Standards-Initiative/. This is a candidate for future elaboration in Beacon.

Notwithstanding the short range of propagation of light in the ocean and other bodies of water, applications of light and other electromagnetic radiation are so important that these are included in the remit of two TCs. It can be imagined, correctly, that the use of underwater still and video cameras at short range can provide extremely high-resolution data for many applications. These include, among many others, inspection of offshore oil and gas installations, inspection of vessel hulls, observation of coral reefs and other benthic habitats, and observation of algae growth on the underside of sea ice. These applications are represented by the Subsea Optics and Vision TC. Observation of the sea by airborne and satellite-borne cameras, including lidar measurement of the shallow seafloor and water column, and hyperspectral imaging, are well-known modalities represented by the Airborne/Spaceborne Ocean Remote Sensing TC. This TC also represents diverse radar observations of the ocean, e.g., of surface currents and waves.

Thus far, underwater vehicles have only been mentioned fleetingly. However, it is well appreciated by the community that remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), including gliders, and manned submersibles are widely used by industry, e.g., offshore oil and gas and subsea mining; by academia, as for research; and by navies for diverse applications. Such vehicles have become part of the infrastructure of marine operations. The underlying technology is being represented by the Unmanned Maritime Vehicles and Submersibles TC, with a very active outreach program to engage students through periodic, organized international competitions. The TC is currently preparing to participate in the European AUV Robotics Competition, namely the euRathlon 2015 Challenge, Piombino, Italy, 17–25 September, in a judging capacity. The TC will also be participating in AUV 2016 Tokyo: Autonomous Underwater Vehicles 2016, IIS, the University of Tokyo, Tokyo, Japan, 6–9 November 2016, and is making plans to participate in the 2018 and 2020 events, although at different venues.

Another set of infrastructure activities is represented by the Underwater Cables and Connectors TC. The importance of such devices to the ocean engineering community cannot be overstated. It is hard to imagine an underwater measurement or marine industrial activity that does not involve cables and connectors. This may be addressed at proposed special sessions at the upcoming OCEANS 2015 Washington, DC, Conference, 19–22 October.

Some conspicuously far-sighted TCs include those on Ocean Energy, Environmental Technology, and Innovative Technology. The transformative potential of the underlying technologies cannot be ignored. Similarly, matters of ocean policy and education are far-reaching, impacting ocean engineering activities directly through regulations and the law, for example, and ultimately also through recruitment of students to ocean engineering. Such matters are addressed by the Ocean Policy and Education TC.

In addition to representing technologies through its technology committees, OES supports a Distinguished Lecturer Program. Details on lecturers and their lecture topics are listed on the website at http://www.oceanicengineering.org/page.cfm/cat/16/Distinguished-Lecturers/.

OES invites colleagues to participate in its technical activities, as through the described Technology Committees. Contact information is provided in this article, with more details available at http://www.oceanicengineering.org/page.cfm/cat/3/Technical-Activites/.

Chapters' Meeting Incentive Program

Jim Collins, OES Chapter Coordinator

With nearly 30 Chapters around the world the IEEE OES is in a very good position to perform a valuable communication promotion service for its members. This service could compliment and support student STEM sport competitions, young professional initiatives to link with other young professionals, women in oceanic engineering initiatives and promotion of our distinguished lecturer program. To do this our colleagues in other Chapters need to know what we are doing in our own Chapters so they can pick up on our ideas or give us some of their own.

To this end the Society is making funding available for the Chapters that report on their meetings and other activities in the OES Beacon so that interaction is encouraged and facilitated between members with similar mutual interests. The following rules govern the funding allocation:

To qualify for (up to) US$1000 funding support:

1) Chapters must report at least two technical meetings per calendar year on the L31 report system managed by IEEE Headquarters.
2) The meetings must be judged relevant to oceanic engineering technically. The OES Vice President of Professional Activities is the final judge of relevance.
3) Chapters that are Joint Chapters with more than one parent Society will have the funding support prorated by the percent of members in the Chapter that are OES members. Membership counts from the preceding IEEE Secretary's Annual Report will be used.
4) In order that support can be paid from the current year's funds, L31 reports must be submitted by December 1st.

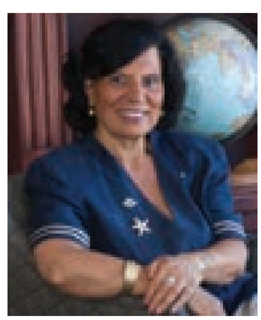
In order to qualify for (up to) an additional US$1000 of funding, Chapters must prepare an article for at least two meetings each year for the OES Beacon. Articles must be published in the Beacon within six months of the meeting or event.

Please note that funds dispensed are obviously dependent on the funds available for this program at year-end.

For further information please contact Jim Collins, OES Chapters Coordinator at j.s.collins@ieee.org.

OES Membership Development Activities

Ferial El-Hawary, Fellow IEEE, OES Membership Development Chair



As the current IEEE/OES Membership Development Chair, I would like to encourage all our devoted members to reach out to colleagues with OCEANS background to introduce them to OES in order to help us reach our goal in raising the number of new members and developing new OES Chapters in the IEEE Sections and connect with our geographical IEEE Region. Our areas of interest aim to promote close cooperation and exchange of technical information among members and with other IEEE Groups and Societies through publications & meetings. As so succinctly stated at a recent IEEE meeting by our society president, Rene Garello, "The scope of OES includes all aspects of science, engineering, technology that address research, development, and operations pertaining to all bodies of water. OES aims to create new capabilities & technologies from concept design through prototypes, testing, & operational systems to sense, explore, understand, develop, use, & responsibly manage natural resources, ultimately to improve quality of life." In addition to specialized workshops and symposia that support our membership development activities, our society holds OCEANS conferences twice a year.

A primary goal of our membership development activities is the outreach to our Chapters to promote student and young professional membership and ensure that candidates are aware of the benefits of society membership. Thebenefits for students includes awarding 8 scholarships per year. The amount has been raised this year from $ 2,000 to $ 5,000. In addition, the student paper competitions offer prizes of $3000.00, $2000.00 and $1000.00 to the top three students. Travel expenses to attend the OCEANS Conferences are also supported. The society, along with financial support from the Office of Naval Research Global, supports 20–25 students to attend the competition at each OCEANS Conference.

Many other valuable benefits are available to regular members. Please check the OES Website for more details. Hope you maintain your communication line open and provide us with your suggestions in order to speed up the society's growth, especially with our young professions. Contact: f.el-hawary@ieee.org, TEL: (902) 449-5110

Dr. Ferial El-Hawary, P. Eng., F. IEEE, F.EIC, F.MTS
IEEE-Canada President 2008–2009
IEEE-Region 7 Director 2008–2009
IEEE/OES Board Member 2015–2017
IEEE/OES Chair, Membership Development

OCEANS'16 MTS/IEEE Shanghai

April 10–13, 2016 Shanghai China

The Local Organizing Committee (LOC) for OCEANS'16 MTS/IEEE Shanghai has selected the following six topics with both special local interest and broad international significance. Those topics were chosen in line with the conference theme, Our Future is with OCEANS. Starting in October 2015, abstracts can be submitted on the conference website under those topics, in addition to the Core Topics common to all OCEANS conferences, and special technical sessions, workshops or panel discussions can be formed depending on the submissions.

Marine Renewable Energy

Marine Renewable Energy refers mainly to the energy carried by ocean waves, tides, currents, salinity, and ocean temperature differences, whose development has created opportunities for supporting science, technology, and engineering. OCEANS'16 will highlight the present and future states of these energy sectors, from technologies to environmental effects.

Integrated Marine Science, Technology and Information

To fully understand and ultimately predict the constantly changing 3D ocean, oceanographers must use large numbers of instruments coupled with data assimilative numerical models. OCEANS'16 will bring together scientist, technologists, and information technology specialists to focus on scientific drivers, sensors, platforms, communication links, forecast models, and data management and delivery for achieving sustainable, affordable, and reliable data streams in 3D ocean monitoring.

Natural Disaster Prevention and Damage Reduction

Typhoon/storm surge and earthquake/tsunami are common natural disasters at sea, which people in the coastal suffer the most. OCEANS'16 will address the technology needs and advances in disaster real-time monitoring/tracking, predicting/forecasting, and engineering structure design to counter various disasters.

Manned and Unmanned Submersibles for Deep Sea Exploration

Deep sea exploration is the investigation of physical, chemical, and biological conditions on the sea bed, for scientific or commercial purposes. The extreme conditions in the deep sea require elaborate methods and technologies, and the submarine is one of the safest ways to explore deep waters. OCEANS'16 will highlight the new progresses on the development of deep sea manned and unmanned submersibles with focus on the field experiments.

Search and Rescue at Sea

Missing MH 370 has been painful for many families. It also triggered a multi-national collaboration effort of searching and rescuing, which was reportedly largest in human history. OCEANS'16 will address the requirements, challenges, and advances for supporting technology and engineering, for various types of search and rescue missions at sea.

Law and policy of the Sea

The United Nations Convention on Law of the Sea has relevance to energy, research, exploration, defense, and fisheries. The OCEANS'16 meeting in Shanghai provides a forum for discussion of UNCLOS in the context of the science and technology that support the impacted sectors.

Exhibition and Patron Opportunities

Shanghai welcomes all the guests from home and abroad. OCEANS'16 Shanghai will be an excellent chance for companies and organizations to increase their market and to reach a highly qualified target audience in this international metropolitan. Details of these opportunities can be found on the conference website.

For more information, contact info@oceans16mtsieeeshanghai.org.
URL: http://oceans16mtsieeeshanghai.org/

OES Awards Student Scholarship

OES recently awarded a student scholarship to Colin MacKenzie, a master of applied science candidate at Engineers Nova Scotia, Dalhousie University. The following statement was written by the scholarship recipient.

Personal statement by Acholarship Recipient by Colin MacKenzie:

My interest in engineering began at a young age, in part because of my father's work as a civil engineer. Some of my earliest memories are of taking toys and other everyday items apart to see how they worked, before trying to put them back together. In high school I developed an early interest in robotics and began to read extensively about their construction and programming. In my senior year of high school I had the opportunity to work on a science fair project where my partner and I created a "self-replicating robot" which attempted to make copies of itself. The robot was constructed from several block modules assembled together with magnetic connections. The magnets also acted as electrical contact points between various motors and the robotic controller. The finished machine had the capacity to lift and connect other robot modules together using their magnets. The project won the senior project scholarship at the Nova Scotia Sci-Tech Expo for that year.

My undergraduate degree in mechanical engineering at Dalhousie University provided a general background in machine design, and offered more focused courses in marine craft design and autonomous robotics. I began to concentrate on oceanic engineering after a co-op work term with Defense Research Development Canada – Atlantic (DRDC) working under the supervision of Dr. Mae Seto, one of my current graduate supervisors, in the Mine Warfare Group. I initially applied for the DRDC position because of a general interest in robotics, but quickly became fascinated with their application to ocean environments, and with the unique challenges designing and controlling autonomous underwater vehicles (AUVs). Having the opportunity to work with DRDC's dynamic team gave me an excellent overview of many aspects of current underwater research, especially research related to AUV's.

My co-op work term with DRDC was in many respects a defining moment for me, providing a large measure of the inspiration that eventually led me to graduate studies in oceanic engineering. My work at DRDC focused on intelligent path planning of AUV's used in mine counter measure missions. I found the complex obstacles to underwater communications and the resultant need for effective autonomous robotics a fascinating challenge. When I returned to my undergraduate course work I took all available elective courses offered in marine craft design, machine learning and autonomous robotics. These courses offered a more in depth look at image processing, supervised learning and provided a basic technical background on vehicle movement though aquatic environments.

I decided to return to Dalhousie for my Master's degree in large part because of professors, Dr. Ya-Jun Pan, Dalhousie's Advanced Control and Mechatronics Laboratory and Dr. Mae Seto (Intelligent Marine Systems Lab). My research is part of a joint project between DRDC – Atlantic and MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) on improving the data association component of simultaneous localization and mapping (SLAM) for use with AUV's. This research, if successful, will allow AUV's to navigate their environment and perform assigned tasks more effectively and with more independence.

In underwater exploration many areas that cannot be searched by remotely operated vehicles due to practical tether length limitations, and the need to use acoustic communications underwater with their limited bandwidth and reliability. The field of SLAM is, and will continue to be, a critical tool in underwater ocean exploration and research. It allows an autonomous agent to track its location and environment by keeping logs of the relative position of landmarks viewed by the vehicle. One of the fundamental building blocks of SLAM is the data association process, where a viewed landmark is analyzed and either identified as a previously seen marker, or determined to be a new reference point. Locations of previously viewed landmarks are normally known to a higher degree of accuracy than new points. Matching a landmark to a previously identified point is a major aid to the AUV's navigation process, allowing correction of the estimated vehicle position to the landmark location. Data association is a difficult undertaking in frequently changing underwater environments where the sea floor and potential navigation landmarks vary drastically from area to area. An added complication is that

General Call for Scholarship Applications

The IEEE Oceanic Engineering Society recognizes that the future of ocean engineering depends on the recruitment of talented, engaged young people. To encourage advanced education in ocean engineering, OES offers up to eight awards annually for $5,000 each. Graduate and undergraduate students are encouraged to apply for these grants at any time. Selections are made twice each year, with deadlines of 1 March and 1 September. Information on the application process is available on the OES website: http://www.oceanicengineering.org/page.cfm/cat/81/OES-Student-Scholarship-Program/

Applications for OES scholarships are reviewed. This requires the time of volunteer members. The following have served in 2014: Christophe Sintes, Chair; Kenneth G. Foote, Liesl Hotaling, Marinna Martini, and Sophie Scappini, André Lesaout.

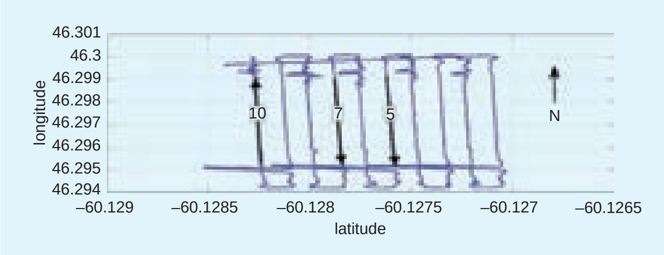


Figure 1: North-South AUV lawnmower pattern.

over time landmarks can shift location or orientation, or be covered or uncovered by silt, making a correct 'association' even more challenging.

Currently the most commonly used algorithm for data association is joint compatibility branch and bound (JCBB). This algorithm utilizes information about multiple landmarks and how they are associated relative to each other, as well as to the vehicle, instead of more naïve approaches looking at only a single target at a time. JCBB has demonstrated an acceptable level of performance in a number of simulation and controlled environments. However, there are many instances where environmental factors (noise, thermoclines, high/low backscatter) cause false associations which can lead the localization to fail. My research will attempt to extend the abilities of these algorithms, making them more adaptive and persistent. This will improve the AUV's ability to identify known landmarks in a real world environment, and ultimately reduce mission failures.

One potential area of improvement in the data association process I have been researching is incorporating local seafloor gradients intersecting potential landmarks in the localization process. If the direction and magnitude of changes in seafloor elevation can be consistently identified from different viewpoints, it should assist in successfully identifying and locating the landmarks. Gross environmental features such as sea floor slopes will be less likely to change over time.

To test the feasibility of this idea we attempted to associate a set of three targets from a navel mine counter-measures survey. The AUV ran in a North-South lawnmower style path collecting side-scan sonar images from the vehicle's port and starboard sides for each leg of the mission. Figure 1 shows the path that the AUV travelled. The starboard side scan image from legs 5, 7 and 10, identified in the Figure 2, were then examined for potential landmark associations.

The red box in legs 10 and 7 show a matching target, while leg 5 shows a similar but incorrect match from the same area.

Three dimensional elevation data was calculated using the side-scan sonar files and other sensor data from the vehicle (depth, speed, pitch and roll). The unique elevation profile created approximates the seafloor contours. These are then directly compared using the change in depth from the landmark to points 5-30 meters away. Four slopes were determined and compared for each landmark to the North, East, South and West of the targets. Figure 3 shows a section of the elevation map created from the AUV sensor data for leg 7. Height values in the elevation map are in altitude from the seafloor to the AUV.

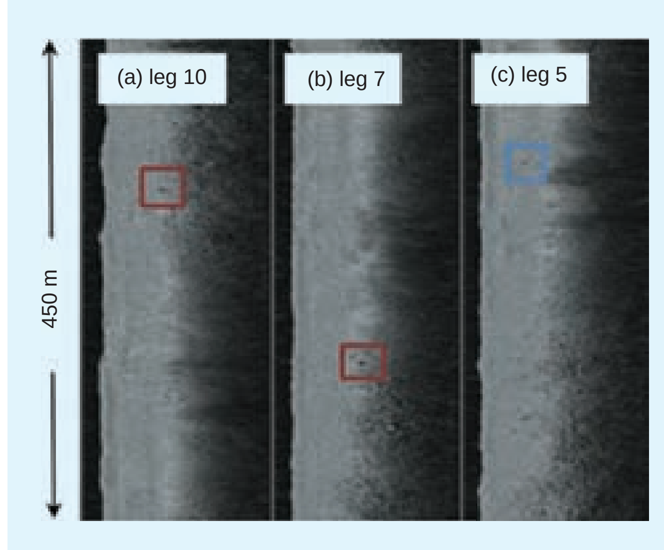


Figure 2: Side-scan sonar images with targets outlined.

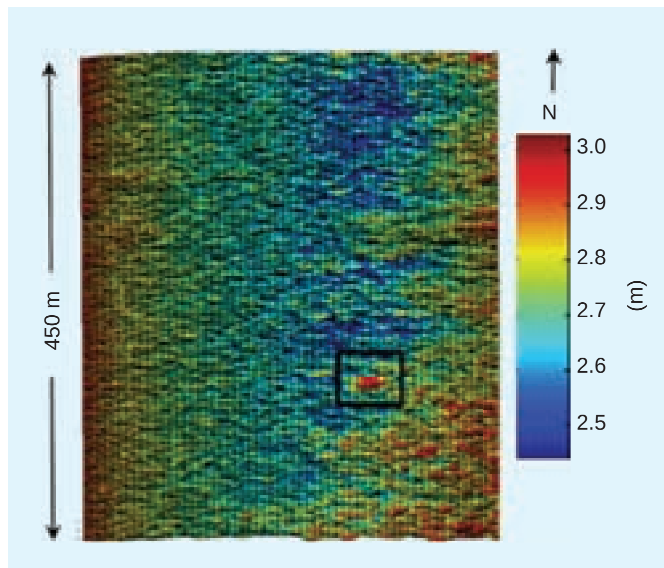


Figure 3: Elevation map from Fig. 2b.

The initial experimental results for this process correctly yielded a better association for the matching landmarks than for the incorrect target. Avoiding false positive associations is as important to SLAM as finding correct ones. I have just submitted a paper, a continuation of the work from my CCECE 2015 conference paper, to the IEEE conference IROS that outlines the results of incorporating these local elevation slope features as a joint feature set used in a JCBB algorithm to identify landmark associations. This work was done on a hardware in-the-loop simulator to validate its potential to run in real time on the embedded processors available in a DRDC AUV. I hope to further test this method during in-water trials to obtain a larger data set capable of verifying the enhanced data association process.

In the short term my main professional goal is to complete my MASc degree at Dalhousie University, bringing my elevation profile research to the point where AUV trials can demonstrate it to be functional. For the purposes of my thesis a successful test would prove incorporating seafloor gradients enhance the current SLAM data association process. Going forward I want to continue research in this field, focusing on increasing the reliability of AUV's real time navigation. I believe we are living in an era where significant advances in AUV navigation are imminent, with machine learning, improved sensors, and advances in processor power bringing previously unattainable goals within our reach.

In the course of my work I've been very fortunate for the opportunity to work directly and indirectly with personnel from organizations such as DRDC and CSAIL, who have a tremendous wealth of knowledge in this area and have directly supported my work. I would also like to thank the IEEE – Ocean Engineering Society for its support, which will help with my future graduate studies developing the underwater SLAM process. I want to continue to be part of this exciting and very meaningful work, and contribute to revolutionizing the way the ocean frontier is explored.

Publications

IEEE CCECE 2015 – Extracting Seafloor Elevations from Side-scan Sonar Imagery for SLAM Data Association

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Chapter News

New OES Chapter for Malaysia

Mohd Rizal Arshad

IEEE Malaysia Section has been around for many years. Various activities such as international conferences, technical seminars and short courses organized by the various chapters have benefited many students and researchers. The establishment of IEEE OES Malaysia Chapter is a very significant event for the ocean technologists and researchers perspectives in this region and Malaysia in particular. Malaysia being a maritime nation has tremendous marine resources which need to be exploited and utilized in the best of ways. The future of Malaysia in various ocean related industries such as oil and gas and mineral prospecting will require the cooperation and collaborations of all interested parties. With this intent in mind, IEEE OES members have endeavored to establish a more solid presence in Malaysia.

Hence, on Friday—17th April 2015, the IEEE OES Malaysian Chapter held its first protem committee meeting in the School of Electrical and Electronic Engineering, Universiti Sains Malaysia (USM) which is situated in Penang, Malaysia. The meeting was attended by 13 founding members of IEEE OES Malaysia.

The attendees came from various public (USM, UTM, IIU, UTHM, UPSI, UMP) and private universities (UTP) around Malaysia including those members from the Royal Malaysian Navy (RMN). The main agenda of the meeting was to appoint the ex-comm members for OES Malaysian Chapter, and subsequently to discuss the list of upcoming activities for 2015. After the election and voting processes, the following standing committee members for IEEE OES Malaysia Chapter were selected;

Discussion among colleagues.

Chair:	Mohd Rizal Arshad (USM)
Vice Chair:	Franklin Joseph (RMN)
Secretary:	Rosmiwati Mohd Mokhtar (USM)
Treasurer:	Zool H Ismail (UTM)
Ex-Comm (1):	Zulkifli Zainal Abidin (IIU)
Ex-Comm (2):	Zainah Md Zain (UMP)
Ex-Comm (3):	Khalid Isa (UTHM)

Sitting from left: Zool, Rizal, Franklin, Rosmiwati
Standing from left: Erni Harmiza, Herdawati, Addie, Saad, Zulkifli, Khalid, Ikhwan & Nasiruddin.

As an outcome of the ensuing discussion, the following activities were agreed upon and planned for the rest of 2015. The activities will be organized on shared basis among various institutions supporting IEEE OES Chapter Malaysia. It is hoped the activities will spur higher interests among IEEE members and will directly help to bring sustainable ocean research and development to the forefront.

No.	Month of 2015	Program/Events/Activities
1.	April	Technical Visit to TLDM (Royal Malaysian Navy)
2.	May	Short Course on Principle of Underwater Acoustics
3.	July	Technical Seminar
4.	August	Distinguished Lecturers Program (DLP)
5.	September	a) Workshop for Undergraduate b) Workshop: ASV System Development c) UROVEC 2015
6.	October	International Conference on Electrical, Control and Computer Engineering

IEEE OES Malaysia hopes more international linkages and networking will be established in the coming months. This will certainly put Malaysia as one of the key players in ocean explorations and utilizations in the South East Asia (SEA) region.

Further information about IEEE OES Malaysia can be addressed to:

Prof. Dr. Mohd Rizal Arshad (Chair) – eerizal@usm.my
Dr. Rosmiwati Mohd Mokhtar (Sec) – eerosmiwati@usm.my

IEEE OES Malaysia: 1st Activity

81st Navy Day Celebration – Open Ship at Lumut Naval Base Jetty

A group of IEEE OES Malaysia members with their families visited the Royal Malaysian Navy (RMN) Naval base in Lumut, Perak. The technical visit was done on the 25th of April 2015 in celebration of the 81st Navy Day Celebration. Nine RMN vessels in Lumut Naval Base jetty were opened to the public for tours. Through this tour OES members had the opportunity for an up close look on warships and in understanding the various functions of the navy ships equipment and instrumentations. Members also had the experience of eating on board as floating restaurants which provide valuable experience to on-board dining.

Boat ride activities were also available at the shallow water jetty for those who liked something different and adventurous. Two combat boats were available to the public. For visitors who wanted to know more information related to RMN, promotions and career outlets are also provided near the pier. Exhibition of Hydrographic Centre, the Dive Center and Mine Warfare and the Special Force Team were also available. The most attractive activity was the Sunset Ceremony. This is a traditional naval ceremony performed at sunset everyday. This ceremony was held on the flight deck of KD HANG TUAH. In summary, the visit has provide a beneficial exposure to IEEE OES members on the technologies and capabilities available in the RMN.

IEEE OES Malaysia and family members joining the visit.

Naval ship on display in Lumut Naval Base.

On deck at the gun side.

RMN Mine Detection AUV.

IEEE Oceanic Engineering Singapore Chapter-Activity Report for The Year 2014

Prepared by Dr Venugopalan Pallayil & Rubaina Khan

The Singapore Chapter organised a number of technical talks and an industrial workshop with the support from some of the local industries in the year 2014. One of the major activities of the Chapter has been organisation of the Singapore AUV Challenge 2014, an underwater robotic competition and the details have been covered in a previous edition of the BEACON Newsletter. The Chapter also hosted visits by Dr Albert J Williams (Sandy Williams), Emeritus scientist, Woods Hole Oceanographic Instiitution (WHOI) and Vice-President of Conference Development, IEEE OES and Dr Kenneth G Foote (Ken), Senior Scientist, WHOI and OES Vice-President for Technical Activities. One of the objectives of the visit was to do a recon of conference venues in Singapore as Singapore has put up a bid to host the OCEANS'20 conference. A tour to various conference venues were organised with support from the Singapore Tourism Board and discussions were held. IEEE OES distinguished lectures were also delivered by both Dr Sandy Williams and Kenneth G Foot. Sandy spoke on 'Historical Development of currents, waves and turbulence measurements including those by MAVS. Dr Ken delivered a talk on 'Acoustic quantification of marine organisms including a developing application with parametric sonar'.

The chapter also organised talks by Dr Nicholas Chotiros from Applied Research Laboratory, UT, Austin on the 'Acoustic sediment classification' and 'Current and future technological advances in maritime systems' by Dr Marc Pinto, Programme Manager, ECA Robotics, France.

The industrial workshop, an annual event jointly organised with some local companies who deal with marine products, was well attended by IEEE OES members, students and industry representatives. This is the 4th time in a row that the chapter is organising this event. Many technical talks were organised as part of this programme. Prof. Nicholas Patrikalakis from MIT spoke on the 'Path planning and surface reconstruction for inspection'. Dr Michael Benjamin, Research Scientist from MIT gave a talk on 'Autonomy algorithms for adaptive control of unmanned marine vehicles'.

Sandy and Ken enjoying the 'Singapore sling' after the site visits.

Prof. Patrikalakis giving his keynote presentation during the annual industrial workshop.

The Sea and Land Technologies Pte Ltd., Singapore was one of the major sponsors of the event. The company had exhibited some of its products during the event and presented them to the attendees. Other companies who exhibited and presented their products were Kongsberg, Singapore and Subnero Singapore. The event was also well supported by the

Ken taking a closer look at the STARFISH AUV Section developed at ARL during his visit to the lab.

Election of new oce bearers in progress during the annual general body meeting after the workshop.

Industrial workshop participants.

Singapore-MIT Alliance Research & Technology (SAMRT), who provided the venue for the talks and also provided refreshments. The annual general body meeting of the Chapter was held along side with the above event and the new office bearers were also elected. The event ended with a BBQ dinner.

Another notable technical talk was given by Dr Nicholas Makris, Prof. MIT and Dr Poornima Rathilal, Assoc. Prof. The talk was jointly organised with the Centre for Sensing and monitoring (CENSAM), Singapore-MIT Alliance Research & Technology (SMART), National University of Singapore.

Victoria Chapter Technical Meeting

Nick Hall-Patch OES Victoria Chapter

On May 5 2015, Sabuj Das Gupta presented a seminar at the University of Victoria, co-sponsored by the OES Victoria Chapter concerning the topic "Underwater object detection by using narrow beam lasers". Mr. Gupta is a graduate student at University Victoria's Department of Electrical and Computer Engineering.

In his talk, Mr. Gupta proposed using reflections of narrow laser beams from the ocean bottom and capturing those reflections using an oblique camera, and after correcting for perspective distortions, detecting bottom features, including height. As a single beam would not detect many features, he further proposed the use of multiple laser beams using an array of lasers or a diffraction mask of a single laser beam. Using a diffraction mask for example, a sizeable array of points of light could be projected on the bottom, and the reflections recorded.

After suitable correction of the images, he had found that objects on the ocean floor could be defined with an error rate below 5%. He pointed out that a denser diffraction mask would be required to obtain higher resolution, especially as the distance to targets was increased. He also pointed out that reflective objects could confuse his algorithm, and that it was important that images recorded do not overlap each other.

A discussion over coffee and doughnuts followed the talk, where it was surmized that such a system would require fewer computational resources for short range object detection than optical cameras would, and that would provide potential for faster repeated surveys, using an AUV for example.

Sabuj Das Gupta presented a seminar at the University of Victoria.

IEEE OES Canadian Atlantic Chapter is Celebrating the 30th Anniversary

Dr. Ferial El-Hawary, P.Eng., F.IEEE, F.EIC, F.MTS

Left to right (from back to front): Ferial El-Hawary, James McFarlane, Mo El-Hawary and Joe Geza.

Thank you IEEE Region 7 for recognizing 2015 as the year of celebrating the 30th year of the IEEE OES Canadian Atlantic Chapter which was established in 1985. The Region has taken this opportunity and chose Halifax to be the site of its Flagship IEEE Canadian Conference on Electrical and Computer Engineering (CCECE'2015) which was held, May 3–6, 2015. The conference attracts researchers and practitioners to exchange and explore the issues, ideas and opportunities in electrical and computer engineering from Canada and around the world. The conference theme was "Celebrating 30 Years of OCEAN Frontiers". It motivated our organizing committee and the local chapter to reach out to high calibre invited speakers for special Sessions on Oceanic Engineering and Marine Technology.

The OES local Chapter was heavily involved in the choice of the Keynote Speakers with the Ocean related topics such as:

- John Leonard, Professor in the Department of Mechanical Engineering at MIT, USA who spoke on "Long-term View of Simultaneous Localization and mapping for Mobile Robots"
- James McFarlane, President of International Submarine Engineering, Vancouver, Canada who spoke on "The Evolution of Underwater work Capably in British Columbia"
- Doug Wallace, Chair-holder, CERC Ocean, Halifax, Canada "The Next 30 years of Ocean Frontiers"
- Ken Meade of EMERA Newfoundland who spoke on "Underwater Transmission Power Cable between Nova-Scotia and Newfoundland".

The highlight event during the conference was on the Student Posters Competition showcasing Oceans related papers. Many thanks to OES Society who supported the prizes for the top three students:

1st. prize was awarded to:
Graham McIntyre, M.Sc. student, Dalhousie University, Halifax, Canada

2nd. Prize awarded to:
Chokri Jeebali, M.Sc. student, École Polytechnique de Montréal, Quebec, Canada

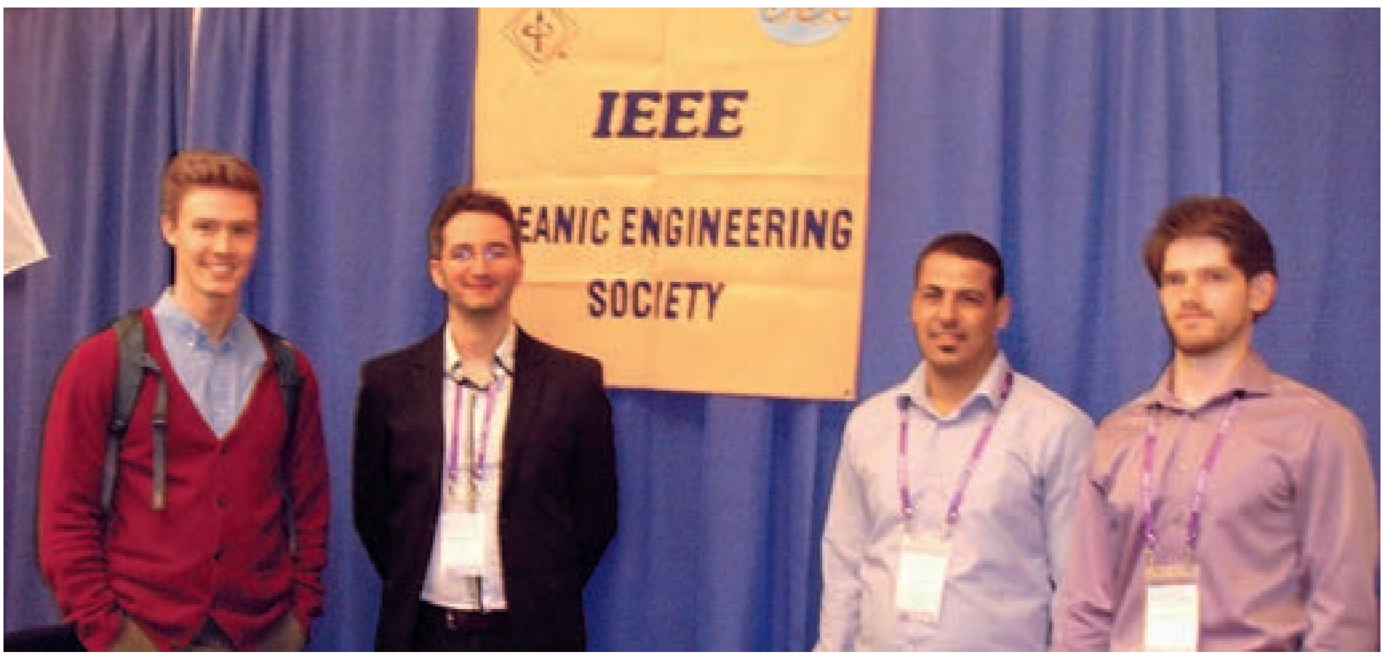
Third prize was shared by F. Sanfiliippo, Ph.D. Student, Norway, and Jianping Liang, M.Sc. Student, University of Waterloo, Ontario, Canada.

I am very thankful to all who made this event a success.

James McFarlane delivering his keynote lecture.

Left to right: Mao Sito, James McFarlane & John Leonard handing third prize to Jianping Liang, far left is Ferial El-Hawary.

Ferial El-Hawary with a student as potential OES member.



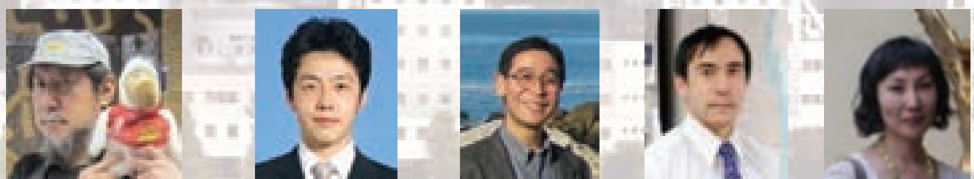
Four student prize IEEE OES winners.

Left to right: Guest, Jason Gus, Ferial El-Hawary, F. Sanfilippo, Collin Mackenzie, Jianping Liang, Amir Aghdam and Chokri Jeebali.

AUV 2016

IEEE OES AUV2016 Workshop in Tokyo

November 6- 9, 2016
IIS Conference Hall " Haricot" Tokyo, Japan



Important Dates

Abstract Submission Page Open: April 8, 2016
Deadline for Abstract Submission: June 20, 2016
Deadline for Full-paper Submission: September 2, 2016

Organizers

Institute of Industrial Science, the University of Tokyo
IEEE/OES Japan Chapter
IEEE/Oceanic Engineering Society (IEEE/OES)

Technical Co-Sponsor

Society for Underwater Technology (SUT)

For Inquiries, please contact:

AUV2016 Secretariat: **info@auv2016.org**

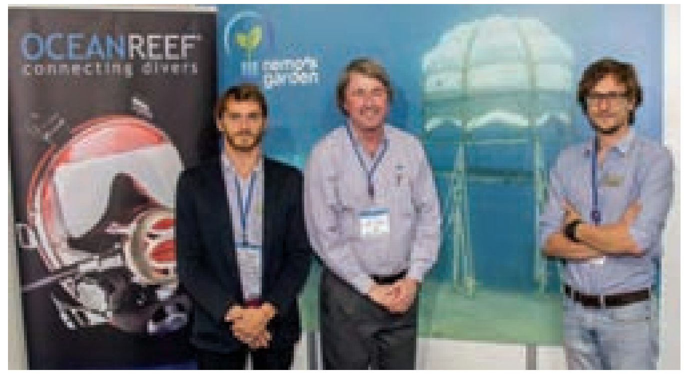
URL: http://www.auv2016.org/

Interaction at OCEANS'15 Genova, Italy

Kevin Hardy, Associate Editor-in-Chief

I recently attended a lecture at the University of California, San Diego (UCSD) by former MASH 4077 actor **Alan Alda** in which he asserted the difference between humans and other species, or even our evolutionary ancestors like Neanderthals, is our penchant for sharing experiences through language. The use of tools doesn't set us apart, it's the passing along the value of the tool to others, adding to the collective knowledge of the tribe that does. It's how we have progressed so far, so fast as a species. That really struck me. I test the idea as I attend chapter meetings and society conferences, and see it validated each time. Conference attendance is so valuable in so many ways, though hard to assess the value in a strict business sense. It's like gravity: we know it works, we just can't explain why it works. At a conference, the personal interactions, meeting people you've read about, the chance for idea surfing, seeing ideas passed from the experienced to the eager, maybe studying the size, scale and detail of someone else's approach to a problem, all happen. An engineer might beat his head against a wall for a month or more, where he might solve the problem in a couple of days with the interaction of the people he meets at a conference. That's return on investment (ROI). At OCEANS'15 Genova, we were part of a large number of people from everywhere. Diaspora and native, they were all engaged in the grand process of idea exchange.

Those I met in Genova included two young Italian gentlemen, **Luca Gamberini** and **Gianni Fontanesi**, from Ocean Reef Inc., who have developed a full-face mask SCUBA system with LED indicators of air pressure and battery power, plus a built-in LED brow light. The product design implementation is truly to be admired. They are also experimenting with shallow undersea greenhouses they call "Nemo's Garden". There are places in the world, like the countries bordering the Red Sea, where something like this could be a big help. Another youthful engineer from Singapore, **Tian Chang**, with the company "Sub-Nero", described an idea for cleaning the Pacific Gyre garbage patch with AUVs powered by wave energy. I can introduce him to researchers working to characterize that problem because those scientists shared their story with me earlier. A dedicated scientist and engineer, **Dr. Konstantin Kebkal**, and his lovely family, moved to Berlin from Croatia. His company is experimenting with free ranging Surface AUVs, sharing experiences, marketing existing models, pondering obstacle avoidance techniques, and curious about what might be the next application. **Dr. John Watson**, Chair of OCEANS'17 Aberdeen, is a lovely Scotsman who knows his single malt. The passion he brings to calling the clans to his village guarantees a superior conference to come. In the course of things a PhD student at the University of Southern California (USC), **Stephanie Kemna**, and I discussed options for low-cost pressure housings for her work. I shared what another grad student at Scripps Institution just south of her had found. That led to an engaging conversation with **Dr. Stephen Wood** of the Florida Institute of Technology. All manner of business cards were exchanged, with notes scribbled in bare spaces. It's your global peers who come to listen to your paper presentation and ask insightful questions, and the vendors who may be willing to discuss what's in their R&D queue. Here is strange math where 1+1 makes more than 2, a Breeder Reactor where what you get out is more than you put in. There are some similarities to the OES Beacon newsletter, but that's another story for another day!



Kevin Hardy with Nemo's Garden Team (Photo by Stan Chamberlain).

From the President *(continued from page 3)*

main outcome in the next issue of the Newsletter (as promised), after the final approval at the June TAB meeting.

Finally, we are working very hard on supporting our chapters all over the world, with coordination by Jim Collins. We are promoting exchanges between the chapters (per Region) and of course with us. For that purpose, the website is in the process of being revamped with additional means of communication available (smartphone app, twitter, forum, etc.). As I said in my previous editorial: "*we are setting up an Outreach Committee for a better interaction between you, members, and the leadership of OES. If you have ideas, comments, suggestions, do not hesitate to contact me (r.garello@ieee.org). A few hundreds e-mails more in my mailbox won't be a problem*".

OES is working and looking for YOU, then look for OES.

René Garello,
OES President

Student Poster Competition, OCEANS'15 MTS/IEEE GENOVA

Philippe Courmontagne, Student Poster Contest Committee Chair, Photos by Stan Chamberlain

The Student Poster Program has been initiated by Norman Miller in 1989 and became an integral part of the OCEANS conferences in 1991. Since then, more than 700 students have participated in this program. This 36th Student Poster Program of the OCEANS Conferences was held at OCEANS'15 MTS/IEEE Genova, at the Centro Congressi di Genova, from May 18 to May 21. As for the previous Student Poster Competitions, outstanding posters describe the work that the students were presenting and were particularly appreciated by the attendees of the conference. Moreover, the student participants greatly appreciated the opportunity to display, exchange and describe their research work to the community.

The program was organized by Paola Picco as local coordinator and Philippe Courmontagne, SPC Chair, from IEEE OES. For this 36th edition, 52 abstracts were received, 21 were selected, not without difficulty given the high quality of the received abstracts. The students were from schools in Europe, Asia and the USA. The program was supported by funding from the US Navy Office of Naval Research Global and from AUVSI, which enabled the students to attend the conference.

The roster of students, their schools (in order of appearance of the Program Book) are:

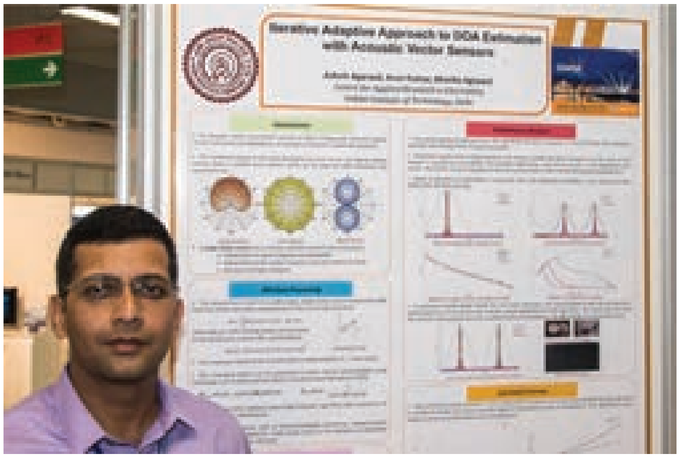
- Ashish Agarwal, Indian Institute of Technology, Delhi
- Mohammadreza Babaee, Technische Universität München
- Josep Bosch, Universitat de Girona
- Arnau Carrera Viñas, Universitat de Girona
- Javier Pérez Soler, Jaume I University of Castellon
- Ridha Fezzani, ENSTA Bretagne
- Christopher Gianelli, University of Florida
- Sheng-Wei Huang, National Taiwan University
- Guillem Vallicrosa, Universitat de Girona
- Yann Le Gall, ENSTA Bretagne
- Graham McIntyre, Dalhousie University
- Ugo Moreaud, DCNS – Underwater detection Dpt, Acoustic signature R & D
- Alain Olivier, Department of Information Engineering, University of Padova
- Benjamin Ollivier, Institut Mines-Télécom Bretagne
- Albert Palomer, Universitat de Girona
- Antonio Peñalver Monfort, Jaume I University of Castellon
- Laurent Picard, Lab-STICC UMR CNRS 6285 ENSTA Bretagne
- Andrew Stuntz, Fort Lewis College
- Lingji Xu, Northwestern Polytechnical University
- Rui Yang, ENSTA Bretagne & Ocean University of China
- Yang Zhang, Ocean University of China

The posters were judged by a team organized by IEEE OES. The student award winners were announced during the Gala Dinner at the Palazzo Ducale.

Dr. Philippe Courmontagne opened the awards ceremony and presented, with Paola Picco, each student with a Certificate of Participation in the OCEANS'15 MTS/IEEE GENOVA. Then, René Garello, IEEE OES President, and Ray Toll, MTS President, presented the third place winner to Mohammadreza Babbaee, from Germany. Next, they presented the second prize to Hugo Moreaud, from France. The first prize, the "Norman Miller's Prize", has been presented by Patricia Gruber, Technical Director at Office Naval of Research Global, to Ridha Fezzani, from France, for his poster entitled "*Swath bathymetric data fusion – Application to underwater vehicle*". All the students received a round of applause for their accomplishments and participation in the Student Poster Program of Genova.

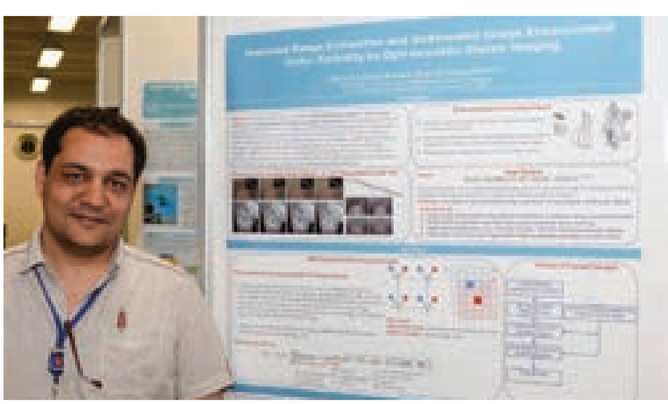
The poster session and the awards ceremony.

Ashish Agarwal, Indian Institute of Technology, Delhi
Iterative adaptive approach to DOA estimation with acoustic vector sensors



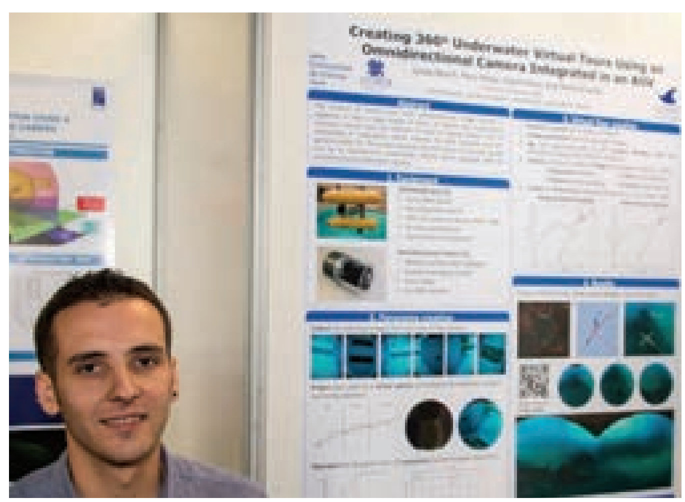
Acoustic Vector Sensors are underwater sensors that measure acoustic pressure as well as the acoustic particle velocity to estimate the acoustic intensity. The acoustic intensity, which is a vector quantity, represents the magnitude and direction of the active or propagating part of an acoustic field thus indicating the DOA (Direction of arrival) of a received signal. This paper dwells on an Iterative Adaptive Approach (IAA) for DOA and signal power estimation of underwater acoustic emissions, using a single vector sensor, which is of significance in several passive surveillance applications. The proposed IAA algorithms are robust in resolving partially correlated or coherent sources which is a known phenomenon in shallow water conditions due to multipath. It has been observed that in case of a single vector sensor, the proposed IAA Amplitude and Phase Estimation Scheme (IAA-APES) performs better than a standard Capon beamformer even in the presence of correlated/coherent sources, the performance being measured in terms of Mean Square Angular Error (MSAE). Also another version of IAA, namely the Iterative Adaptive Approach – Maximum Likelihood (IAA-ML) estimation provides better resolution than all the other schemes.

Mohammadreza Babaee, Technische Universität München– **The third place winner**
Improved Range Estimation and Underwater Image Enhancement Under Turbidity by Opti-Acoustic Stereo Imaging



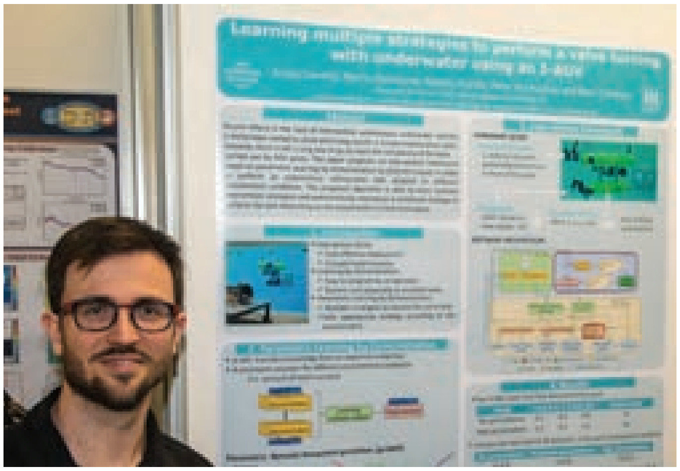
Images recorded in turbid waters suffer from various forms of signal degradation due to light absorption, scattering and backscatter. Much of the earlier work to enhance color, contrast and sharpness follow the single-image dehazing approach from the atmospheric imaging literature. Requiring knowledge of both range to scene objects and ambient lighting, various techniques differ in how they estimate the information from various image regions. Moreover, some assumptions are made that hold for most images recorded in air and clear waters, but are often violated in turbid environments, leading to poor results. Alternatively, stereo imaging and polarization have been explored for simultaneous range estimating and image dehazing, however, these can become ineffective with low visibility and (or) weak polarization cue. This work explores a methodology that utilizes the visual cues in multi-modal optical and sonar images, namely, the occluding contours of various scene objects that can be detected and matched more robustly than point features. Calculating the sparse 3-D positions of these contours from opti-acoustic stereo data, we infer a dense range map by exploiting an MRF-based statistical framework, where image intensities and range values serve as observation and hidden variables. Additionally, the opti-acoustic epipolar geometry guides the interference of the MRF by refining neighborhood pixels. The improved performance over other state-of-the-art techniques is demonstrated using images recorded under different turbidity conditions.

Josep Bosch, Universitat de Girona
Creating 360° underwater virtual tours using an omnidirectional camera integrated in an AUV



The use of omnidirectional cameras underwater is enabling many new and exciting applications in multiple fields. Among these, the creation of virtual tours from omnidirectional image surveys is expected to have a large impact in terms of science and conservation outreach. These surveys can be performed by Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) that can cover large marine areas with precise navigation. Virtual tours are relevant in zones of special interest such as shipwrecks or underwater nature reserves for both scientists and the general public. This paper presents the first results of surveys carried out by an AUV equipped with an omnidirectional underwater camera, and explores the process of automatically creating virtual tours from the most relevant images of the datasets.

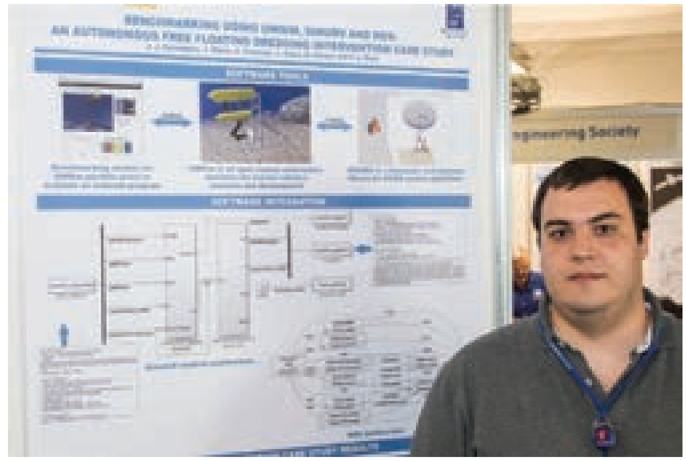
Arnau Carrera Viñas, Universitat de Girona
Learning multiple strategies to perform a valve turning with underwater currents using an I-AUV



Recent efforts in the field of intervention autonomous underwater vehicles (I-AUVs) have started to show promising results in simple manipulation tasks. However, there is still a long way to go to reach the complexity of the tasks carried out by ROV pilots. This paper proposes an intervention framework based on parametric Learning by Demonstration (p-LbD) techniques in order to acquire multiple strategies to perform an autonomous intervention task adapted to different environment conditions. The manipulation skills of a pilot are acquired thought a set of demonstrations done under different environment circumstances, in our case different levels of water current. The proposed algorithm is able to learn these different strategies and depending on the estimated water current, autonomously reproduce a combined strategy to perform the task. The p-LbD algorithm as well as its interplay with the rest of the modules that take part in the proposed framework are described in this paper. We also present results on a free-floating valve turning task, using the Girona 500 I-AUV equipped with a manipulator and a customized end-effector. The obtained results show the feasibility of the p-LbD algorithm to perform autonomous intervention tasks combining the learned strategies depending on the environment conditions.

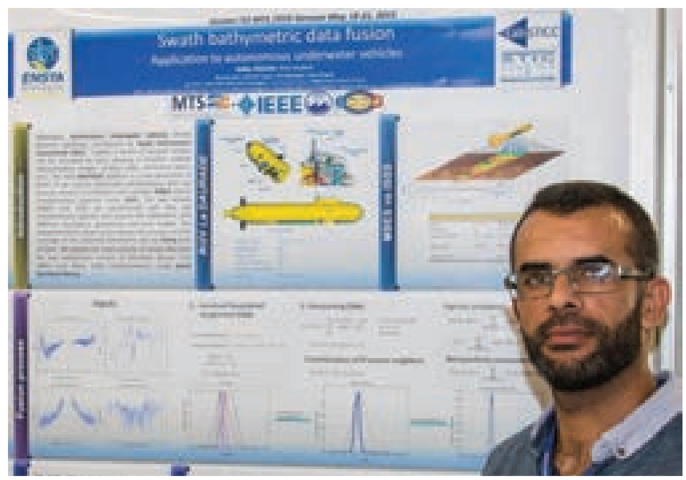
Javier Pérez Soler, Jaume I University of Castellon
Benchmarking using UWSim, Simurv and ROS: an autonomous free floating dredging intervention case study

This paper proposes the use of UWSim (an underwater simulator) in combination with Simurv (a kinematic and dynamic library for Underwater Vehicle-Manipulator Systems control algorithms) and ROS (a well-known robotics framework) in order to simulate the dynamics of an Intervention



Autonomous Underwater Vehicle and its application to the benchmarking of autonomous control algorithms in the field of archaeology dredging.

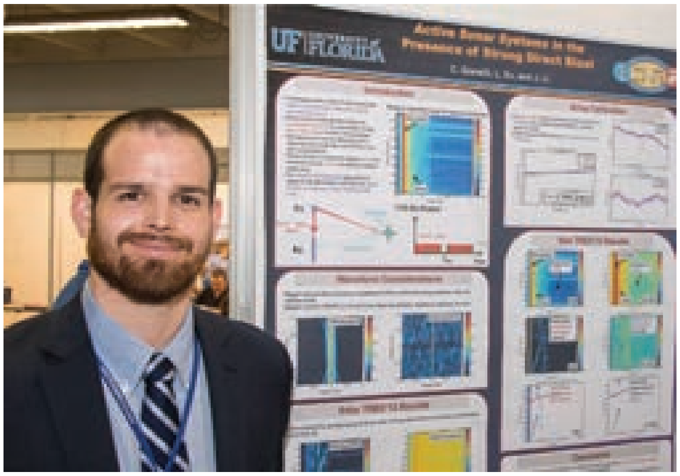
Ridha Fezzani, ENSTA Bretagne **– The first place winner**
Swath bathymetric data fusion – Application to autonomous underwater vehicle



The autonomous underwater vehicle (AUV) DAURADE platform can acquire bathymetry with two acoustic sensors: a multibeam echo sounder (MBES) and an interferometric sidescan sonar (ISSS). The two sensors (MBES and ISSS) are synchronized and they can simultaneously operate and acquire the bathymetry with different resolutions, geometries and error models. This complementarily allows us to improve the accuracy and the coverage of the collected bathymetric data by fusing both of them. We applied the fusion process on actual data from the two bathymetric sensors of DAURADE (Reson 7125 MBES and Klein 5000 Interferometric); the obtained results are presented and discussed.

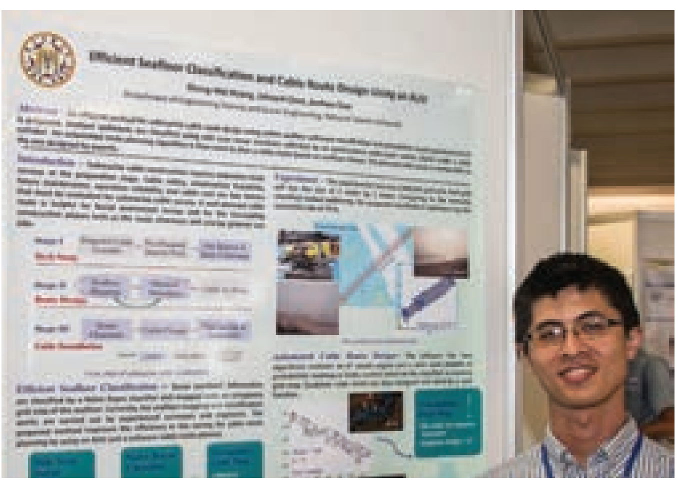
Christopher Gianelli, University of Florida
Active Sonar Systems in the Presence of Strong Direct Blast

Active sonar system performance in the presence of strong direct blast, or reverberations from the projected waveform, is considered. The presence of these reverberations may severely limit target detection performance and the applicability of the continuous active sonar (CAS) paradigm. Signal processing



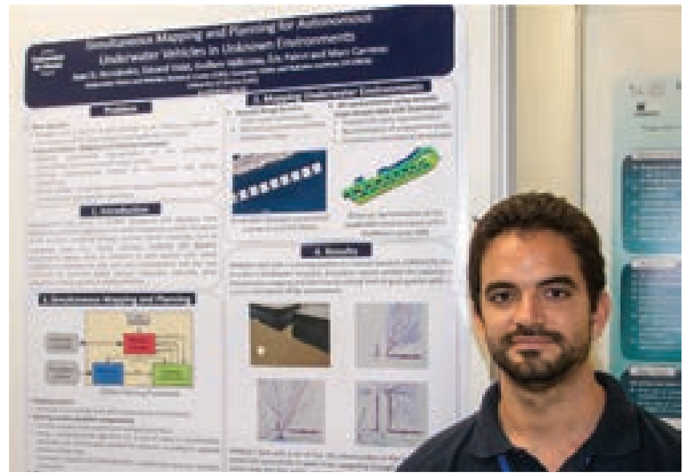
approaches to detect objects of interest and estimate relevant target parameters are described for signals subjected to these powerful reverberations. Results obtained by processing data from the TREX'13 experiment are presented and discussed.

Sheng-Wei Huang, National Taiwan University
Efficient Seafloor Classification and Cable Route Design using an AUV



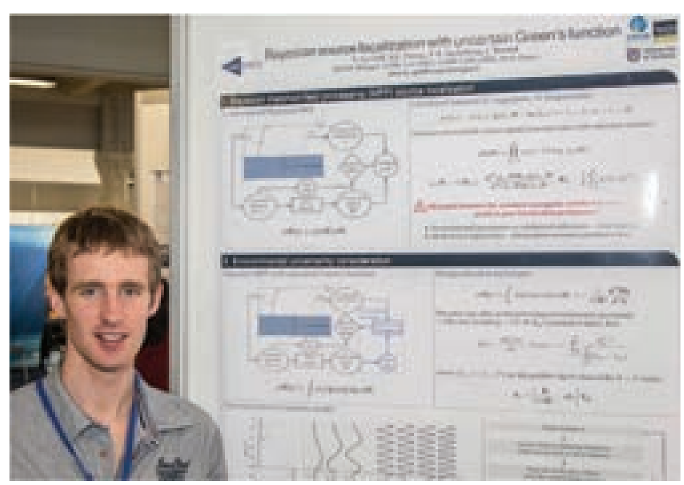
This paper aims to an efficient method for submarine cable route design using online seafloor classification from sonar scanlines conducted by an autonomous underwater vehicle (AUV). Currently, the cable route design works are carried out by experienced surveyors and engineers by hand. An online seafloor classification using an AUV with automated route planning method can improve the efficiency for submarine cable construction. Side scan sonar is a common device used for seafloor mapping and obstacles detection. In order to implement online seafloor classification and mapping, an AUV equipped with a side scan sonar is utilized to gather sonar scanlines. Scanlines are analyzed on the fly to classify sea floor using a probabilistic classifier based on Bayes' theorem and Naïve assumption to distinguish different types of seafloor. Based on the classified seafloor map, a probabilistic roadmap is constructed and an A* algorithm is applied to determine appropriate cable routes on the cable corridor. Seafloor classification, bathymetry, steep slope, angle of alter course, and cable length are the five factors of route design. A result of a cable route survey work between islands was demonstrated. The planned route using the proposed method is close in range to the one recommend by experts.

Guillem Vallicrosa, Universitat de Girona
Simultaneous Mapping and Planning for Autonomous Underwater Vehicles in Unknown Environments



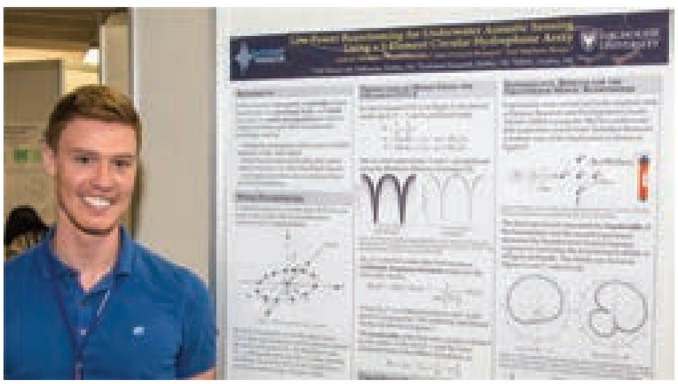
New potential applications of autonomous underwater vehicles (AUVs) involve operations in unknown and cluttered environments, therefore increasing the vehicle exposure to collisions. To cope with these situations, we use an AUV framework for planning collision-free paths in unknown environments, which adapt and replan the paths according to nearby obstacles perceived during the mission execution using different range sensing sonar. We present simulation and real-world results for the SPARUS-II AUV, a torpedo-shaped vehicle, performing autonomous missions.

Yann Le Gall, ENSTA Bretagne
Bayesian source localization with uncertain Green's function



The localization of an acoustic source in the oceanic waveguide is a difficult task because the oceanic environment is often poorly known. Uncertainty in the environment results in uncertainty in the source position and poor localization results. Hence, localization methods dealing with environmental uncertainty are required. In this paper, a Bayesian approach to source localization is introduced in order to improve robustness and obtain quantitative measures of localization uncertainty. The Green's function of the waveguide is considered as an uncertain random variable whose probability density accounts for environmental uncertainty. The uncertain distribution over range and depth is then obtained through the integration of the posterior probability density (PPD) over the Green's function probability density. An efficient integration technique makes the whole localization process computationally efficient. Some results are presented for a simple uncertain Green's function model to show the ability of the proposed method to give reliable PPDs.

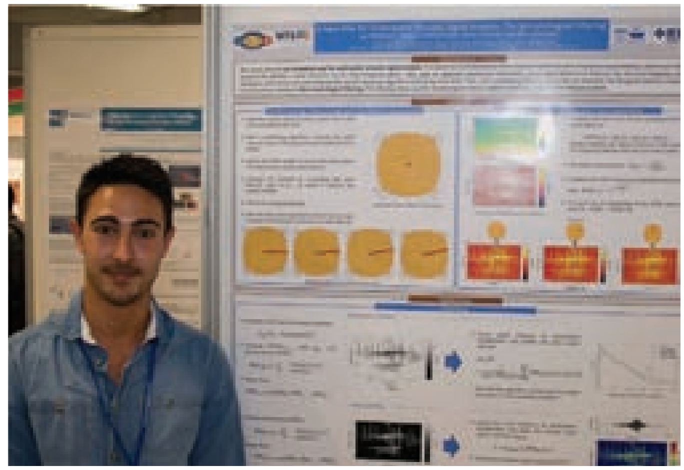
Graham McIntyre, Dalhousie University
Low-Power Beamforming for Underwater Acoustic Sensing Using a 5-Element Circular Hydrophone Array



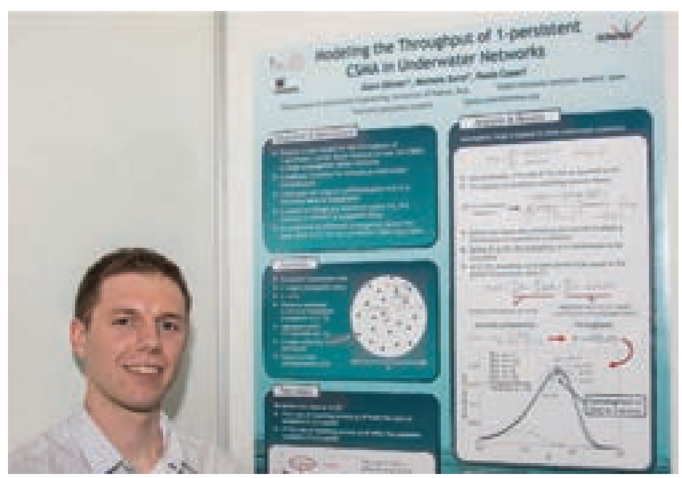
In this paper we present a technique for underwater acoustic beamforming based on soundfield recording that encodes both the temporal and spatial characteristics of a signal. Here, we introduce the basic theory behind soundfield recording and present a first-order beamformer that beamforms the encoded data in a specific direction (θ, ϕ) and with a variable polar pattern, p. The appeal of this beamformer being that a 2-dimensional beam can be created using only 4 multiplications and 2 additions. A method for implementing a wideband, planar soundfield recorder using a 5-element array is then discussed. Results from underwater experimental trials using this 5-element array are then presented that compare the measured beam patterns and frequency response of the physical beamformer to the ideal, theoretical beam patterns and frequency response.

Ugo Moreaud, DCNS – Underwater detection Dpt, Acoustic signature R & D **– The second place winner**
A new way for underwater acoustic signal analysis: The morphological filtering

This study presents an innovative way for underwater acoustic signal analysis. It is based on multi-directional filters implementation on time-frequency representation, where each filter is designed to enhance a given direction on the time frequency plane. To do so, the proposed technique processes the time-frequency plane by taking into account the actual atom and its neighborhood for each direction, up to a given distance. Thus, such an approach emphases information about signal directional features into the time-frequency plane. Derivation of the technique relies first on the use of a recursive algorithm which estimates noise level. Then, after establishing filters responses for one direction, the design method is extended to all-direction, leading to the morphological filtering, which allows specific morphological feature patterns detection from the time frequency plane. This paper finally presents experimentations on real underwater acoustic recordings to show performances obtained with this technique when objective is SNR enhancement and acoustic signature features preservation.

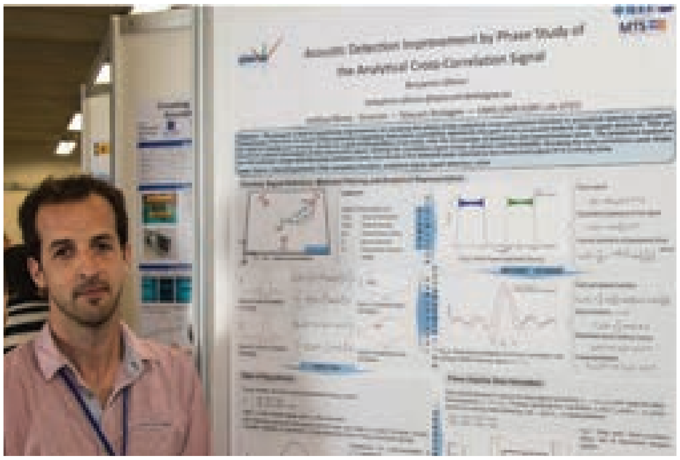


Alain Olivier, Department of Information Engineering, University of Padova
Modeling the Throughput of 1-persistent CSMA in Underwater Networks



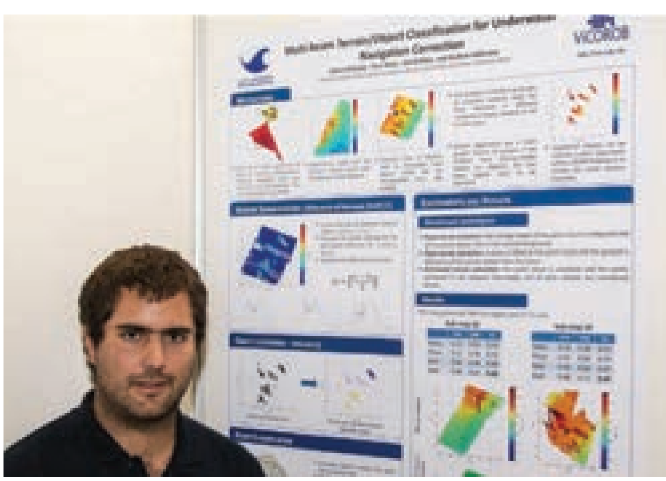
The aim of this paper is to present a model for the throughput of the 1-persistent CSMA protocol in underwater networks, where the typically large propagation delay with respect to the packet transmission time requires to take into account the spatial distribution of the nodes. Our model is developed based on the analysis carried out in [1] for the non-persistent CSMA protocol. Our results show that the 1-persistent CSMA model developed by Tobagi and Kleinrock is still valid as an approximation, with a few small adjustments, even though it considers an equal propagation delay for all pairs of nodes in the network. The proposed model is validated against simulation results based on the network simulator OMNeT++.

Benjamin Ollivier, Institut Mines-Télécom Bretagne
Detection Improvement by Phase Study of the Analytical Cross-Correlation Signal



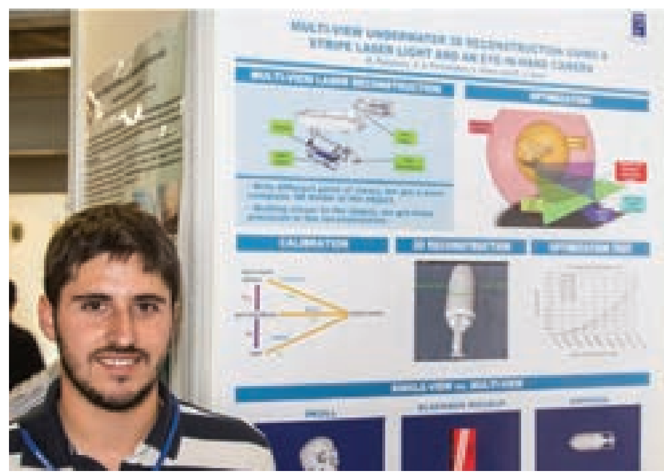
In this paper, we propose a test of hypothesis improvement, by phase study of the analytical cross-correlation function in acoustical detection application. Robustness of false alarms probability for the Time Of Arrival (TOA) estimation represents the goal of the proposed method. After signal detection, TOA will be used to localize one receiver, thanks to a grid of transmitters (more than 3), thanks to the knowledge of positions and transmissions times. The presented method is based on a priori information of the researched signal, forming the correlation signal shape (duration and bandwidth). Knowing the auto-correlation peak shape, we will estimate a range with the cross-correlation peak, and deduce if the detected peak corresponds to the researched signal or to a strong noise.

Albert Palomer, Universitat de Girona
Multibeam object segmentation for underwater navigation correction



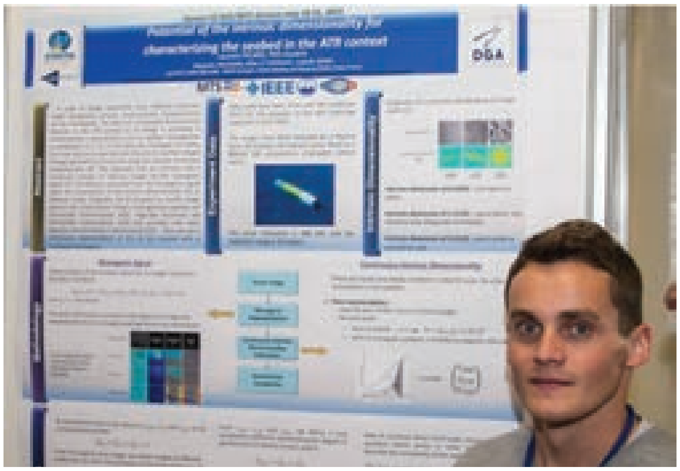
Building accurate bathymetries of the seabed has been a focus of study in the last decade. For this purpose seabed point cloud registration has been a focus for some researchers. Some of these registration methods are based on gathering the points of the cloud that contain more information for the registration (i.e. that are flat or smooth, normally being the seabed) and using them as part of ICP-derived methods. For this point picking purpose, we present a segmentation technique that distinguishes between objects (interesting for registration) and ground (smooth and not interesting for registration). The method proposed here uses difference of normals for object's border detection and a variation of the Density-Based Spatial Clustering of Application with Noise for object clustering. Once the objects boundaries are detected and the points are clustered the rest of the points are classified as object or ground. This classification is done by taking all the points that lie within the object's border and checking it's depth compare to its closest border point. The method is evaluated using a multi-beam dataset gathered on the La Lune shipwreck, a site of archaeological interest.

Antonio Peñalver Monfort, Jaume I University of Castellon
Multi-View Underwater 3D Reconstruction using a Stripe Laser Light and an Eye-in-Hand Camera



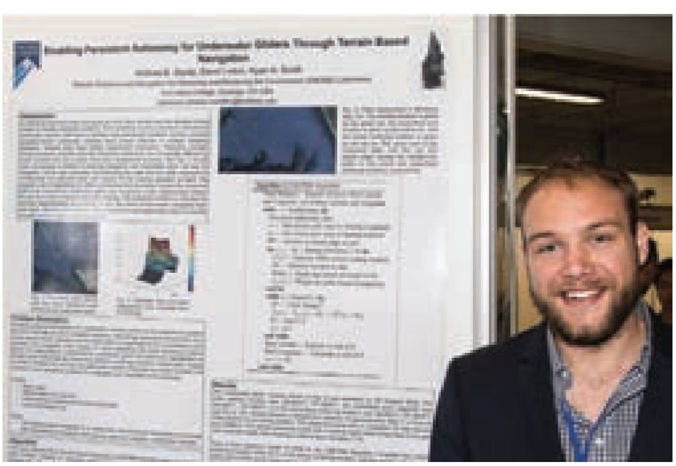
Autonomous manipulation in unestructured underwater scenarios is a high challenging skill that has been poorly studied and is becoming more and more important in the last years. One of the main problems regarding the autonomous manipulation, is to find out the characteristics of the object which is going to be manipulated. This paper presents a new approach to obtain an accurate 3D reconstruction of this object. This approach consists in attaching a laser stripe emitter and a camera in the forearm of a robotic arm. Moving the arm, the laser scans the scene where the object is and, at the same time, the camera records the scan. Thanks to the arm and the position of the camera, the scene can be reconstructed from different views and from a position close to the object. The recorded images are processed to obtain the 3D position of the part of the scene projected by the laser. Before the intervention, a process of calibration is needed to calculate the relationship between each part of the system. Furthemore, in order to reduce the time of processing of the images recorded during the scan, an optimization algorithm is presented which consists in discarding, before the processing, the pixels of the image which do not contain relevant information. The approach herein presented and the optimization algorithm are tested using an underwater simulator.

Laurent Picard, Lab-STICC UMR CNRS 6285 ENSTA Bretagne
Potential of the intrinsic dimensionality for characterizing the seabed in the ATR context



Up to now in mine warfare context, most of Automatic Target Recognition (ATR) processes suffer from environmental effects and therefore try to erase them by image filtering or thresholding before performing shadow and/or echo extraction of the target. In order to design potentially more effective methods, environmental characterization can be investigated. The idea is to incorporate environmental features in the ATR process or to design it according to environmental characteristics such as seafloor homogeneity or complexity. In this way, this paper studies the ability to decompose sidescan sonar images through geometrical structures using the concept of intrinsic dimensionality (iD) and scale-space representations.

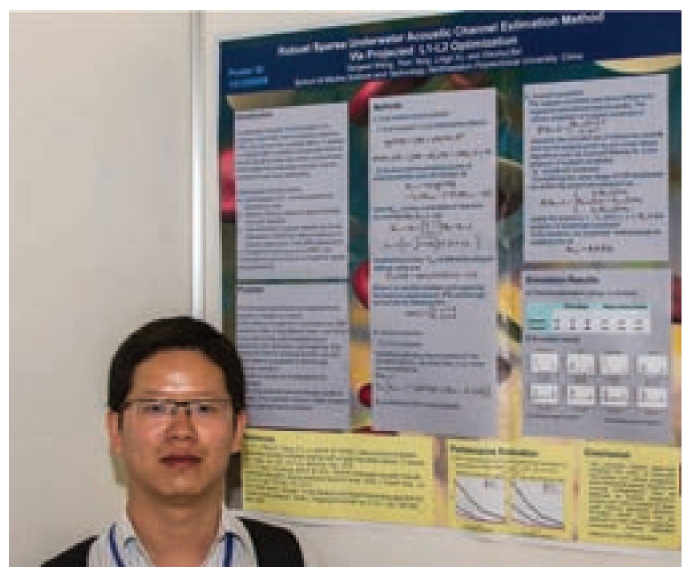
Andrew Stuntz, Fort Lewis College
Increasing Navigation Accuracy and Localization for Autonomous Gliders to Enable Persistent Autonomy



To effectively examine ocean processes we must often sample over the duration of long (weeks to months) oscillation patterns. Such sampling requires persistent autonomous underwater vehicles, that have a similarly long deployment duration. Actively actuated (propeller-driven) underwater vehicles have proven effective in multiple sampling scenarios, however they have limited deployment endurance. The emergence of less actuated vehicles, i.e., underwater gliders, has enabled greater energy savings and thus increased endurance. Due to reduced actuation, these vehicles are more susceptible to external forces, e.g., ocean currents, causing them to have poor navigational and localization accuracy underwater. This is exacerbated in coastal regions, where current velocities are the same order of magnitude as the vehicle velocity.

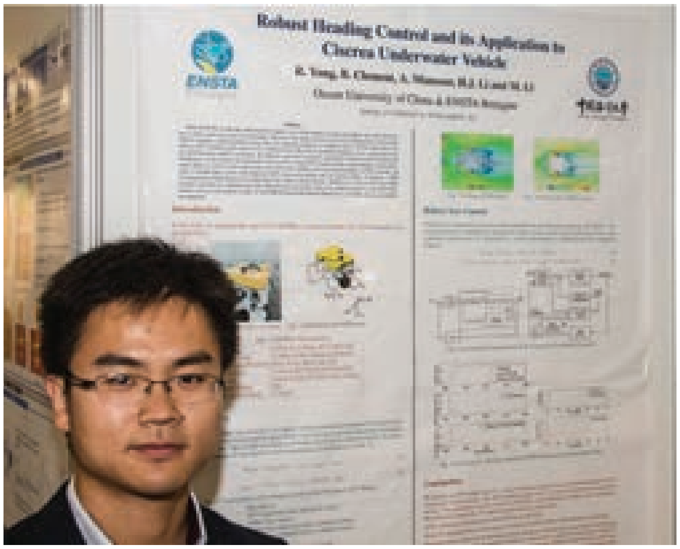
In this paper, we examine a method of reducing navigation and localization error, not only for navigation, but more so for more accurately reconstructing the path that the glider traversed to contextualize the gathered data, with respect to the science question at hand. We present a set of algorithms for offline processing that accurately localizes the traversed path of an underwater glider over long-term, ocean deployments. The proposed method utilizes terrain-based navigation with only depth, altimeter and compass data compared to local bathymetry maps to provide accurate reconstructions of traversed paths in the ocean.

Lingji Xu, Northwestern Polytechnical University
Robust Sparse Underwater Acoustic Channel Estimation Method Via Projected L1-L2 Optimization



By exploiting the intrinsic sparse structure of the underwater acoustic channel, we adopt l_1–l_2 optimization criterion, which incorporates least squares with the penalized l_1 minimization to reduce noise effects while inducing channel sparsity. However, the estimate of channel parameters might not be in the feasible region. Therefore, we then define convex sets and utilize convex projection as a supplement to l_1–l_2 optimization method to further improve the estimation accuracy. In addition, we elaborate matrix multiplications of the l_1–l_2 solution into vector computation efficiently implemented by FFT. Simulation results show that the proposed method outperforms some conventional channel estimation techniques in low SNR scenarios, and it can resolve multipath effectively even when SNR equals –5 dB.

Rui Yang, ENSTA Bretagne & Ocean University of China
Robust Heading Control and its Application to Ciscrea Underwater Vehicle

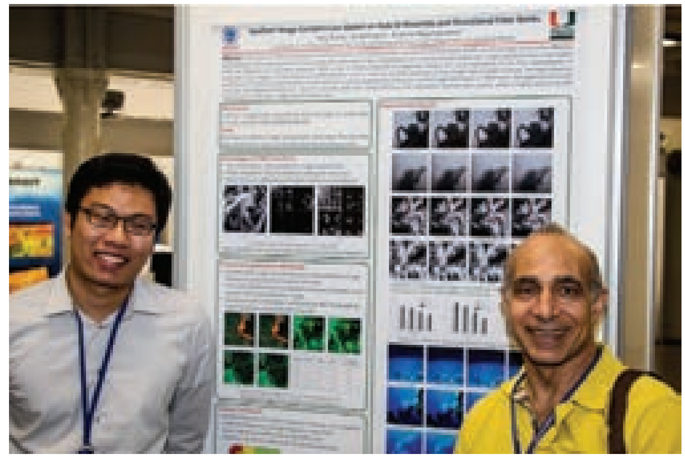


Deep inside the ocean, the earth magnetic signal is one of the merely existing information that tells the heading of robots with very good cost efficiency. Therefore, this paper focuses on the AUV (Autonomous Underwater Vehicle) heading control problem using only one magnetic compass as feedback sensor. In this application, we address AUV modeling and control issues simultaneously. Because of quadratic damping factor, underwater vehicle hydrodynamic model is nonlinear. In addition, unmodeled dynamics, parameter variations and environmental disturbances create significant uncertainties between the nominal AUV model and the reality. Finally, sensor noise, signal delay as well as unmeasured states also affect the stability and control performance of AUV motions. In order to handle these issues with improved AUV observation quality and navigation ability, we propose a CFD (Computational Fluid

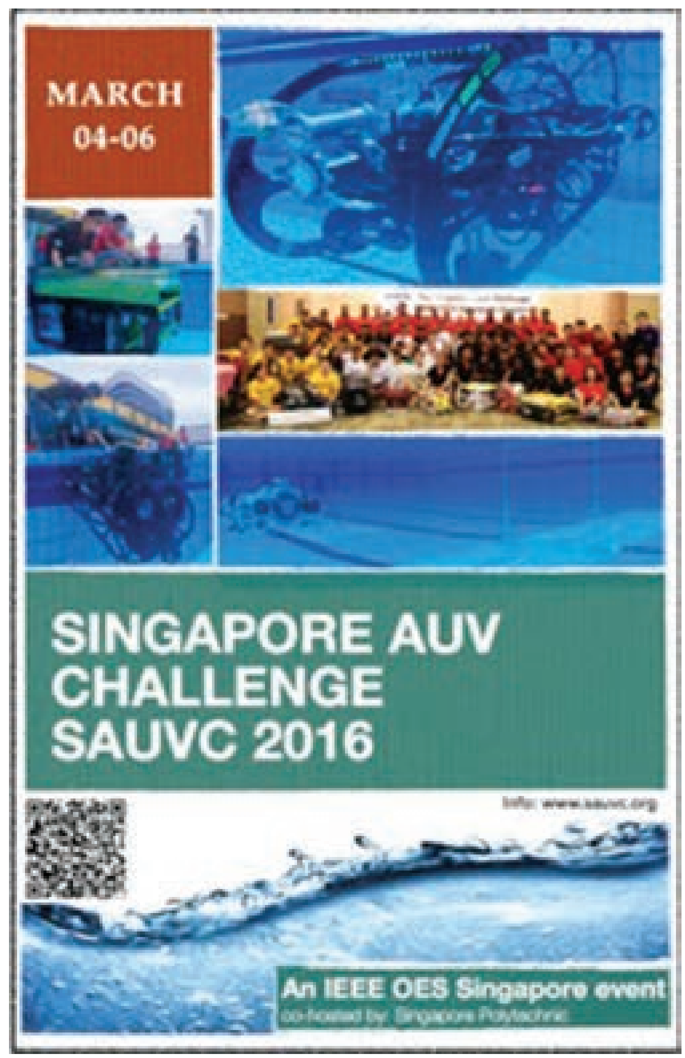
Dynamics) model based H1 robust control scheme. Without loss of generality, the robust heading controller was implemented and validated in the sea on low-mass and complex-shaped Ciscrea AUV. Simulation and sea experimental results of both PID (Proportional Integral Derivative) and robust heading controller are analysed.

Yang Zhang, Ocean University of China
Seafloor Image Compression Based on Hybrid Wavelets and Directional Filter Banks

We present an efficient compression method based on the hybrid wavelets and directional filter banks (HWD), to achieve high compression efficiency while keeping visually pleasing reconstruction quality for underwater images. According to the characteristics of underwater images and the human vision system (HVS), an improved just noticeable distortion (JND) model is initially employed to adaptively remove the visual redundancy of underwater images in the HWD domain. The low-frequency coefficients are then quantized in the fixed length and encoded losslessly. The high-frequency coefficients



are quantized by variable precision and fixed length method, and are coded by the difference reduction algorithm based on HWD trees. The experimental results show that the proposed compression algorithm provides both high coding efficiency and satisfactory reconstruction quality, which is highly desired for the transmission of underwater images at very low-bit rates.



Swath bathymetric data fusion
Application to autonomous underwater vehicles

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***Abstract*—The autonomous underwater vehicle (AUV) DAURADE platform can acquire bathymetry with two acoustic sensors: a multibeam echo sounder (MBES) and an interferometric sidescan sonar (ISSS). The two sensors (MBES and ISSS) are synchronized and they can simultaneously operate and acquire the bathymetry with different resolutions, geometries and error models. This complementarily allows us to improve the accuracy and the coverage of the collected bathymetric data by fusing both of them. We applied the fusion process on actual data from the two bathymetric sensors of DAURADE (Reson 7125 MBES and Klein 5000 Interferometric); the obtained results are presented and discussed.**

I. INTRODUCTION

A major issue for the international hydrographic community is how to build an accurate digital terrain model (DTM) knowing the irreducible uncertainties in modern surveys. In fact, DTM estimation requires a huge amount of soundings which are usually noisy. Various automatic data-cleaning systems and DTM production package have been recently developed using the Combined Uncertainty and Bathymetry Estimation (CUBE) [1] or the Cleaning through Hierarchic Adaptive and Robust Modeling (CHARM) [2]. The latter two algorithms are implemented in order to process full coverage multibeam data in which every sounding should include an estimation of its uncertainty (CUBE case). This requirement is achievable using the quality factor in [3]. However CUBE and CHARM algorithms can not integrate heterogeneous and qualitative data as it can be done by an expert. When many bathymetric data with different spatial resolutions, coverage and uncertainties are available for the same area, a question arises out of this problem: can this redundancy and complementarities be used to generate more accurate DTM? In the last decade, autonomous underwater vehicles (AUV), equipped with a wide variety of acoustic sensors or sonar systems, have been deployed to collect bathymetric data. In shallow water and for full coverage area survey, the two most used systems are the multibeam echo sounder (MBES) and the interferometric sidescan sonar (ISSS). The MBES is considered as the reference system for an accurate hydrographic survey. Unfortunately MBES on AUV navigating close to the seafloor suffers from its limited angular coverage. With such limitation, a full coverage is time consuming and not compatible with the battery autonomy. Therefore ISSS can advantageously be used in this case. An ISSS has a swath width over 10-times the altitude of the sonar and produce high resolution bathymetry across track. The latter propriety helps significantly reducing the time of the survey for a full coverage. On the other hand, such system suffers from many drawbacks: The geometry of ISSS transducers does not allow gathering data in nadir area, it has a limited bathymetric accuracy about 2-3% of water depth, and it is penalized by the baseline decorrelation and the shifting footprint effect. In spite of these significant disadvantages, recent developments in system electronics and processing algorithms have improved ISSS performance. In many AUV survey missions (such as detecting and mapping submerged wrecks, rocks and obstructions), the fuse of bathymetry derived from MBES and ISSS can improve the productivity.

This paper is organized as follows: Section II describes the fusion model of bathymetric data, AUV DAURADE and the two swath bathymetric sonars are presented in section III, and section VI discusses the results.

II. BATHYMETRIC DATA FUSION PROCEDURE

In radar community, the most used fusion algorithm to combine DTMs (SAR interferometry, LIDAR, *etc.*) is a weighted average of inputs in each grid cell. As the weight factors are not usually available, data accuracies are estimated from DTM (roughness, slope, etc...). To be robust against blunders, other methods are used by representing local patches as a sparse combination of basis patches [4]. These algorithms can not integrate a prior knowledge about the precision and reliability of sensors which can vary with time and environment conditions. In order to overcome limitations of each DTM, an intelligent fusion which considers uncertainty and reliability of each sensor becomes necessary.

To deal with such kind of measurement, many theories have been proved suitable for modelling the uncertainty. It is worth mentionning that imprecise probability, possibility theory and theory of belief functions are widely used in the literature.

The theory of belief functions, also known as Dempster-Shafer Theory (DST), was developed by Shafer [5] and initiated by the work of Dempster on imprecise probabilities. Actually, it is one of popular approaches to handle uncertainty in literature for data fusion and it is often considered as a generalized model of the probability and possibility theory. The basic of this theory is omitted in this manuscript. Interested readers

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can find sufficient interpretations of evidence theory in the literature ([6], [7]).

A. Fusion model

In our application, inputs are the sounding z_i with a known position y_i and a standard deviation σ_i obtained from MBS and ISSS. We are aiming to improve the accuracy of z_i values by combining the outputs of the sonars. In [8], Petit-Renaud and Denoeux propose an evidential regression (EVREG) analysis of imprecise and uncertain data. In their model, evidential theory are extended to fuzzy sets where focal elements are fuzzy variables. The basic idea is to construct a fuzzy belief assignment (FBA) in two steps: discounting FBAs mi according to a measure of dissimilarity among input vectors, and the combination of a discounted FBAs [8]. The model in our case may be summarized as follows.
Given a set of n sounding values $(y_i, z_i, \sigma_i, p_i)$ a FBA m_i can be defined for each pair (y_i, m_i) as:

$$\begin{aligned} m_i(F_i) &= p_i \\ m_i(Z) &= 1 - p_i \end{aligned} \quad (1)$$

where F_i is a Gaussian fuzzy number with a mean z_i and a standard deviation σ_i and p_i stand for the reliability of the sonar. Each input element e_i ($I = \{e_i | e_i = (y_i, m_i), i = 1, 2, ..., n\}$) is a piece of evidence concerning the possible value of z_i in a given position y, which can be represented by a FBA $m_z[y, e_i]$ as a discounting of m_i:

$$m_z[y, e_i] = \begin{cases} m_i(A)\varphi(\|y - y_i\|) & \text{if } A \in F(m_i) \setminus \{Z\} \\ 1 - \varphi(\|y - y_i\|) & \text{if } A = Z \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

where $\varphi(.)$ is a decreasing function from $R^+ \to [0, 1]$ satisfying that $\varphi(0) \in]0, 1[$ and $\lim_{d \to +\infty} \varphi(d) = 0$. $\varphi(.)$ can be considered as a discounting function that measures the dissimilarity of the variable of interest z using a suitable metric $\|.\|$ between input vectors y and y_i. If y is close to y_i, $m_z[y, e_i]$ and m_i become very similar to each other and vice versa. When the metric $\|.\|$ is defined as the euclidian distance, an evident choice for $\varphi(.)$ becomes [8]:

$$\varphi(d) = \gamma \exp(-d^2) \quad (3)$$

where $\gamma \in]0, 1[$ (usually $\gamma \in]0.9, 1[$). The information provided by each element of the input set can be combined by the conjunctive rule of Dempster. In practice, the effect of inputs y_i far from the position of interest y can be neglected and we should consider only k nearest neighbors. The final FBA becomes:

$$m_z[y, I] = \cap_{i=1}^{k} m_z[y, e_i] \quad (4)$$

The presented EVREG model is applied for each sensor, and its outputs are combined using Dempsters rule to form a new FBA $m_i = m_i^{s_1} \oplus m_i^{s_2}$. The probabilistic density $BetP[y, I]$ (named pignistic probability function) associated to $m_z[y, I]$ has the following expression:

$$BetP[y, I](z) = \sum_{A \in F(m_z^*[y, I])} m_z^*[y, I](A) \frac{A(y)}{|A|} \quad (5)$$

where $m_z^*[y, I]$ is the normalized version of $m_z[y, I]$ and $|A|$ is the cardinality of A.
To predict the $\hat{z}$ value, we can use the center of gravity of A (z_A^*). Therefore, $\hat{z}$ can be expressed as:

$$\hat{z}(y) = \sum_{A \in F(m_z^*[y, I])} m_z^*[y, I] z_A^* \quad (6)$$

The uncertainty involved in the prediction of FBA can be calculated using the *measure of nonspecifity* generalized for belief functions [9] which is defined as:

$$N(m_z[y, I]) = \sum_{A \in F(m_z[y, I])} m_z[y, I](A) \log_2 |A| \quad (7)$$

The *measure of nonspecifity* represents our inability to distinguish true from false possible alternatives.

B. Measurement of sounding uncertainty

Recently, a new quality factor was proposed by Lurton *et al.* in [3] and [10] to measure the bathymetric uncertainty of each sounding directly on the received sonar signal. This factor represents the ratio between the estimated sounding and its standard deviation obtained from signal characteristics. In case of MBES, the quality factor depends on the detection algorithm applied to the complex signal. When the amplitude signal is processed using a centre of gravity approach, the uncertainty is measured as in [10]:

$$q_A = \frac{\sqrt{12}}{B\sqrt{\frac{4}{\pi} - 1}} \frac{t_D}{\sqrt{N} T_{eff}} \quad (8)$$

where t_D is the estimated detection instant, N is the number of independent time samples, B is a factor depending on the envelope shape and T_{eff} is twice the second order moment of the envelope.
For zero-phase difference instant estimation, the uncertainty is defined by [10] as:

$$q_\phi = \frac{\alpha t_D}{\delta\Delta\phi} \frac{1}{\sqrt{\frac{(t_D - \bar{t})^2}{\sum_{i=1}^{N} (t_i - \bar{t})^2} + \frac{1}{\frac{N}{N_p}}}} \quad (9)$$

Where α is the phase ramp slope, $\delta\Delta\phi$ is the phase standard deviation and Np is the number of samples in transmitted signal.
$\delta\Delta\phi$ can be computed from the variations of the actual phase values around the ideal fitted curve.

In the case of ISSS processing, phase difference fluctuations cause uncertainty in sounding detection as [3]:

$$q_{F\phi} = \frac{1}{\tan\theta\sqrt{(\frac{\lambda}{2\pi\cos\gamma}\delta\Delta\phi)^2 + (\frac{cT\cos^2\theta}{2H\sqrt{12}\sin\theta})^2}} \quad (10)$$

where a is the interferometer baseline, λ stands for the wavelength, γ is the angle of arrival referenced to baseline axis, the arrival angle is θ, T is the signal duration and H represents the depth. The phase-difference standard deviation $\delta\Delta\phi$ can be estimated in similar way to zero-phase difference instant processing over a time interval around the detection instant.
These quality factors were tested on simulated and actual data and they provide a promising perspective.

III. DATA AND SONAR DESCRIPTION

A. AUV Daurade

The Daurade vehicle was built by ECA Company for the benefit of the French hydrographic and oceanographic service (SHOM) and the Atlantic undersea studies group (GESMA). It is a multi-purpose experimental AUV for Rapid Environment Assessment (REA), which is a military concept to acquire and transmit rapidly environment data on a poorly known area. The vehicle is 5m length and has 10 hours autonomy at 4 knots. It contains a PHINS Inertial Navigation System, GPS receiver and Doppler Velocity Log which improves navigation accuracy and extends full autonomous operation. Daurade also comes with a navigation post-processing system (DELPH INS), which can be applied to increase the navigational integrity and to maximize the position accuracy using GPS surface fix.

B. Swath bathymetric sonars

The DAURADE carries a multibeam echosounder and an interferometric synthetic aperture sonar both mapping sensors. The multibeam echosounder is a SeaBat 7125-AUV characterized by: 512 beams of width $0.5° \times 1°$; a total aperture of $128°$; a frequency of transducer 400 kHz; equidistant beams; 300 m max range; depth resolution 5 mm. The interferometric sidescan sonar is a Klein series 5500, a frequency of transducer 455 kHz, baseline spacing 6.5 wavelengths, 75m-150m range.

C. Data processing methods

The study area is located near the west coast of France, in the harbor of Brest. The water depth of the area ranges from 19 to 34 meters. The seabed presents a slope in the south to north direction. Two survey lines spacing of 115m were used. This provided a light degree of overlapped data for the interferometric sonar and no overlapping for MBS soundings. The AUV depth was maintained to 7m during the survey which is not appropriate for our study to show the disadvantage of the MBS when operating in shallow water. The area covered by the two ISSS lines is about 260 by 135 meters.

For the survey the klein 5500 was run on a range scale of 75m per channel (the other range scales are very noisy). Bathymetric data is measured using the so-called Vernier Method which consists of estimating a unique receiving angle by combining pairs of stave measurements ([11], [12]). The standard deviation of each sounding is estimated according to (10). The final soundings were de-spiked for gross outliers and down sampled to one sounding each 20 cm across track distance to reduce the huge amount of data (2276 per channel per ping). Bathymetric soundings from MBS are calculated from the raw formed beam data using a center of gravity approach for the amplitude data and a zero-phase difference instant estimation for the phase difference data. The standard deviation of each sounding is estimated according to (8) and (9). Sounding with better quality factor was maintained for each ping.

The sound speed profile was not available so data wasn't corrected for the water column refraction which affected the horizontal and vertical positions of soundings for both systems, specially the ISSS with more grazing angles. For purpose of MBS-ISSS bathymetry fusion, we gridded the area covered by ISSS. Gridding was carried out to a 0.2 meter pixel resolution. Following gridding, 5 nearest neighbors soundings from each sonar were employed to estimate the fused sounding. Reliability pi is set to 1, so only sounding uncertainty is used in fusion process.

IV. EXPERIMENTAL RESULTS

Fig.1 and Fig.2 present the bathymetric data which should be fused. A blind zone can be observed on the nadir of the ISSS bathymetry and the noisy outer beams. MBS bathymetry has a gap in southern line due a malfunction of the sonar when recording raw formed beam data. Notice that bathymetric data aren't smoothed to not bias the estimated standard deviation.
Fig.3 presents outcomes of our algorithm i.e the obtained bathymetry. Some parts of the image are noisy because of the residual outliers of ISSS data, uncorrected bathymetry with water column celerity profile and the AUV drift which is not perfectly corrected by DELPH INS software.

to have an idea about the quality of the fused bathymetry, Fig.4 and Fig.5 show respectively the measure of nonspecificity and the first to the ninth deciles of the pignistic probability interval. As expected, the area covered by the MBS data was more precise than the other. This is clearly identifiable on a cross profile (south to north) of a single grid line of the measure of the nonspecificity (Fig.6) which expresses the uncertainty of the fused bathymetry.
Fig.7 presents the estimated depth along a cross profile and the 0.1 and 0.9 quantiles of the pignistic probability, as a confident interval. In Fig.6, we can notice that the presence of MBS data makes the confident interval very narrow. We can notice also, the *bow tie* effect of the end of across swath due to the noisy outer beams of the interferometric sidescan sonar.

As with all interferometric systems, when the slopes on the seabed reach certain stage, the phase calculation begins to fail. This is the case of ISSS data on Fig.5 for the northern line, where the confident interval is wider than the other line without slope.

V. CONCLUSION

In this manuscript, bathymetric data fusion using belief function has been described. This approach allows us to

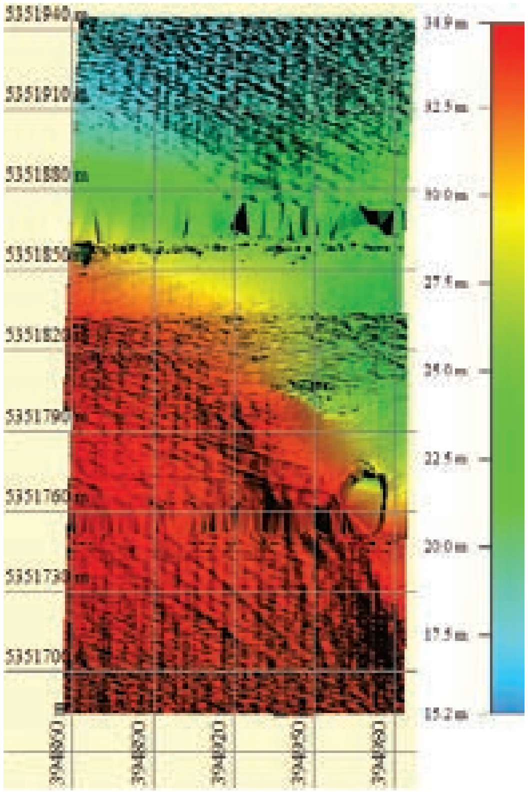

Fig. 1. Gridded Klein 5500 bathymetry on two parallel lines.

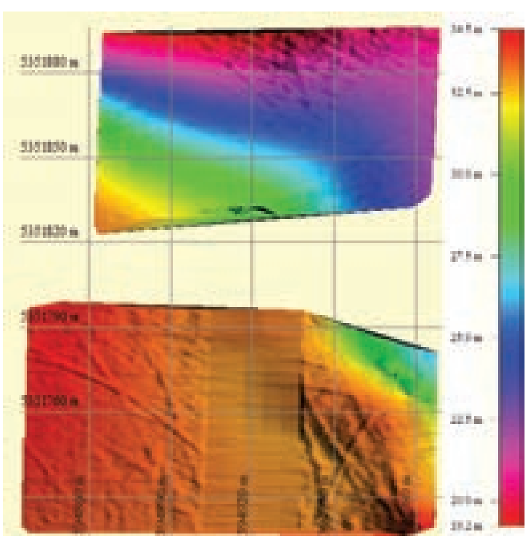

Fig. 2. Gridded Reson 7125 bathymetry on two parallel lines.

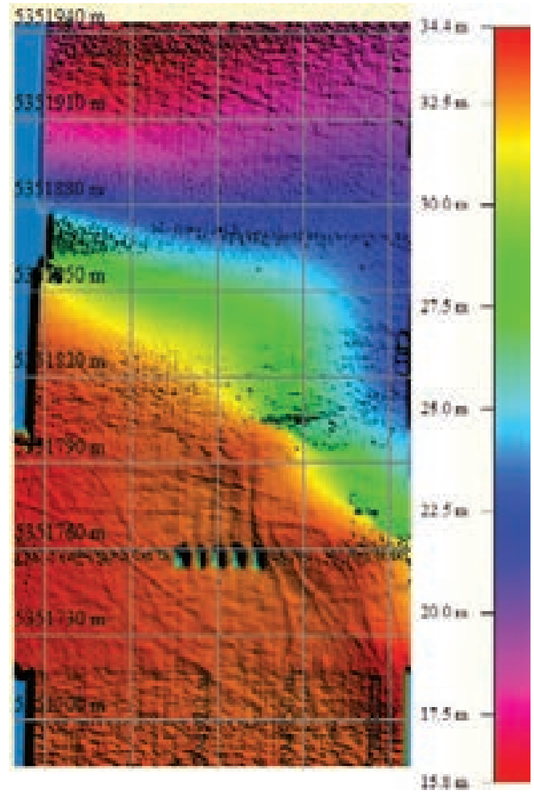

Fig. 3. Gridded bathymetry after fusion.

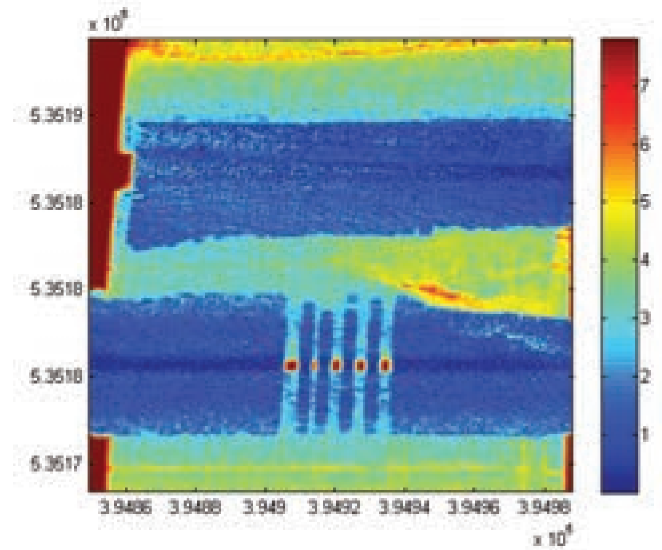

Fig. 4. The measurement of nonspecificity of fused bathymetry.

integrate the precision and the reliability of source data. The targeted estimator of the bathymetry error associated with every sounding involved in the fusion process should gives an objective quality of the fused bathymetry.

In spite of the difficult steady area and the use of data not corrected with water column celerity profile, the fusion method allows us to obtain a bathymetric data with quality factors very useful for Rapid Environment Assessment(REA). The fusion process depends on AUV navigation (horizontal position) and all common sounding corrections. Our future work consists in applying the fusion process to a corrected bathymetric data on a flat seabed and to define an optimum adaptive survey using the fused bathymetric quality.

Acknowledgment

The authors would like to express their gratitude to A. Bertholom (Atlantic undersea studies group) for providing the DAURADE data presented in this work.

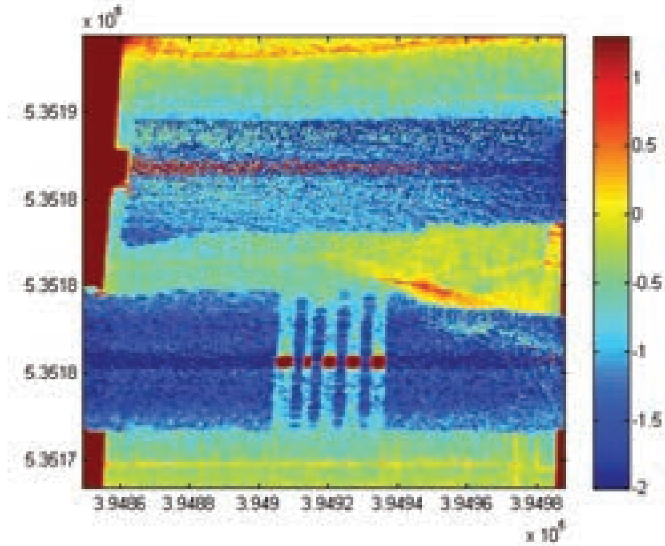

Fig. 5. The difference between 0.9 and 0.1 quantiles of pignistic probability on log scale.

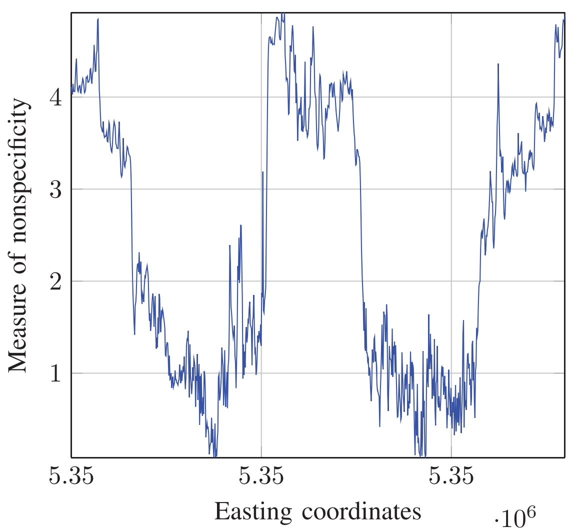

Fig. 6. A cross profile of a single grid line

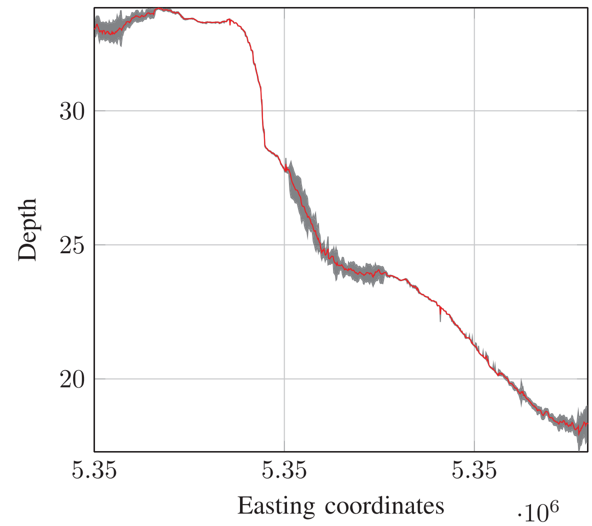

Fig. 7. A cross profile of a single grid line. First and ninth deciles of the pignistic probability (grey area). Estimated depth(red line)

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The Sea and OCEANS'15 Genova

Kevin Hardy, Associate Editor-in-Chief

The yearly transit of the OCEANS Conference from port-to-port gives attendees the chance to visit places they may have only heard of in their schooling or reading. This year the conference landed in Genoa, Italy, a treasure ship of maritime history, wonderful people and extraordinary cuisine in a rugged, canyon-strewn village by the sea.

The history of Genoa goes back to at least the 6th century BC, with solid evidence of a Greek colony inhabiting the site. There is suggestion the ancient Etruscans from northern Italy may have been the first settlers in the 7th century BC. Genoa's natural harbor was loved as a shelter by the seafarers of the ancient world as much as today.

Hannibal and his Carthaginian army sacked Genoa during the Second Punic War in 209 BC because it was an ally of Rome. Maybe that's why they made the streets so narrow, in case the elephants came back.

Christopher Columbus was born here in 1451 during the Renaissance. When he was just 41, he led three ships west from Spain on an educated guess and changed the course of history. You can visit Genoa's GALATA, Museo del Mare, and see, and be, centimeters away from carefully preserved original documents written and signed by Columbus. In his formal signature, more complex than his everyday one, he honored the three monotheistic religions of his time with an X M Y: Christianity, Muslim, and Jewish, the "Y" for Yahweh. Columbus made room for diversity in his thinking.

An earlier, unwilling resident of Genoa is known to have been an inspiration to Columbus. The Venetian, Marco Polo, was taken prisoner by the Genoese in the naval battle of Korcula between the Venetian and Genovese Republics, in 1298. Held in a Genoese prison for 11 months, Marco's cellmate, Rusticello from Pisa, would later publish a book 'The Travels of Marco Polo', written as the stories were told him. The first copies appeared in 1307.

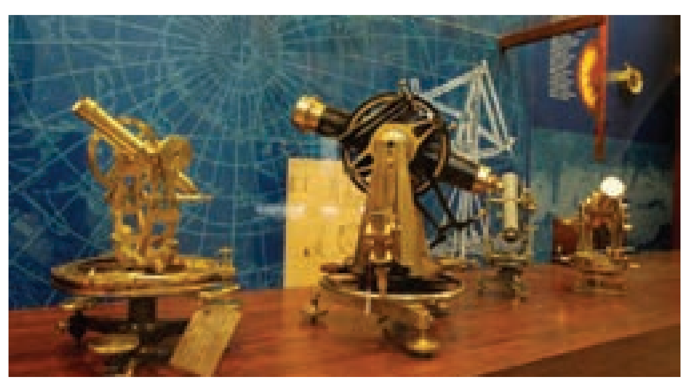
The incredible and vast maritime history of Genoa is captured in the GALATA, Museum of the Sea, <http://www.galatamuseodelmare.it/jsp/index.jsp>, a four-story stone building originally constructed in 1590, now encased in a glass outer structure, giving it a fifth open-air floor. It is the largest maritime museum in the Mediterranean. They go over-the-top with every exhibit. That must have been their directive. Most impressive for me was the *Storms & Shipwrecks* exhibit on the second floor. Been there, done that, and this exhibit gave the uneasy sense of an angry sea that didn't want me around. The GALATA provides an epic journey through time on every floor: a 17th century Genoese galley, a 19th century brigantine schooner, a believable steamer that brought immigrants to Argentina, Brazil, and America by the millions.

Ancient maps and leather parchment globes held the great secrets of empire (from the collections of GALATA).

Maritime museums and other local points of interest are some of the deeper and broader benefits of taking the OCEANS conference around the world. OCEANS travels next to Washington, DC (18–22 Oct 2015), then Shanghai, China (10–13 April 2016). There is more rich maritime history to discover at both. Standing on the shoulders of giants, we should remember who they are, and what they did. It's how we got here.

(Thanks to GALATA's Anna Dentori, Patricia Oblitas, and Eleonora Errico for their very warm hospitality and wonderful help in writing this story. Grazie.)

Models of Columbus' Nina, Pinta, and Santa Maria, appear like spaceships of an earlier time (from the collections of GALATA).



Commerce required the ability to return to a new place. That took knowledge of mathematics and the tools of navigation (from the collections of GALATA).

Member Highlights

Contact the editors if you have items of interest for the society

Toshihiro Maki – Hello from Woods Hole Oceanographic

I have been staying at the Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA, USA since last March. I would like to tell you some of the things around me.

Do you know another aspect of Dr. Marinna Martini, our new OES secretary? She is an accomplished curling player. She plays at the Cape Cod Curling Club, and has for a long time. She organized 2015 Scrod Bonspiel, the club's annual tournament for beginners. Prof. Diane DiMassa, Massachusetts Maritime Academy and OES VP for Conference Operations, is also a skilled curler. She attended the bonspiel as a player.

Sandy, or Dr. Albert Williams, has an office in Bigelow Hall, one of the most historic buildings at WHOI. He kindly told me about the history of the institution in the lounge, which was once the WHOI director's office.

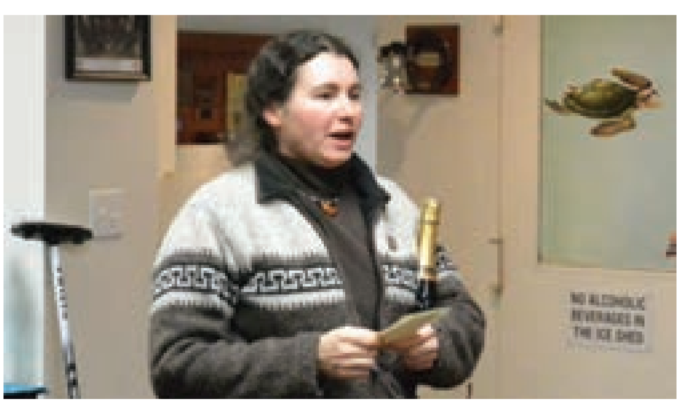
Finally, I would like to talk about myself. I fortunately received funding from the University of Tokyo to visit WHOI for one year. I work with Hanu, or Dr. Hanumant Singh at the Applied Ocean Physics and Engineering department (AOPE), mainly on the new AUV project for arctic surveys. It is amazing that autonomous platforms such as AUVs, ASVs, and UAVs are widely accepted in the U.S. as tools for science. I strongly think that we have to work hard to improve the situation in Japan, where they are not so common.

However, I declare Japan the winner when it comes to dining. The embarrassing thing is that I had cooked almost nothing (except cup ramen) before I came here. Being apart from my family and beef-bowl shops (and also ramen shops!), I have no other choice but to cook for myself. Now, I can cook some of my favorites: tuna pasta, ginger-fried pork, and, of course, curry and rice. Cooking seems to be my fastest growing skill since I arrived here.

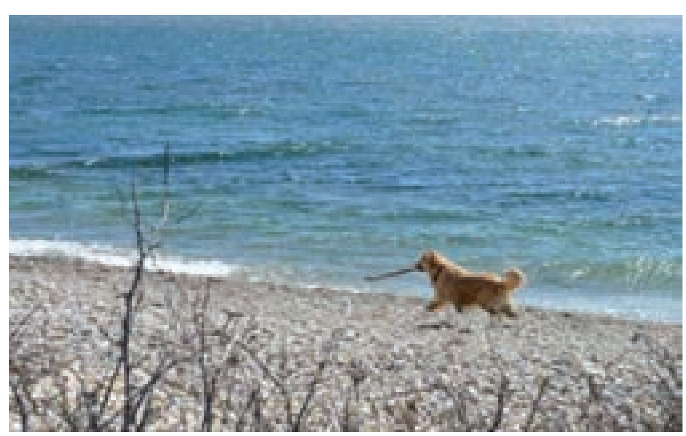
Summer is quickly approaching Cape Cod. Trees are covered with new green. Sea breezes bring comfort (and many tourists). Please contact me if you have a chance to come to Woods Hole. I will make you a dish with a somewhat Japanese-taste!

With Dr. Diane DiMassa, MMA, at the Cape Cod Curling Club.

Sandy Williams in the lounge of Bigelow Hall.



Dr. Marinna Martini, WHOI, awards champagne to the winner of the 2015 Scrod Bonspiel.



Vineyard Sound from the Shining Sea bike path.

Sandy Williams (OES VPCD) – Ocean, Wind, Waves

In 2004 my wife, Izzie, and I toured in Japan, our first experience in that country. It was just before OCEANS'04 Kobe. In Kyoto we took a calligraphy lesson with others with whom we were touring and after an hour of practice we were given good paper and instructed to copy three characters. I chose Ocean, Wind, and Waves because I had been measuring them with my current meter and it was appropriate. When the three characters were done the instructor affixed a seal in red on each and mounted them. We carefully packed them and when home again, I mounted them above my desk in my office at Woods Hole Oceanographic Institution. Each time a Japanese or Chinese student first saw them I asked him or her if she could translate the three characters. Without hesitation each said the first was Sea. The second took a little longer but was correctly identified as Wind. The third took longer yet but was always identified as Waves. I am very proud of my achievement because my own handwriting is terrible and I always print so I can at least read it. But these characters are readable to my students.

Ocean, Wind and Waves

Welcome New and Reinstated Members

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Lashika Janith Medagoda
Christopher Philip Rawlins
Amir Mehdi Yazdani

Brazil
Juan J Langhi
Rafael Alberto Valpacos De Lemos Leal

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