OES BEACON

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IEEE OCEANIC ENGINEERING SOCIETY EXECUTIVE COMMITTEE

EX-OFFICIO ADMINISTRATIVE COMMITTEE

ELECTED ADMINISTRATIVE COMMITTEE

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From the President

Welcome to the New Year—2012. We have many activities planned for the year starting with our Offshore Technology Conference OTC 2012 April 30–3 May in Houston, Texas. Last year's Conference was the largest in recent years and we expect another good turnout.

The IEEE/OES 2012 Baltic International Symposium will be the following week May 8–10 in Klaipeda, Lithuania. This will be our 5th Baltic Symposium and we are looking forward to getting together with all our friends in the Baltic area. Our good friend and mentor, Joseph Vadus, will be the co-chair for the Conference and it will be a pleasure to have him at the Symposium.

OCEANS 2012 MTS/IEEE Yeosu will be May 21–24 at the Ocean Resort in Yeosu, Republic of Korea, and will feature the Living Ocean and Coast with Expo 12. This will be a great opportunity for the attendees to participate in the OCEANS Conference and to attend activities at Expo 12 and see some of the most pristine wetlands in the world. This should be a very unique and exciting Conference.

In September we will have our 2012 IEEE/OES Autonomous Underwater Vehicles conference September 23–25 in Southampton UK.

OCEANS 12 MTS/IEE Hampton Roads, Virginia, will be at the Virginia Beach Convention Center October 14–19. We have a very excellent Organizing Committee for the Conference and will have an outstanding technical program. We look forward to our visit to the Hampton Roads, Virginia Beach, Norfolk area.

We will conclude the year with the second Arctic Offshore Technology Conference December 3–5 at the George R. Brown Convention Center in Houston, Texas. The first Arctic OTC was very successful and well attended.

The November IEEE Spectrum Magazine had many interesting articles on OCEAN related subjects and continues to be an excellent publication. I highly recommend you read Spectrum each month. The October issue of our OES Journal was also excellent and thanks to our Chief Editor Bill Carey for all his hard work, to the authors and to the reviewers. Quality and peer review are the cornerstone of the Journal.

Congratulations to our two OES Members who are members of the IEEE FELLOWS class of 2012—Malcolm Heron and Shahriar Negahdaripour—for this recognition and your contributions to the Oceanic Engineering Society.

We are very pleased with the support our members provide to IEEE as volunteers. Our Junior Past President James Barbera is a member of the TAB Ethics and Conflict Resolutions Committee and Chair IEEE-USA R&D Policy Committee.

(continued on page 6)

Welcome New Members

Angela Maria Rodriguez Alonso	Colombia	Benjamin Halfpenny	United Arab Emirates
Davide Anguita	Italy	Matthew T.J. Hall	Canada
Hitoshi Anzai	Japan	Philip Henry Hall	Australia
Joseph Everett Armstead	USA	Brahim Hamadicharef	Singapore
Dong R. Bang	USA	David Estaban Hozman	Colombia
Leonardo M. Barreira	Brazil	Holly Ibanez	USA
Sidney S. Batchelder	USA	Jonas Lars Jonsson	Sweden
Kim C. Benjamin	USA	Sean Patrick Jungbluth	USA
Lucas Braganga Bersan	Brazil	Jeffrey K. Kaszubinski	USA
Glen Bever	USA	ChadD. Kecy	USA
Ben Buholtz	USA	Brad Keogh	United Kingdom
Javier Busquets	USA	Ayoun Kim	USA
Shaonu Cai	China	Toshinori Kimura	Japan
Danilo Pereira Calderoni	Brazil	Wilhelm Blov Klinger	USA
Tarun Chandrayadula	USA	Nicholas David Kraus	USA
Yen-Chen Chen	Taiwan	Nathan N. Krohn	USA
Hajime Chiba	Japan	Richard Larivee	Canada
Fernanda Magalhaer Correia	Brazil	Stefan Leier	Germany
Juliana Kuhn Countinho	Brazil	Manny Leyden	USA
Nicholas J. Crowder	USA	Ashley Lloyd	USA
Chris Crowther	United Kingdom	Elizabeth Ann Magliula	USA
Catalin David	Germany	Jessica Makowski	USA
Vitri Fava Desousa	Brazil	Jason P. Mccullough	USA
Scott E. Demers	USA	Chuck Melchin	USA
Gabriel Scott Deruwe	USA	William J. Miller	USA
Fabio Cabral Pinha Domingues	Brazil	Zaki D. Mouztafa	USA
Glenn Donovan	USA	Edmund S. Neil	Australia
Vanderson M. Donublas	Brazil	Chi Due Ngo	USA
Jaqueline Cunha Dossantos	Brazil	Richard V Nkosu	USA
Richard J. Dowling	USA	Jerica Dawn Nolte	USA
Donald G. Dunn	USA	Scott Thomas O'connor	USA
Judith Rachel Farman	United Kingdom	Camille Pagniello	Canada
Valerie Ferdin	USA	Terri Paluszkiewicz	USA
Renata Romao De Oliveira Fernandes	Brazil	Michelle Jean Pare	USA
Hugo Pelle Ferreira	Brazil	Carlos E. Parente	Brazil
Charles D. Field	USA	Hisu Heidi Park	USA
Scott Fraser	USA	Serena Parton	USA
Dustin K. Gaessner	USA	Richard Peisch	USA
Amy R. Gao	USA	Nicos Pelavas	Canada
Diego Alejandro Castro Garcia	Colombia	Rodrigo Miranda Da Silva Pertora	Brazil
Carlos Manuel Garcia	USA	Eric C. Piper	USA
Peter Jungmin Gels	USA	Bradford D. Powers	USA
Amy M. Glover	USA	Margaret M. Ray	USA
Rachael E. Hager	USA	D H. Reekie	Canada

Serni Ribo	Spain	Akiteru Takamori	Japan
JohnL. Robinson	Australia	Teemu Ilmari Tares	Finland
Moninya Roughan	Australia	Glenn Tober	USA
Anant Semwal	India	George A. Valdes	USA
Julie L. Shebroe	USA	Ryan Anthony Vandermeulen	USA
Tassio Simioni	Brazil	Thomas Vergutz	Brazil
Christopher Joseph Simmins	United Kingdom	Shengwei Wang	China
John P. Smith	USA	Alexei Ivan Winter	United Kingdom
Thomas Allen Smith	USA	Brian Woodward	USA
Zhanjie Song	China	Huiping Xu	China
Michel N. Stamoulis	Brazil	Cody Youngbull	USA
Corey Arthur Stewart	USA	Ding Zhiping	China
Ismail Sultan	USA	Michele Zorzi	Italy
Navid Tahvildari	USA	Izabele Christine Neves Marques	Brazil

Clifford Carter Receives IEEE Jack S. Kilby Signal Processing Medal

Clifford Carter has been selected to receive the IEEE Jack S. Kilby Signal Processing Medal. The medal is being awarded "for contributions to the fundamentals of coherence and time-delay estimation and to underwater acoustics signal processing."

G. Clifford Carter contributed key advances in the signal processing field. His algorithms are widely in use today for detection, classification and localization of signals. His work in Coherence and Time Delay Estimation revolutionized the field and is cited in many fields, including medicine. The statistics of the coherence estimates are useful in establishing a constant false alarm rate (CFAR) receiver for detecting underwater acoustic signals from widely separated sensors. As a recognized expert, he has been an invited lecturer throughout the free world.

Following graduation from the Coast Guard Academy, he served as a communications and sonar training officer, where he learned challenges of real-world electronics. Upon honorable discharge from active duty, he went to work for the Navy and attended graduate school at the University of Connecticut, where he studied under Professor Charles H. Knapp, and earned an M.S. degree in 1972 and Ph.D. degree in 1976.

Dr. Carter's career began as a researcher and evolved to positions of increasing leadership responsibility, including assignments at the Office of Naval Research. By extending earlier work in digital signal processing and collaborating with others, he was able to help develop important methods successfully applied to underwater acoustic signals.

He is a prolific author, holds eleven patents, and has co-authored work in three engineering handbooks. He was editor of a benchmark Institute of Electrical and Electronics Engineers (IEEE) text. He taught graduate courses, served on Ph.D. advisory committees and as an evaluator for the Accreditation Board for Engineering and Technology (ABET).

As part of the science and technology community, he has eagerly shared his knowledge with future generations of engineers. Dr. Carter received the prestigious IEEE-USA Harry Diamond Award in 2006; thereafter, he was promoted to "ST", the government's highest career senior professional rank; he held this position until his retirement in 2009. He is a Life member of the Senior Executive Association and a Life Fellow of the IEEE.

The Jack S. Kilby Signal Processing Medal was established in 1995 in honor of Jack S. Kilby, whose innovation was a monumental precursor to the development of the signal processor and digital signal processing. The award may be presented for outstanding achievements in signal processing. The achievement may be theoretical, technological or commercial. Sponsored by Texas Instruments Inc., the award consists of a gold medal, a bronze replica, a certificate, and an honorarium.

William Carey

President's Corner *(continued from page 3)*

Senior Past President Thomas Wiener is Chair of the IEEE Committee on Earth Observations and VP for Technical Operations for the Sensors Council. Bob Bannon is our new representative to the Sensors Council and serves on the IEEE Fellows Committee. Marinna Martina is our representative on the IEEE Women in Engineering Committee. For 2012 I will be serving on the MGA Geographic Unit Operations Support Committee. I have appointed several of our EXCOM Members as corresponding members of TAB Committees to get them more involved with IEEE activities. I also intend to request one of our new ADCOM members for 2012 Ferial el-Hawary to help get our EXCOM/ADCOM members in more IEEE positions based on her extensive experience with the IEEE.

The IEEE Sections have many interesting activities and I recommend our members take advantage of these. I recently attended an evening meeting and dinner honoring past Presidents of the New Orleans Section. The Section has over 800 members and many events organized by their Society Chapters.

Finally thanks again to our EXCOM/ADCOM members for their service in 2011 and to our new class for 2012. We are very fortunate to have very dedicated and extremely competent volunteers.

Jerry Carroll,
OES President

SYMPOL 2011, Kochi, India

Dr. P. R. Saseendran Pillai

Introduction

The eleventh biennial Symposium on Ocean Electronics, 2011 (SYMPOL-2011), addressing the global oceans, systems and technologies, organized by the Department of Electronics of the Cochin University of Science and Technology, Kochi was held during 16–18 November 2011. SYMPOL is being organized as a biennial program and the first symposium of the series was held in the Cochin University of Science and Technology, during 18–20 December 1991 to highlight the formal opening of the Center for Ocean Electronics established in this Department as a joint venture of the University Grants Commission and Ministry of Human Resource Development, Government of India. This Symposium is intended to provide a forum for the researchers in the area of Ocean Electronics to interact with each other and present their innovative ideas and findings.

OES Support for SYMPOL

SYMPOL has received boundless support and cooperation from many enthusiastic groups of professionals as well as professional organizations across the globe. The enthusiasm, encouragement, cooperation and support extended by the IEEE-OES led to wide popularity for SYMPOL. SYMPOL 2009 and SYMPOL 2011 had bagged the technical co-sponsorship from IEEE-OES as well as from the Acoustical Society of America (ASA).

Venue

The venue of the International Symposium on Ocean Electronics (SYMPOL 2011) was the Convention Center of The Gokulam Park, which is one of the best known landmarks in the city and a lavish four star property in Kochi. The inaugural function, key note address, technical sessions and presentations were held in this Convention Center. With a location close to the prime business and shopping centers, the hotel is easily a favorite with the business and leisure travelers. The presence of good business amenities and conference facilities give an extra advantage to the corporate travelers to the place. Gokulam Park has taken care to ensure that the guests enjoy a good culinary experience too. Restaurants here served multi-cuisine dishes while there was a seafood special restaurant too.

Review Process

Starting from the inception of SYMPOL in 1991, the SYMPOL organizers used to insist for submission of full paper text rather than extended abstracts. The full papers received for consideration of presentation and publication in the Proceedings of SYMPOL used to be subjected to the following two levels of screening.

- A preliminary screening of the papers will be carried out by the Technical Program Committee
- Those papers that have been recommended by the Technical Program Committee of SYMPOL for consideration of presentation in the Symposium used to be reviewed by subject experts.

Towards maintaining the standard and quality of the papers presented and published in the Proceedings of SYMPOL2011 as well as hosted in the IEEE Xplore, from SYMPOL 2009 onwards the second level of screening of the papers were carried out by the reviewers/technical panel identified by the IEEE-OES and this review process was being coordinated by one of the Technical Program Co-chairs of SYMPOL, Dr. Albert J. Williams, Vice-President, Technical Activities, IEEE-OES. The technical panel consisted of Dr. Albert J. Williams III (Woods Hole Oceanographic Institution), Dr. James S. Collins (University of Victoria), Kenneth G. Foote (Woods Hole Oceanographic Institution), Timothy Duda (Woods Hole Oceanographic Institution), Jim Candy (University of California), Ananya Sen Gupta (Woods Hole Oceanographic Institution), Dr. Jean Pierre Hermand (Free University of Brussels (ULB)), Prof. Milica Stojanovic (Massachusetts Institute of Technology), Dr. Kenneth Sharp (NAVOCEANO), Dr. Ilya Udovdehenkov (Woods Hole Oceanographic Institution), Dr. Alain Maguer (NATO Undersea Research Center).

To further enhance the international visibility of SYMPOL, a Technical Program Committee with the representatives drawn from various premier universities, R&D laboratories and other institutions of international repute has been formed.

Inaugural Function

SYMPOL 2011 was inaugurated on 16th November 2011 by Professor M. Raveendran, Chairman of the Naval Research Board, New Delhi and former Director, National Institute of Ocean Technology, Chennai, in a function presided over by

Professor M. Raveendran, Chairman, Naval Research Board and Former Director NIOT, Chennai, inaugurating the 2011 International Symposium on Ocean Electronics (SYMPOL 2011) organized by the Department of Electronics, CUSAT during 16th–18th November 2011. Vice Chancellor, Dr. Ramachandran Thekedath, Chairman of SYMPOL Dr. P.R.S. Pillai, Dr. Supriya M.H. (Coordinator) and Dr. Albert J. Williams 3rd(IEEE-OES) are also seen.

Prof. Ramachandran Thekkedath, Vice-Chancellor, Cochin University of Science and Technology. While inaugurating the Symposium, Professor Raveendran opined that India has to develop several key cutting-edge technologies for surveying the country's existing potential Exclusive Economic Zones as well as to design the required Underwater Systems for harvesting the Oceanic Resources from various depths. He further elucidated that there exist tremendous technology gaps in the country in various spheres of Ocean Technology and emphasized the need for developing Multiple Technologies to tap our sea bed resources without ruining the oceanic environments. Presenting an estimate of food, gas hydrates, minerals and renewable as well as non-renewable energy resources available in the country's existing Exclusive Economic Zone, he stressed the need to device cheaper fish finding sonars for enhancing the catches and meeting the livelihood of the poor fishermen. With its extended Exclusive Economic Zone, the nation needs a huge multidisciplinary, scientific and technical manpower to tap the rich ocean resources. He further indicated that the government has to invest large quantum of funds for strengthening the Research and Development activities and the researchers should take the initiatives and come forward for developing the systems and technologies to make the harvesting of the ocean resources easier as well as for the generation of the technical knowhow in diverse areas of ocean technologies and systems.

Dr. Ramachandran Thekkedath, who presided over the inaugural function, also elucidated the importance of promoting research & development activities in the area of the ocean systems and technologies, as India has a very long coastal line and an extended Exclusive Economic Zone of two million square kilometers and is stacking the claim for an additional one million square kilometers of EEZ. Dr. A. Unnikrishnan, Associate Director, Naval Physical and Oceanographic Laboratory released the Proceedings of SYMPOL 2011. Dr. P. R. S. Pillai, Chairman, SYMPOL and IEEE-OES India Chapter welcomed the gathering. Dr. Albert J. Williams and Professor K. Vasudevan felicitated on the occasion of the inaugural function while Dr. Supriya M. H, Coordinator of SYMPOL 2011, proposed vote of thanks. The entire proceedings of the inaugural function had been live streamed to enable the OES communities and other interest groups across the globe to have a glimpse of the inaugural ceremony of SYMPOL 2011.

Technical Program

The technical program of SYMPOL 2011 commenced with a key-note address on Challenges in Ocean Technology by Professor M. Raveendran. While delivering the key-note address, he emphasized the fact that the oceans around the world have tremendous resources apart from the variety of sea food it offers. Oceans bring also hazards in the form of cyclones and tsunamis. In a country, with a very long coast line, the oceans could bring security threats to closer homes. On one side, oceans could provide valuable resources for the mankind, while on the other side, oceans bring calamities. The expertise in ocean electronics and underwater acoustics is an important need of the hour. Only a very few institutions in the country are involved in the capability development in the area of underwater electronic systems and more efforts need to be invested towards strengthening the R & D activities in this highly specialized area of technology. He also presented an overview of the state of the art technologies for ocean explorations as well as exploiting the ocean resources for the well being of the mankind.

The following state of the art invited talks on emerging topics in Ocean Electronics were delivered by eminent working engineers/scientists.

- Innovative Technology in Oceanography: Past, Present and Future by Dr. Albert J. Williams III, Woods Hole Oceanographic Institution, USA
- Fluid Structure Interaction: From the Beginnings till Now by Dr. D. D. Ebenizer, Naval Physical and Oceanographic Laboratory, Kochi, India
- Autonomous Sea Vehicles & Systems by Shri. Manu Korulla, Naval Science and Technological Laboratory, Visakhapatnam, India
- Manned Research Submersibles by Dr. G. A. Ramdass, National Institute of Ocean Technology, Chennai, India
- MEMS Sensors for Underwater Applications by Dr. V. Natarajan, Naval Physical and Oceanographic Laboratory, Kochi, India

Apart from these, original research papers in areas such as Signal Processing, Ocean Acoustics, Underwater Sensors & Applications, Acoustic Data Telemetry/Sensor Networks,

Prof. M. Raveendran delivering a keynote address on the "Challenges in Ocean Technology" on the occasion of SYMPOL 2011.

Dr. Albert J. Williams III delivering a plenary talk on Innovative Technology in Oceanography: Past, Present, and Future.

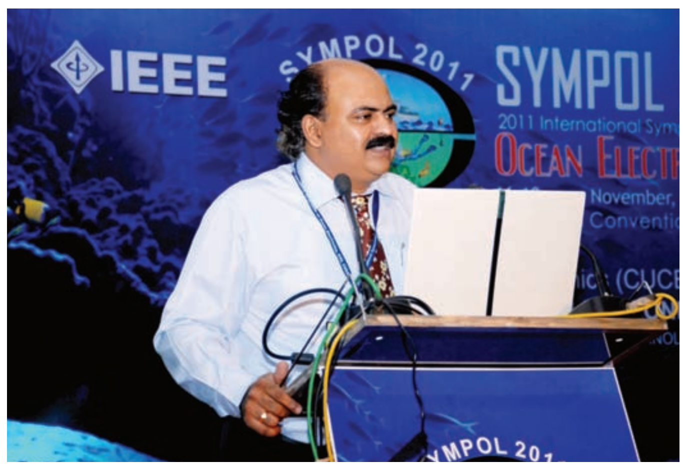
Classification & Pattern Recognition, etc. were also presented by working engineers/scientists from various Laboratories, Universities, Institutions, etc. from India and abroad.

Recommendations of the Technical Panel of SYMPOL2011

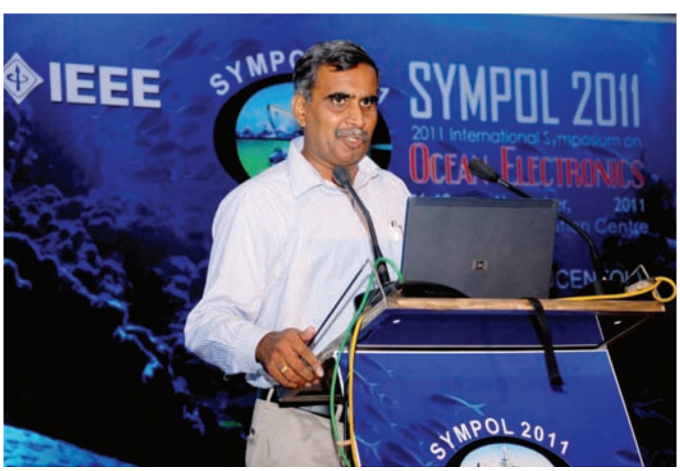
The organizers of SYMPOL 2011 have convened a meeting of the Technical Panel comprising of the chairpersons of various technical sessions, invited speakers, representatives from OES and Government Agencies/Departments. Dr. P. R. S. Pillai formally welcomed the panelists to the meeting. During the course of the Panel Discussions, Dr. P. R. S. Pillai reported that the IEEE-OES India Chapter is working with the OES, to bring one of the OCEANS to India in the near future. Accordingly, he had presented this long cherished desire of the OES community of India at the AdCom and RECON meetings held on the occasion of the OCEANS 2011, Santander, Spain during 6–9 June 2011. The RECON meeting suggested that either SYMPOL 2013 or UT 15 has to be organized, with the financial support of IEEE-OES, as a prelude to hosting the OCEANS 2018 in India, towards creating a good track record for India in successfully organizing a smaller IEEE Conference, before OCEANS 2018 is tried. This proposal of the RECON meeting was discussed in depth at the Executive Committee Meeting of the OES India Chapter held on 7th July 2011, and the Organizing Committee Meeting of SYMPOL 2011 held on 9th November 2011. Based on these discussions, the OES India Council and SYMPOL Organizing Committee resolved to organize SYMPOL 2013 at Cochin during 23–25 October 2013 with the financial support of IEEE-OES for creating an acceptable track record towards hosting the OCEANS – 2018, in India. The Technical Panel of SYMPOL 2011 made the following recommendations, based on the deliberations at the Panel Meeting.

- The quality and standard of the papers presented and published in the Proceedings of SYMPOL 2011 were better than those in the earlier SYMPOLs.
- The two-level review process for the research papers of SYMPOL is laudable.
- The technical panel of SYMPOL resolved to place on record its gratitude and acknowledgments to the IEEE-OES and the Acoustical Society of America for extending their support and co-operation by way of rendering Technical Co-sponsorship for SYMPOL 2011. The technical panel also resolved to place on record its appreciation to all the reviewers for rendering their intellectual services for making SYMPOL 2011 a grand success.

Dr. D. D. Ebenezer delivering an invited talk on Fluid Structure Interaction: From the Beginnings till Now.



Dr. G. A. Ramdass delivering an invited talk on Manned Research Submersibles.



Mr. Manu Korulla delivering an invited talk on Autonomous Sea Vehicles & Systems.

Dr. V. Natarajan delivering an invited talk on New Generation Acoustic Sensors.

Thiruvathirakali (also known as Kaikottikkali), a very popular dance form of Kerala, presented by women folk to attain everlasting marital bliss.

Kalarippayattu, a 3000 year old art form originated in ancient South India, and one of the oldest fighting systems in existence.

Kathakali, one of the oldest theater forms in the world and a highly stylized classical Indian dance-drama peculiar with the attractive make-up of characters, elaborate costumes, well defined body movements, etc.

Bharatanatyam, a classical dance form of South India, originated in Thanjavoor in the state of Tamil Nadu during 500 BC.

- The technical panel noted that CUSAT has decided to organize SYMPOL 2013 jointly with the OES India Chapter with the financial support of IEEE-OES during 23–25 October 2013 for creating an acceptable track record for the OES India Chapter prior to hosting the OCEANS 2018 in India.

Valedictory Function

A valedictory function was organized at 3.00 p.m. on 18th November 2011. Prior to commencement of the formal valedictory function, the delegates were given an opportunity to express their views/observations as regards to the organizational issues of SYMPOL 2011. All the delegates unanimously opined that they were all very much impressed by the way in which the local logistics arrangements and scheduling of the Technical Programs of SYMPOL 2011 were made. They further opined that they are eagerly and anxiously looking forward to participate in SYMPOL 2013.

During the formal valedictory function of SYMPOL 2011, the Technical Program Co-Chair, Dr. Albert J. Williams has announced the winner of the Best Paper presented and published

Apart from the Kerala fusion dance, the Bamboo Orchestra – a brief musical transcend, which epitomizes the composition of music with vivid instruments made of bamboo was also performed. A short bamboo concert held the audience spellbound during the cultural evening of SYMPOL 2011.

Mohiniyattam, a traditional South Indian dance from Kerala, which has elements from the two South Indian dance forms, viz., Bharatanatyam and Kathakali.

in the Proceedings of SYMPOL 2011, High Resolution Bearing Estimation in Partially Known Ocean using Short Sensor Arrays, co-authored by G. V Anand and P. V. Nagesha of the Indian Institute of Science, Bangalore. He also announced the Best Student Paper Mitigating Ambient Noise in Underwater Acoustic Receivers using Independent Component Analysis, by Suraj Kamal of Cochin University of Science and Technology.

Sponsorship

SYMPOL 2011 had the technical/financial co-sponsorship from the following Government Agencies/ Departments and Professional Bodies.

- IEEE Oceanic Engineering Society
- Acoustical Society of America
- Ministry of Earth Sciences, Government of India, New Delhi
- Department of Science & Technology, Government of India, New Delhi
- Naval Research Board, Defense Research & Development Organization, New Delhi
- Council of Scientific and Industrial Research, New Delhi
- University Grants Commission, New Delhi
- Kerala State Council for Science, Technology and Environment, Government of Kerala.
- Office of Naval Research Global (ONRG)

Cultural Evening

To provide a flavor of the social, cultural and traditional art forms of the state of Kerala, a Kerala Fusion Dance comprising of thiruvathirakali, kalaripayattu, kathakali, bharatanatyam, and mohiniyattam as well as Bamboo Orchestra were performed in the cultural evening of SYMPOL 2011 held at 5.30 p.m. on 16th November 2011.

Announcement of SYMPOL 2013

The twelfth biennial Symposium on Ocean Electronics (SYMPOL 2013) is scheduled to be held at Cochin during 23–25 October 2013 with the financial support of the IEEE-Oceanic Engineering Society (IEEE-OES), the proposal for which is being sent to the IEEE-OES.

Conclusions

An Activity Report on SYMPOL 2011, touching upon the background and rationale in organizing the Symposium on Ocean Electronics as a biennial event along with the salient highlights of the technical program has been presented here. The entire Ocean Engineering community in India is anxiously looking forward to participate in the twelfth biennial Symposium on Ocean Electronics (SYMPOL 2013) scheduled to be held during 23–25 October 2013 with the financial support of IEEE-OES.

Senior Members

The following members have been elevated to the grade of Senior Member.

Mandar Chitre
Guillermo Kalocai

Senior Member is the highest grade for which IEEE members can apply. To be eligible for application, candidates must:

- be engineers, scientists, educators, technical executives, or originators in IEEE-designated fields;
- have experience reflecting professional maturity;
- have been in professional practice for at least ten years;
- show significant performance over a period of at least five of their years in professional practice.

To learn more about the Senior Member program or start the application process, visit: http://www.ieee.org/ membershipservices/membership/senior/index.html

Personal Anecdotes from my Acquaintance with Albert Bradley

Albert (Sandy) J. Williams III

My colleague and friend Al Bradley has blazed a path of idiosyncratic genius through ocean engineering. As one of the very first to use a microprocessor in an autonomous underwater instrument, and then as one of the first to build a deep diving AUV that could hover and make precise maps of the bottom in hydrothermal vent country, Al deserves more exposure than he receives. His construction of nearly everything begins with first principles and he has no hesitation about starting. The joke goes that at the beginning of any new project, Al first goes to the beach to get sand so he can make the silicon semiconductors he will need. While this story is not true, Al prefers to use more elementary semiconductors over the more highly specialized ones since the elementary ones do not go out of production as fast as the specialized ones do. However, he built a lot of his early instruments on the RCA 1802 microprocessor and taught me to program in machine language using his own format to prevent blunders that less careful accounting for address space might expose one to. When cross assemblers for the 1802 became available, Al was careful to verify that they didn't pervert his code since they didn't assign absolute addresses until they were compiled. But assemblers made the code easier to read and eventually he accepted the convenience.

Al and his wife, Deborah, celebrated the anniversary of their first date every Halloween with a party at their house in North Falmouth. While it is now more than two decades since the last party, Al's costume and house decorations are legendary. He built a wizard costume with a hat that was electronically controlled from a keypad in the palm of his hand. Questions were answered by a display on a medallion around his neck while a bat came out of the hat and said "cuckoo". The improvements on the wizard's costume occupied evenings for Al for a month or more before each party. Among the final tours de force was light-writing of the answers to questions from his wand whisking through the air.

A fine mentor to students of all levels, Al passed development of the Fast Profiler to a MIT/WHOI Joint Program student, Josh Hoyt. This instrument was to have saved several hours per CTD station for deep profiles to the bottom by eliminating the need to pay out wire from a winch slowly enough to prevent the wire going slack, about 1 m/s in all but the lowest sea state. The Fast Profiler with its streamlined body and 50 lb descent weight could make a descent to 5000 m and ascend back to the surface in less than 45 minutes but then the issue was how to recover it back aboard without losing the time saved on the profile. For this, a radio controlled target was deployed from the ship while the Fast Profiler was making its profile. On the ascent, the Profiler acoustically homed on a beacon on this target and except when a direct hit compromised the target for the next deployment the Grabbit latched on to a line from the tail of the Fast Profiler and hauled it back aboard. Josh Hoyt had the educational experience of developing the first multiprocessor system that was employed at WHOI where each steering fin angle and the other functions were under control of their own microprocessor with a master controller communicating with them by Al's co-development of a communication system, SAIL. Sadly, the Fast Profiler window of opportunity closed with completion of the World Ocean Circulation Experiment, WOCE. Without the impetus of hundreds of deep CTDs of that program, the demand for the Fast Profiler disappeared. But the lessons taught by the Fast Profiler development enabled ABE, the Autonomous Benthic Explorer.

ABE was designed to occupy a hydrothermal vent region and remain parked for weeks or months at a time, making periodic surveys close to the bottom between research cruises to the site. Batteries were a major issue and the newly available lithium ion rechargeable batteries got Al's attention. Power management was an unexplored issue with batteries of large numbers of these cells and Al built battery structures that monitored every cell in the battery for voltage, temperature, and current; and controlled their discharge and charging. ABE was to navigate in an acoustic transponder net and return to a mooring where it could be recharged and go to sleep until its next programmed survey. In practice, it became the Alvin submersible's nighttime companion, making survey runs while the sub was being recharged. But the precision of its surveys and autonomy put it in great demand, so much so that it was taken out of retirement in 2010 and finally lost off Chile when it reoccupied a hydrothermal vent it had located on its previous mission too precisely and is thought to have imploded by exposing its glass buoyancy spheres to superheated hydrothermal vent fluid.

Sentry, the ABE successor, is now heavily booked but others are taking the brunt of its seagoing use. This permits Al to do some of the things that he loves most. There is the clock for his grandson's education that has two mechanical integrators in tandem such that a sine and cosine are generated and turn the hand on a clock. Accuracy is ensured by generating an error signal that adds or subtracts increments of voltage to the electric motor driving the mechanical mechanism. He remains available and helpful to those in need and endlessly regales us with tales of idiosyncratic solutions to problems we didn't know we had.

OCEANS '11 MTS/IEEE Kona Student Poster Program

Norman D. Miller, OES Student Activities Coordinator Photos by Anne Gant

The 29th Student Poster Program of the OCEANS Conferences was held at OCEANS'UMTS/IEEE Kona September 19–22, 2011 at the Convention Centre at the Hilton Waikoloa Village, Kona, Hawaii. Once again outstanding work was displayed on the posters. Their work was appreciated by all who attended the conference and the student participants appreciated the opportunity to display their research work. The program was organized by Dr. Reza Ghorbani, University of Hawaii Manoa. He was assisted at the conference by Dr. Christophe Sintes, Telecom-Bretagne, France who coordinated the poster judging team. The program was supported by funding from the Office of Naval Research which enabled the students to attend the conference. Eighty six poster abstracts were received and twenty four students were invited to attend. Twenty one students were able to attend and display their posters. The posters were displayed in the Grand Promenade of the Convention Center. The students were assembled on Monday afternoon and following introductions were given instructions on displaying and attending their posters. The student award winners were announced at the Gala Luau on Wednesday evening at Kamehameha Court. Dr. Sintes opened the awards ceremony and introduced Colonel Norman D. Miller who gave a history of the Student Poster Program and then present each student with a participation certificate. The award winners were then announced and each in turn received their award from Colonel Miller. The students were introduced as a group and received a round of applause from the conference attendees. The students were announced as members of the "OCEANS Student Poster Alumni Association".

The Students receiving awards were then announced and each came forward to receive their plaque and award. The winning students were:

First Place	Angelos Mallios – University of Girona
Second Place	Janice Duty – University of Maine
	Takumo Matsuda – University of Tokyo
Third Place	Brendan Cahill – University of Cork
	Amy Gao – MIT
	Mathew Hall – University of Victoria

Following the presentation of the Student Awards the Luau continued with a wonderful evening of Hawaiian music and dance on the stage. It was a fitting end for another very successful Student Poster Program!

The students, their schools, poster titles and abstracts are listed below. The full paper of the winning paper is reprinted following this article.

Brendan Cahill, Hydraulic & Maritime Research Centre, University College Cork (Ireland), *Wave Energy Resource Characterization and the Evaluation of Potential Wave Farm Sites*

Abstract—In theory, the energy that could be extracted from ocean waves is in excess of any current, or future, human requirements. Methods to evaluate and compare the wave energy resource at different locations are required in order to inform the developers of Wave Energy Converter (WEC) projects and allow them to select the most favorable sites for achieving optimal power capture and economic performance from their devices as the wave energy industry begins to approach the commercial deployment of Wave Farms, arrays of full-scale WECs.

In this paper alternative techniques for the characterization of wave energy resource are presented, with particular emphasis on the identification of the practicable power available for extraction and the comparison between different potential locations for Wave Farm developments. The effect of introducing a threshold, beyond which the theoretical wave power is no longer deemed exploitable and ignored for the purposes of resource evaluation, is highlighted in order to account for the reduced device output that can be expected in severe storm conditions. In addition, the relative performance that could be expected of typical WECs located at different sites is determined using the power matrices made publicly available by the a number of device developers.

These methods are applied to measured buoy data to allow for the comparison of the wave energy resource at the Atlantic Marine Energy Test Site, a grid connected location for the testing of full scale WECs being developed near Belmullet, County Mayo, by the Sustainable Energy Authority of Ireland (SEAI), with the incident wave conditions experienced at locations on the Pacific and Atlantic Coasts of the United States. Instances where sea states with the same summary statistics display radically different spectral shapes have been identified, consequently the level of variation in the dominant spectral shapes that can exist between two ocean sites is also investigated. The effect that this spectral variation can have on the characterization of the wave energy resource at different sites and on the performance of WECs is demonstrated and discussed. It is shown that the sea states which are responsible for the largest contributions of wave power, as opposed to the most commonly occurring conditions, which should be deemed most significant for the deployment and operation of WEC installations.

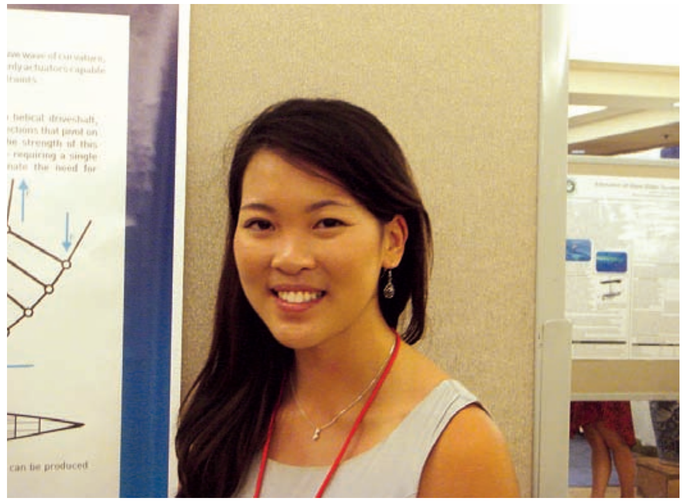
Janice Duy, University of Maine (USA), *Low-cost colorimeter development for the field-based detection of harmful algai blooms*

Abstract—The real-time detection of harmful algal bloom (HAB)-causing organisms is crucial to preventing human illness and death, animal mortalities, and significant economic losses for coastal and fishing communities. However, most identification schemes are time-consuming and costly, which limit their use for rapid risk assessment. To address this problem, a simple colorimetric test for the HAB-causing Alexandrium fundyense/tamarense/catanella dinoflagellate species complex is presented. This work integrates an indicator dye-based bioassay for detecting toxigenic Alexandrium RNA with a custom-built two-color detector. A peptide nucleic acid (PNA) probe is used to capture target RNA, and the formation of the PNA-RNA duplex is visible as a solution color change from blue to purple with the addition of the cyanine dye 3,3'-diethyldithiacarbocyanine iodide (DiSC2(5)). PNA-RNA hybridization and discrimination against mismatched sequences is achieved within minutes at 25°C.

Hybridization signals obtained from the colorimeter are comparable to those from a benchtop spectrophotometer. The advantages of this method represent a step towards fieldcompatible, easy-to-use and inexpensive detection schemes that require minimal training for successful use.

Amy R. Gao, Massachusetts Institute of Technology, Cambridge, Massachusetts (USA), *Design Considerations for Robotic Flying Fish*

Abstract—This paper details an exploration into the design of an aerial-aquatic robotic vessel. A compact robot that could both swim underwater and glide in the air above water has many potential applications in ocean exploration and mapping, surveillance, and forecasting. In the first phase of this project,

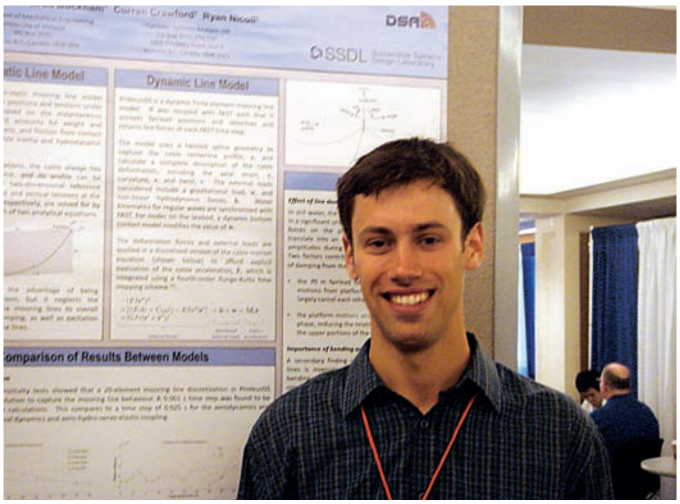


we focus on mechanical design concepts that would enable the biomimetic production of adequate thrust underwater. A brief review of precedent research concerning robotic fish and hydrodynamics is first presented, followed by an in-depth analysis of the mathematical theory relevant to the project. A passive model of a flying fish was constructed and launched from approximately 1 ft. underwater to determine the forces associated with overcoming drag underwater and exiting the water. Based on this, A number of conceptual designs which would produce the motion necessary for propulsion were formulated and are discussed from a mechanical design perspective. Various conventional and nonconventional actuators are reviewed, as well as a control scheme for the concepts presented. We end with a discussion of the future directions for this project, as well as the key challenges that remain to be addressed.

Rachael Hager, University of Hawaii, Manoa (USA), *Geometric Optimization of a Two Dimensional Heaving Body for Power Absorption*

Abstract—This project like so many has been inspired by Salter's paper in 1974 in Nature. Salter's Duck radiates waves only in front of the body allowing up to 80% of the incident wave's power to be absorbed. It is its asymmetric body which allows for such high efficiency. The goal of this paper is to optimize the geometry for maximum power absorption in a two dimensional heaving body. In particular, the geometry of asymmetric bodies such as Salter's duck will be further explored. Two numerical models are being used to evaluate the power absorption efficiency of various buoy geometries, AQWA and OcraFlex. Five of these numerical models will be confirmed via experimental work.

Mathew Hall, University of Victoria, Victoria, B.C.(Canada), *The Importance of Mooring Line Model Fidelity in Floating Wind Turbine Simulations*



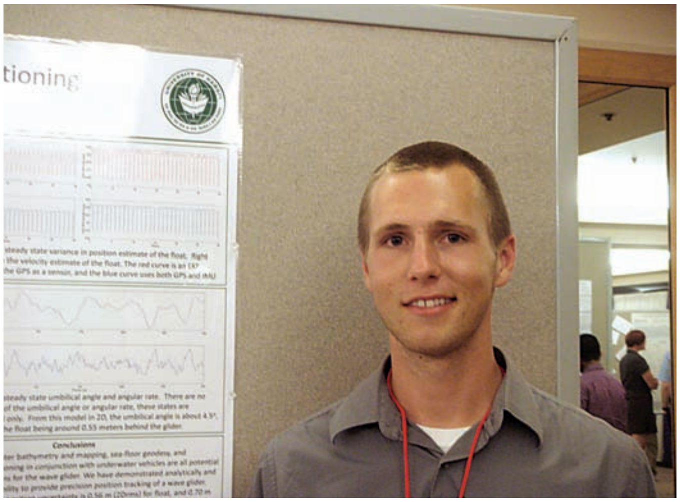
Abstract—Accurate computer modelling is critical in achieving cost effective floating offshore wind turbine designs. In floating wind turbine simulation codes, mooring line models often employ a quasi-static approximation that neglects mooring line inertia and hydrodynamics. The loss of accuracy from using this approach has not been thoroughly quantified. To test whether this widely-used simplified mooring line modelling approach is adequate, the open-source floating wind turbine simulator FAST was modified to allow the use of an alternative, fully dynamic, mooring model based on the hydrodynamics simulator ProteusDS.

The OC3-Hywind floating wind turbine design was implemented in this newly-coupled simulator arrangement and tested using a variety of regular wave conditions. The static equivalence between the built-in quasi-static mooring model and the newly coupled dynamic mooring model is very good. Tests using both models were performed looking at scenarios of the response of the system in still water and the response to regular waves and steady winds. The dynamic mooring model significantly increased the overall platform damping in translational DOFs during motion decay tests in still water. There was very little difference between the models in coupled tests where regular wave excitation was the primary driver of platform motions, except for the addition of small levels of power in the higher frequencies of the platform motion spectrum. The nature of the different tests suggests that it is only in situations where the platform motions and wave velocities are not synchronized that the damping from the dynamic mooring model makes a large difference. This points to irregular wave conditions as providing a better test of the differences between mooring models.

Jonas Jonsson, Uppsala University, Angstrom Space Technology Centre, (Sweden), *Miniaturized submersible for exploration of small aqueous environments*

Abstract—Remotely operated vehicles (ROVs) are commonly used for sub-surface exploration. However, multifunctional ROVs tend to be fairly large, while preferred small and compact ROVs suffer from limited functionality. The Deeper Access, Deeper Understanding (DADU) project aims to develop a small submersible concept using miniaturization technologies to enable a high functionality. An operator is able to maneuver the vehicle with five degrees of freedom using eight small thrusters, while a set of accelerometers and gyros monitor the orientation of the submersible. A single fiber optic cable will connect the submersible to a control station and enable simultaneous data and command transfers. Rechargeable battery packs provide power to the submersibles subsystems during operation. These will be rechargeable through the fiber connection. A forward looking camera is aided by a laser topography measurement system, where distances, sizes and shapes of objects in view can be determined to within 0.5 cm. For murkier environments, or when a more extensive mapping of the surroundings is needed, the small high-frequency side-scanning sonar can be used. Salinity calculations of the water will be available through measurements of the conductivity, temperature and depth. Samples of water and particles within it will be enabled through a water sampler with an enriching capability. Flow sensors will be able to measure the water movement around the submersible's hull. The submersible and its subsystems are under continuous development. The vehicle itself, and its subsystems as stand-alone instruments, will enable the exploration of previously unreachable submerged environments, such as the sub-glacial lakes found in Iceland and Antarctica, or other submerged small environments, such as pipe and cave systems.

Nicholas Kraus, University of Hawaii, Manoa (USA), *Estimation of Wave Glider Dynamics for Precise Positioning*

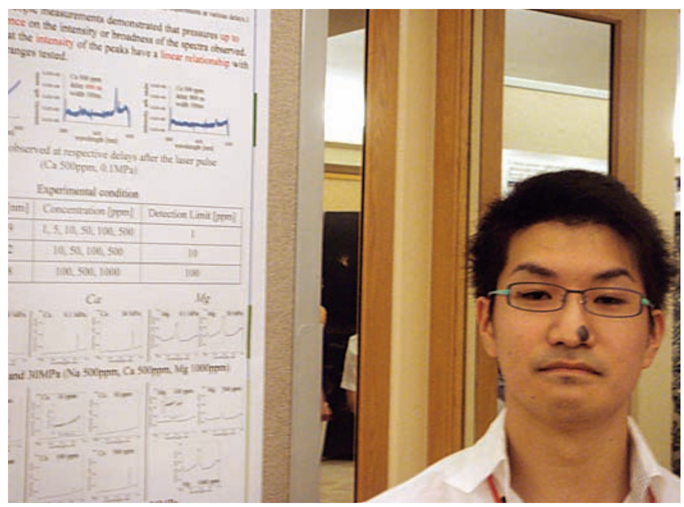


Abstract—The wave glider is a new autonomous surface platform with unique capabilities for persistent observation in a variety of marine environments. The applications of this novel technology continue to expand; some of the potential oceanographic applications will require precise positioning and navigation beyond the platforms current capabilities. In this article we discuss the potential for precise localization of a wave glider based on a augmenting the onboard instrumentation (adding a high quality global positioning receiver and inertial measure unit) and implementing an estimation algorithm (an extended Kalman filter using a two-body dynamic model). To understand the capabilities and limitations of the wave glider's novel propulsion mechanism, consisting of a surface float and submerged glider to harvest wave energy for forward motion, we propose a simplified dynamic model appropriate for real-time implementation. The physical parameters of this model are identified using experimental measurements collected from a wave glider operating in a coastal environment. Finally, we present the results of a proof-of-concept field experiment where the wave glider at the surface was used to precisely position a instrument moored to the seafloor to evaluate the performance of the wave glider for the type of mission that requires precise navigation.

Angelos Mallios, University of Girona (Spain), *Navigating and Mapping with the SPARUS AUV in a Natural and Unstructured Underwater Environment*

Abstract—In spite of the recent advances in unmanned underwater vehicles (UUV) navigation techniques, robustly solving their localization in unstructured and unconstrained areas is still a challenging problem. In this paper, we propose a pose-based algorithm to solve the full Simultaneous Localization And Mapping (SLAM) problem for an Autonomous Underwater Vehicle (AUV), navigating in the unknown and unstructured environment. A probabilistic scan matching technique using range scans gathered from a Mechanical Scanning Imaging Sonar (MSIS) is used together with the robot dead-reckoning displacements. The raw data from the sensors are processed and fused in-line with an augmented state extended Kalman filter (EKF), that estimates and keeps the scans poses. The proposed SLAM method has been tested with a real world dataset acquired from the Spams AUV, guided in a natural underwater environment.

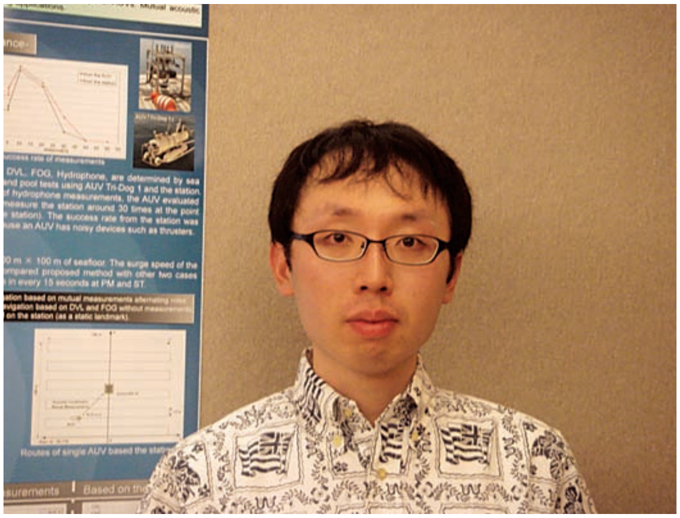
Tatsuya Masamura, Institute of Industrial Science, the University of Tokyo (Japan), *Spectroscopy and imaging of laser induced plasmas for chemical analysis of bulk aqueous solutions at high pressures*



Abstract—Laser-induced breakdown spectroscopy (LIBS) is a chemical sensing technique that has been demonstrated in numerous applications on land. This study investigates the application of LIBS as a technique for in situ analysis of the chemical composition of the ocean. The effects of pressure on the spectral emissions of various different elements in bulk aqueous solution has been evaluated, and imaging of plasmas generated in liquids at pressures between 0.1–30 MPa has been performed. The observations indicate that during the early stages of laser-induced breakdown, in the time frame when spectroscopic measurements are made, the plasma and surrounding phenomena (formation of Shockwaves and cavitation bubbles) are almost independent of the surrounding hydrostatic pressure up to 30 MPa. Spectroscopic investigations found that Na, Ca, and Mg are detectable in liquid at pressures from 0.1 to 30 MPa, at concentrations of 1, 10, and 500 ppm, respectively. These elements are of key importance in the identification

of hydrothermal vent fluids. The results of this study suggest that laser induced spectroscopy is applicable for in situ elemental analysis of liquids at oceanic pressures.

Takumi Matsuda, Institute of Industrial Science, University of Tokyo, (Japan), *Large area navigation method of multiple AUVS based on mutual measurements*



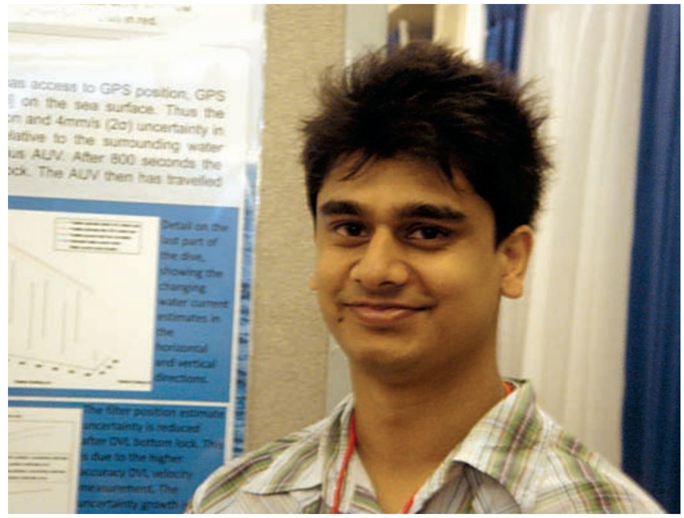
Abstract— In this paper, we propose a large area navigation method of multiple AUVs for accurate seafloor mapping over large area. The key idea of the method is alternating roles of the AUVs between “Moving and Measuring Role (MMR)” and “Landmark Role (LR)”. AUVs in the MMR move based on the AUVs in the LR. On the other hand, AUVs in the LR keep their stations to act as landmarks for the moving AUVs. By alternating their roles, the two groups of AUVs can observe a large area.

AUV position is estimated by mutual measurements of distance and direction among them. These measurements are fused with other on-board sensors such as DVL, angular rate gyro and depth sensor by particle filter, a probabilistic state estimator, in order to realize stable positioning robust against sensor noises and lack of measurements.

We verified the performance of the method through simulation based on data obtained during various experiments performed in pool and at sea. Through the simulation, we demonstrated that the proposed method achieves a positioning error considerably smaller than dead reckoning and thus a stable navigation over an area larger than achieved by a single AUV.

Lashika Medagoda, Australian Centre for Field Robotics, University of Sydney (Australia), *Water Column Current Aided Localisation for Significant Horizontal Trajectories with Autonomous Underwater Vehicles*

Abstract—Survey class Autonomous Underwater Vehicles (AUVs) rely on Doppler Velocity Logs (DVL) for precise navigation near the seafloor. In cases where the seafloor depth is greater than the DVL bottom lock range, localising between the surface, where GPS is available, and the seafloor presents a localization problem since both GPS and DVL are unavailable in the mid-water column. Previous work proposes a solution to navigation in the mid-water column that exploits the

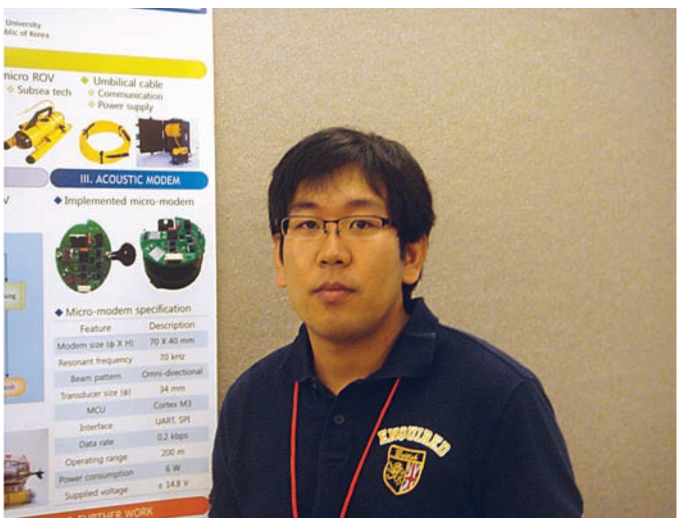


fact that current profiles of water columns are stable over time. With reobservation of these currents with the ADCP (Acoustic Doppler Current Profiler) mode of the DVL during descent, along with sensor fusion of other low cost sensors, position error growth can be constrained to near the initial velocity uncertainty of the vehicle at the sea surface during the dive, and following DVL bottom lock, the entire velocity history is constrained to an error similar to the DVL velocity uncertainty, and coupled with a tactical grade IMU, 12m (2) per hour position error growth is possible. Application on real data coupled with view-based SLAM, without the use of an IMU, has also been demonstrated on the Sirius AUV. The limitation of this method is that it does not accommodate significant horizontal transit such that the water current velocity within the horizontal layer changes spatially, instead focusing on vertical motion through the water column. This paper addresses this limitation by extending the method through a number of modifications, with the result allowing accurate localization during significant horizontal transits. Preliminary results from the Sirius AUV are outlined showing the applicability of this method.

Ruth L. Mullins-Perry, Texas A&M University, College Station, Texas (USA), *Interdisciplinary Ocean Observing Applications for Investigation Coastal Hypoxia in the Gulf of Mexico*

Abstract—Despite advances in ocean observing technologies, operational difficulties and constraints with surveying in coastal waters still remain. Coastal observing awareness has increased recently with the Gulf of Mexico (GOM) Deepwater Horizon oil spill, hurricanes, and persistent environmental hazards, such as harmful algal blooms and hypoxia. To overcome limitations in coastal sampling, we implemented an interdisciplinary approach by integrating traditional ocean observing platforms with advanced shipboard instrumentation and high-resolution numerical models. This integrative effort improves the monitoring and prediction of coastal hypoxia in the GOM. This publication provides an overview our effort by presenting historical, survey, and model observations specific to investigating hypoxia on the TX shelf. The discussion will highlight future directions for integrating and analyzing these data sources and emphasize how coastal integration of these resources can significantly improve coastal hazard science in the GOM.

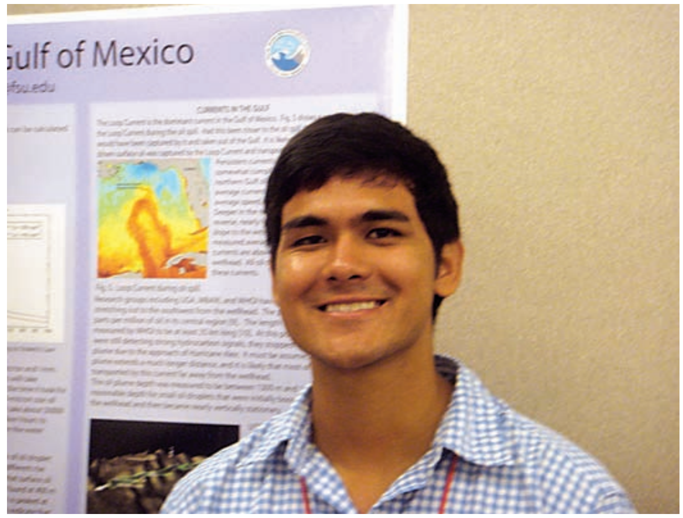
Geol-Ju Kim, Gangneung-Wonju National University (South Korea), *A micro wireless remotely-operated vehicle*



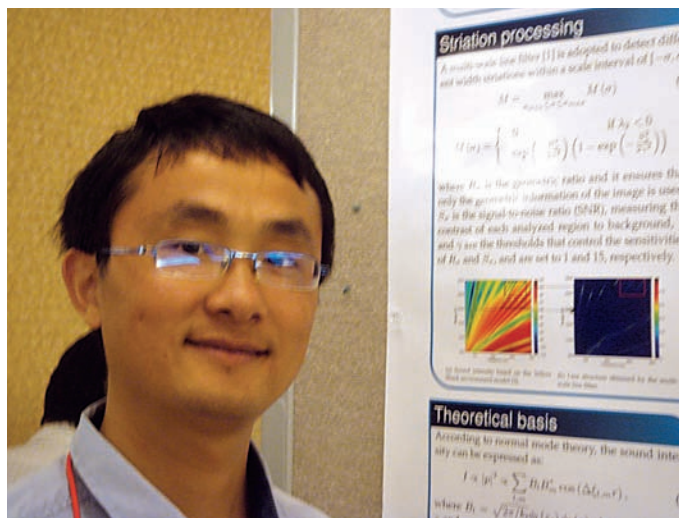
Abstract—For decades remotely-operated vehicles (ROVs) have been designed and implemented in various size and shape. Among them, very small-sized ROV which is called micro ROV has the working range with tens of meters and takes the place of divers. In this paper, we develop a micro ROV operating not by umbilical cable which is troublesome for movements but by wireless acoustic communication. The micro wireless ROV is designed to conduct the commands of movement and measurement from a remote user and to report the result. Experiments in water tanks have verified functional operations of the vehicle and shown the feasibility for applications.

Eric C. Piper, Florida State University (USA), *Oil Droplet Transport in the Gulf of Mexico*

Abstract—The Deepwater Horizon oil spill released 5 million barrels of oil deep in the Gulf of Mexico. The high pressures and turbulent flow at the wellhead resulted in shearing forces that created oil droplets of generally microscopic size. Although initially buoyed upward due to initial velocity and natural gas bubbles entrained in the flow, these oil droplets were eventually transported according to Stokes' Law and ocean currents.

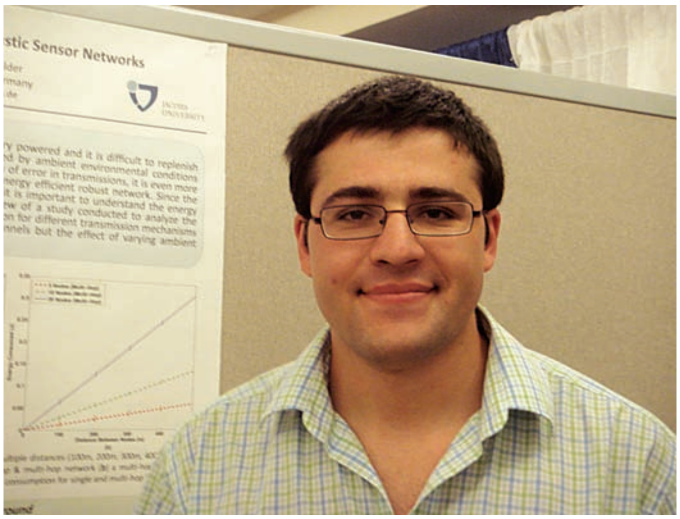


Qun-yan Ren, Universite libre de Bruxelles (Belgium), *A robust passive interferometry technique for sediment geo-acoustic characterization*



Abstract—Due to the dispersive characteristics of acoustic propagation in shallow water, the broad-band sound field excited by a passing ship usually exhibits an interference structure with the form of striations in the space-frequency plane. Waveguide invariant theory is derived to interpret the striation slope and has been used for underwater inverse problems including sediment geoacoustic characterization, source localization, target recognition and others. Owing to the interference structure processing methods previously used, most applications only use the overall striation slope as acoustic observable, however, the local striation structure that is also closely related to the environmental properties was not considered. In this paper, a passive acoustic interferometry technique is proposed for sediment geoacoustic characterization using local striation features extracted by a multi-scale line filter. Based on the Yellow Shark environmental model, a synthetic study using the proposed method is presented for sediment geoacoustic characterization. The robustness of the passive acoustic interferometry technique to source depth and range uncertainties are also studied by theory analysis and numerical simulation. Finally, the acoustic data due to passing ships collected in Mediterranean Sea in 2007 are processed to test the feasibility of the proposed method.

Catalin David, Jacobs University, Bremen (Germany), *Energy Consumption Analysis of Underwater Acoustic Sensor Networks*



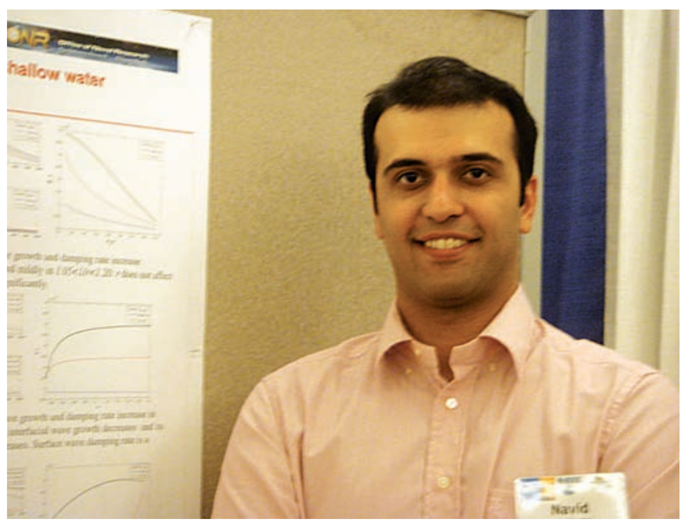
Abstract—Energy-efficiency in underwater networks is essential since nodes are mostly battery powered and it is difficult to replenish their supply. Furthermore, since underwater acoustic sensor networks are effected by ambient environmental conditions leading to volatile network dynamics, large propagation delays and a high probability of error in transmissions, it is even more important to analyze the energy consumption characteristics in order to build an energy efficient robust network. Since the underwater acoustic channel behaves differently in deep water and shallow water it is important to understand the energy consumption characteristics of both channels. In this paper we present an overview of a study conducted to analyze the energy consumption in underwater acoustic sensor networks. The energy consumption for different transmission mechanisms (single-hop, multi-hop, etc.) are analyzed not only in deep and shallow water channels but the effect of varying ambient conditions are also presented.

M. Jordan Stanway, Massachussets Institute of Technology/ Woods Hole Oceanographic Institute, Massachusetts (USA), *Dead Reckoning Through the Water Column with and Acoustic Doppler Current Profiler: Field Experiences*

Abstract—Underwater vehicles currently rely on external acoustic tracking systems to estimate position when away from the surface or the seafloor. Many vehicles dead reckon near the seafloor using a Doppler velocity log. This paper presents a method for dead reckoning through the water column using overlapping water profiles measured by a vehicle-mounted acoustic Doppler current profiler. Under mild assumptions, the

vehicle can simultaneously estimate its own global velocity at the same time as identifying the ocean current profile. The estimation problem is solved using batch least squares, recursive least squares, or a simple online depth bin averaging scheme. We discuss challenges encountered in implementing the approach during three field deployments of the autonomous underwater vehicle Sentry, and provide estimates of the ocean current, the vehicle velocity, and integrated position.

Navid Tahvildari, Texas A&M University, College Station, Texas (USA), *Generation of oblique interfacial waves due to resonant interaction with surface gravity waves in shallow water*



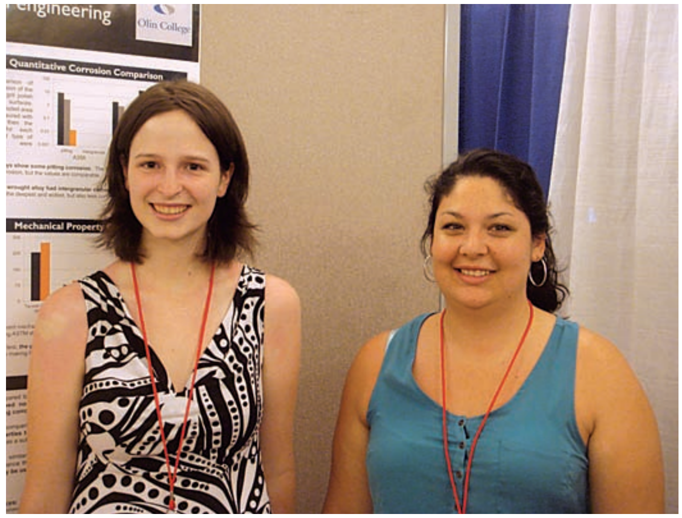
Abstract—Ocean in deep waters and coastal areas is stratified due to vertical gradient of density. Due to nearly distinct interface between the layers of constant density, a two-layer system is a commonly used configuration to model ocean waters. In such models, various mechanisms can lead to generation of surface and interfacial waves. Furthermore, this system admits nonlinear interactions between surface waves and internal waves. As surface waves approach coastal areas, they become long relative to water depth and through nonlinear interactions can induce long interfacial waves over fluidized seabed. This phenomenon will be studied theoretically in the present paper. The fluid is composed of two layers of density stratified, incompressible, inviscid and immiscible fluids. The depth of the top and bottom layers are assumed to be shallow relative to the typical surface wave and interfacial wave length respectively. The waves in this system are weakly nonlinear and weakly dispersive and can be described by Boussinesq-type equations. First, Boussinesq-type equations describing the displacements of the surface and interface and the depth-integrated horizontal velocities in the two layers are derived for mildly varying bathymetry. Secondly, the nonlinear resonant interactions among surface and interfacial modes are analyzed via a second order multiple scales analysis in time. Consequently, coupled transient evolution equations of wave amplitudes are derived. The results of inviscid theory indicates generation of a pair of oblique subharmonic interfacial waves due to energy gain from surface wave. In a parametric study, the influences of the angle of propagation of interfacial waves with respect to surface wave, lower layer viscosity, surface wave frequency, density difference between fluid layers, thickness of the fluid layers, and surface wave amplitude are studied.

Alexei Winter, University of Bristol (UK), *A constrained optimization process for the design of tidal turbine blades with experimental validation*

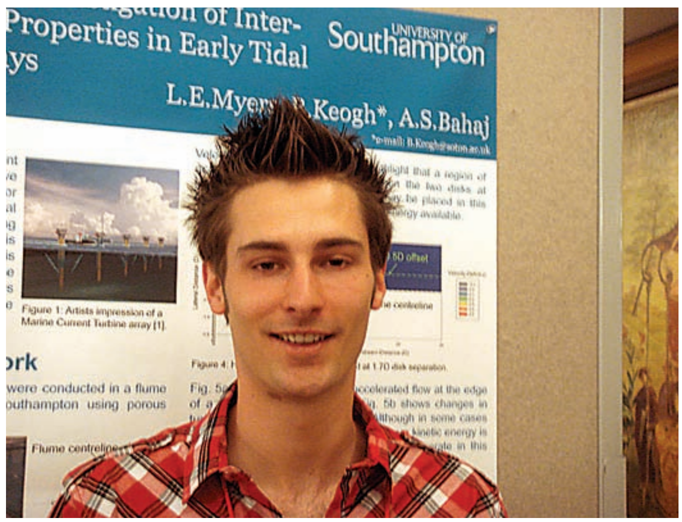
Abstract—This paper presents a way of conceptualizing the design of rotor blades for tidal turbines. The method uses systems principles and attempts to highlight the need to design the rotor within the context of other system components, rather than pursuing the goal of optimizing design point performance in isolation. The method begins by assuming that the axial induction factor is a primary design variable rather than it being fixed at a value of ⅓. Example geometries are presented from this method, as are their performance characteristics. It is shown that blades designed in this way can exhibit thrust characteristics that are significantly different from a rotor designed to operate at an induction factor of ⅓ (one example shows a 68% decrease in runaway thrust). Furthermore, experimental work was undertaken designed to confirm these differences in performance characteristics. Results show very good correlation with predictions.

Ashley Lloyd, Franklin Olin College of Engineering, Massachussets (USA), *Busting the Myth: The Corrosion Resistance of Cast vs. Forged Aluminum for use in Ocean Engineering*

Abstract— The pitting and intergranular corrosion of cast aluminum alloy A3 56 were compared to that of aluminum alloy 6061 to test whether cast aluminum alloys can be used as a substitute for 6061 in select ocean engineering applications. Accelerated corrosion tests were conducted in a salt water and hydrogen peroxide environment at elevated temperature for over six hours. Metallographic samples were then examined for evidence of corrosion. While both aluminum samples showed some evidence of corrosion, there was no substantial difference between the corrosion of the two samples. We conclude that the viable use of certain heat-treatable cast aluminum alloys in a seawater environment has been experimentally verified.



Bradley Keogh, University of Southampton (UK), *Experimental investigation of inter-array wake properties in early tidal turbine arrays*



Abstract—Full-scale marine current energy converter devices have now been operational for several years. These devices have the potential to provide large scale electricity generation when placed in farms/arrays in areas of fast flowing tidal currents. Now the full-scale concept has been proven experienced operators are in a position to provide array developers with devices for such applications, thus at present the first tidal arrays are in the planning and consenting stage around the globe. The inter-device spacing within these arrays can have a profound effect both on the flow field through the array itself and the on the surrounding environment. This paper describes a set of scale experiments aimed at investigating the interaction of devices within an array and potentially highlight some of the pitfalls of future array design which may result in sub-optimal device operation. Experimental results presented herein indicate that particular spacing can lead to regions of accelerated flow which may be exploited to provide greater power production. Further examination of this accelerated flow region is presented, with discourse surrounding the potential issues of placing devices in this region, and impacts the on array geometries as a whole are discussed.

James McFarlane Receives IEEE Vancouver Centennial Award

Dr. James R. McFarlane, founder and president of International Submarine Engineering Ltd. has been awarded the IEEE Vancouver Section Centennial Award for a lifetime of contributions to underwater vehicles and robotics and the Canadian advanced technology sector. This is Dr. McFarlane's third IEEE Award, following a Technical Achievement Award in 1987 and Engineer of the Year in 1998.

The award was presented to Dr. McFarlane by Charles Henley, the IEEE Centennial Awards Committee Chair on August 23rd 2011 at the celebration ceremony of IEEE Vancouver's 100th birthday.

Dr. McFarlane started ISE in 1974 and has been involved with the design, construction, and operation of manned, tethered and untethered Remotely Operated Vehicles as well as subsystems of these vehicles including manipulators and computer control systems. Since that time, Dr. McFarlane has been a part of engineering teams that have built over 400 robotic manipulators and over 200 vehicles. In 2009, ISE was inducted into the Offshore Energy Center Hall of Fame and was also named as one of Canada's top 40 defence companies.

Dr. McFarlane is the author of many papers on submarines, manned submersibles, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), including the world's first automobile refueling system for Shell. He has also made keynote presentations in Europe, India, Japan, China, Korea, USA and Canada. Two notable presentations include the inauguration of the India Chapter of IEEE, Oceanic Engineering Society at the National Institute of Ocean Technology (NIOT) in 2008, and most recently at the Institute of Industrial Science, at The University of Tokyo in 2010.

McFarlane has served on many committees for international meetings and has been honored as guest speaker at many conferences around the globe. He has also received numerous awards including the Officer of the Order of Canada, BC Science Council Award for Industrial innovation, and the BC Science and Engineering Gold Medal.

International Submarine Engineering Ltd.

ISE was formed in 1974 to design and build underwater vehicles. Based just outside Vancouver, Canada, ISE has delivered more than 240 vehicles and over 400 robotic manipulators to more than 20 countries around the world.

The ISE family of vehicles includes ROVs, AUVs, semi-submersibles, active towfish and manned submersibles. ISE has a robotics capability, having built underwater manipulators for a variety of functions and land based robotic systems including an automated car refueling station and the Canadian Space Agency robotic manipulator training system.

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Winning Student Paper

Navigating and Mapping with the SPARUS AUV in a Natural and Unstructured Underwater Environment

Angelos Mallios, Pere Ridao, Marc Carreras and Emili Hernández
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***Abstract*—In spite of the recent advances in unmanned underwater vehicles (UUV) navigation techniques, robustly solving their localization in unstructured and unconstrained areas is still a challenging problem. In this paper, we propose a pose-based algorithm to solve the full Simultaneous Localization And Mapping (SLAM) problem for an Autonomous Underwater Vehicle (AUV), navigating in the unknown and unstructured environment. A probabilistic scan matching technique using range scans gathered from a Mechanical Scanning Imaging Sonar (MSIS) is used together with the robot dead-reckoning displacements. The raw data from the sensors are processed and fused in-line with an augmented state extended Kalman filter (EKF), that estimates and keeps the scans poses. The proposed SLAM method has been tested with a real world dataset acquired from the Sparus AUV, guided in a natural underwater environment.**

I. Introduction

During a long term mission with an autonomous robot it is necessary to keep the track of the vehicle's position. Scan matching is a technique that can be used to estimate the vehicle displacement using successive range scans. Many applications in robotics like mapping, localization, pose tracking or SLAM use this technique to estimate the robot's relative displacement; [1], [2], [3], to mention some but a few. In many senses, scan matching techniques have some resemblance to image mosaicking techniques [4].

This paper is a contribution in this area and the future work of [5], proposing a pose-based algorithm to solve the full SLAM problem of an AUV navigating but this time, in an unknown and unstructured environment, as it is a natural underwater tunnel. The technique incorporates probabilistic scan matching with range scans gathered from a MSIS, taking into account the robot dead-reckoning displacements estimated from a Doppler Velocity Logger (DVL) and a Motion Reference Unit (MRU).

Although a large literature exists reporting successful applications of scan matching and SLAM to mobile robots, very few attempts have been done to use sonar scan matching in underwater applications and even fewer putting them in a SLAM framework. In [6], a non-probabilistic variation of Iterative Closest Point (ICP) is proposed to achieve on-line performance for registering multiple views captured with a 3D acoustic camera. In [7], the authors proposed to use a particle filter to deal with the sonar noisy data but only simulated results are reported. An AUV equipped with an array of 56 narrow beam sonar transducers explores *cenotes* (i.e. sinkholes) in Mexico. The map is stored within a 3D evidence grid which uses the Deferred Reference Counting Octree (DCRO) data structure to reduce the memory requirements [8]. On a similar environment but with a sonar-equipped Remotely Operated Vehicle (ROV), in [9], four different mapping and localization techniques were tested: Sonar image mosaics using stationary sonar scans, SLAM while the vehicle was in motion, SLAM using stationary sonar scans, and localization using previously created maps. Using a MSIS in an AUV, in [10] demonstrated SLAM in the structured environment of a marina. An application combining SLAM and sonar scan matching underwater is reported in [11], were an ICP variant is used for registering bathymetric sub-maps gathered with a multibeam sonar profiler. With the same type of sensor, the authors in [12] modelled the uncertainty in the vehicle state using a particle filter and an EKF.

The paper is structured as follows. In section II, the probabilistic scan matching algorithm is described. The way to overcome the difficulties of the underwater sonar images and the scan matching SLAM technique, are detailed in section III. In section IV, we introduce the Sparus AUV that has been used for the experiments of this paper and section V, reports the experimental results before conclusions.

II. Probabilistic scan matching

The goal of scan matching is to compute the relative displacement of a vehicle between two consecutive configurations by maximizing the overlap between the range measurements obtained from a laser or a sonar sensor. That means, that given a reference scan S_{ref}, a new scan S_{new} and an rough displacement estimation $\mathbf{q}_0$ between them, the objective of scan matching methods is to obtain a better estimation of the real displacement $\mathbf{q} = (x, y, \theta)$ (Fig. 1).

Several scan matching algorithms exists with most of them being variations of the ICP algorithm. The geometric representation of a scan in the conventional ICP algorithm does not model the uncertainty of the sensor measurements. Correspondences between two scans are chosen based on the closest-point rule normally using the Euclidean distance. As pointed out in [13], this distance does not take into account that the points in the new scan, which are far from the sensor, could be far from their correspondents in the previous scan. On the other hand, if the scan data are very noisy, two statistically compatible points could appear far enough, in terms of the Euclidean distance. Both situations might prevent a possible association or even generate a wrong one. To overcome those problems, the authors in [13], proposed the Probabilistic Iterative Correspondence (pIC) which is a statistical extensions of the ICP algorithm, where the relative displacement as well as the observed points in both scans, are modelled as random Gaussian variables.

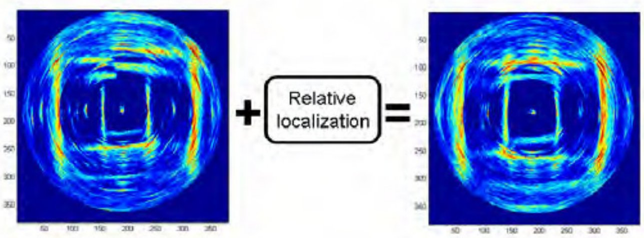


Fig. 2. The distortion produced by the displacement of the robot while acquiring data can be corrected with the relative displacement.

III. Underwater scan matching SLAM

As discussed in the previous section, scan matching is a technique that can provide a better estimation of the vehicle's displacement. However, before the registration of two scans, the building process for each individual scan with a MSIS has to address a number of issues, because the rotation speed of the sonar head is comparable to the vehicle's speed and this introduce distortion in the final scan image. For this reason and to help the reader to follow the algorithm, we will examine the proposed pose-based SLAM algorithm in two separate parts: the ScanGrabbing and the main SLAM algorithm.

A. ScanGrabbing algorithm

ScanGrabbing algorithm's role, is to collect all the beams that forms a full 360^o sonar image sector, analyse them and remove any motion distortion. Following, we will present the three major parts that ScanGrabbing algorithm consists of: Beam segmentation, Relative vehicle localization and Scan forming.

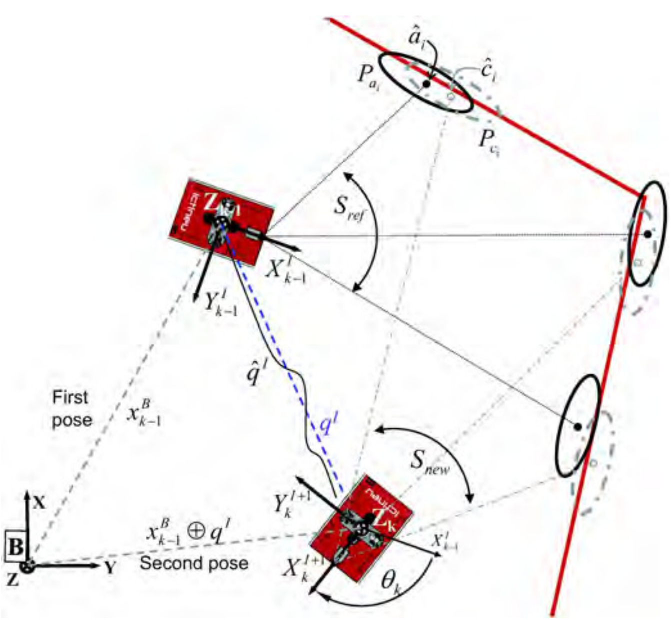


Fig. 1. Scan matching problem description.

1) Beam segmentation and range detection: The MSIS returns a polar acoustic image composed of beams. Each beam has a particular bearing angle value and a set of intensity measurements acquired at known intervals along the beam path. The angle corresponds to the orientation of the sensor head when the beam was emitted. The acoustic linear image corresponding to one beam is returned as an array of acoustic intensities detected at a certain distance. To obtain a range measurement, the beam is then segmented using a predefined threshold to compute the intensity peaks. Due to the noisy nature of the acoustic data, a minimum distance between peaks criteria is also applied. Hence, the positions finally considered are those corresponding to high intensity values above the threshold with a minimum distance between each other.

2) Relative vehicle localization: To maximize the probability for data overlapping, we collect a complete 360^o scan sector and register it with the previous one in order to estimate the robot's displacement. Since MSIS needs a considerable period of time to obtain a complete scan, the robot's motion induces a distortion in the acoustic image when the robot does not remain static, which is very common in water (Fig. 2). To deal with this problem it is necessary to know the robot's pose at the beam reception time. Then, we define a reference coordinate system I, to reference all the range measurements belonging to the same scan. In order to reduce the influence of the motion uncertainties to the scan, we set this reference frame at the robot pose where the centre beam of the current scan was received.

The localization system used in this work to estimate the vehicle motion is a slight modification of the navigation system described in [14]. In this system, a MRU provides attitude measurements and a DVL unit which includes a depth sensor is used to estimate the robot's velocity and depth during the scan. All measurements happen asynchronously with the MSIS beams arriving at 30 Hz rate, while DVL and MRU readings arriving at a frequency of 1.5 and 10 Hz respectively. It is very common that non gliding AUVs are very stable in roll and pitch, performing survey patterns at constant speed, so a simple 4 Degrees of Freedom (DoF) constant velocity kinematic model is used to predict the vehicle's motion. An EKF is used to estimate the robot's pose whenever a sonar beam is received and the model prediction is updated by the standard Kalman filter equations each time a new DVL or

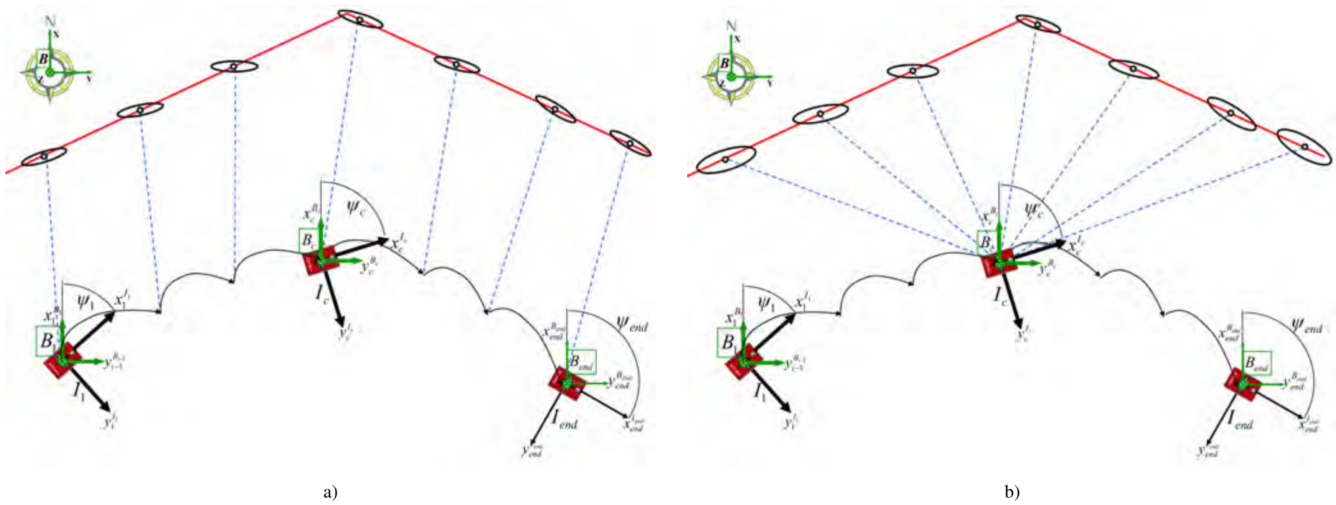


Fig. 3. The scan forming process, simplified for clarity. a) Each beam is grasped in different vehicle poses. b) The beams of a full scan are referenced in the centre I frame of the vehicle trajectory covering that scan. The uncertainty of the motion has been propagated to the scan points.

MRU measurement arrives.

3) Scan forming: The navigation system presented above is able to estimate the robot's pose, but the uncertainty will grow without limit due to its dead-reckoning nature. However, we are only interested in the robot's relative position (and uncertainty) with respect to the centre of the scan (I_c frame, Fig. 3). Hence, a slight modification to the filter is introduced making a reset in position (setting x, y, z to 0 in the vector state) whenever a new beam is emitted. Note that it is important to keep the yaw (ψ) value (it is not reset) because it represents an absolute angle with respect to the magnetic north and a reset would initialise a relative angle and therefore, produce an error during the compass update. Since we are only interested in the uncertainty accumulated during the scan, the reset process also affects the x, y, and z terms of the covariance matrix $\mathbf{P}$. Now, the modified filter provides the robot's relative position where the beams where gathered including their uncertainty accumulated during the scan. After that, it is possible to reference all the ranges computed from the beams to the frame I_c, removing the distortion induced by the robot's motion.

B. SLAM algorithm

The proposed pose-based SLAM algorithm uses an augmented state EKF (ASEKF) for the scan poses estimation. In this implementation of the stochastic map [15], the estimate of the positions of the vehicle at the centre of each full scan at the time step (k), are stored in the state vector $\hat{\mathbf{x}}$, referenced at the base frame B:

$$\hat{\mathbf{x}}_k^B = \left[\hat{\mathbf{x}}_{n_k}^B \ \ldots \ \hat{\mathbf{x}}_{i_k}^B \ \ldots \ \hat{\mathbf{x}}_{1_k}^B\right]^T \tag{1}$$

and the covariance matrix for this state is defined as:

$$\mathbf{P}_k^B = E([\mathbf{x}_k^B - \hat{\mathbf{x}}_k^B][\mathbf{x}_k^B - \hat{\mathbf{x}}_k^B]^T) \tag{2}$$

We remind that a full scan is defined as the final 360^o polar range image obtained after compounding all the robot poses with the 200 beams needed to obtain the full sector. The scan is referenced in the centre of that path, which is the output from the ScanGrabbing algorithm.

1) Map initialisation: All the elements on the state vector are represented in the map reference frame B. Although this reference frame can be defined arbitrarily, we have chosen to place its origin on the initial position of the vehicle at the beginning of the experiment and orient it to the north, so compass measurements can be easily integrated.

The pose state $\mathbf{x}_i$ is represented as:

$$\mathbf{x}_i^B = [x \ y \ \psi]^T \tag{3}$$

where, x, y and ψ is the position and orientation vector of the vehicle in the global frame B. The state and the map are initialized from the first available heading measurement.

2) Prediction: Let,

- $\mathbf{x}_{n_k}^B \equiv N(\hat{\mathbf{x}}_{n_k}^B, \ \mathbf{P}_k^B)$ be the last robot pose, and
- $\hat{\mathbf{q}}_n^{B_n} \equiv N(\hat{\mathbf{q}}_n^{B_n}, \ \mathbf{P}_{q_n}^{B_n})$ be the robot displacement during the last scan, estimated through dead reckoning

then the prediction / state augmentation equation is given by:

$$\hat{\mathbf{x}}_{k+1}^B = \hat{\mathbf{x}}_k^B \odot \hat{\mathbf{q}}_{n_k}^{B_n} = \left[\ \hat{\mathbf{x}}_{n-1_k}^B \odot \hat{\mathbf{q}}_{n_k}^{B_n} \,|\, \hat{\mathbf{x}}_{n-1_k}^B \ldots \hat{\mathbf{x}}_{i_k}^B \ldots \hat{\mathbf{x}}_{1_k}^B \ \right]^T \tag{4}$$

where, given that B and B_n frames are both north aligned, the operator $\odot$ is defined as:

$$\mathbf{x} \odot \mathbf{q} = \begin{bmatrix} a \\ b \\ c \end{bmatrix} \odot \begin{bmatrix} d \\ e \\ f \end{bmatrix} = \begin{bmatrix} a+d \\ b+e \\ f \end{bmatrix} \tag{5}$$

being $\mathbf{J}_{1\odot} = \begin{bmatrix} \mathbf{I}_{2x2} & 0 \\ 0 & 0 \end{bmatrix}$ and $\mathbf{J}_{2\odot} = \mathbf{I}_{3x3}$ the corresponding linear transformation matrices, then the predicted pose uncertainty $\mathbf{P}_{k+1}^B$ can computed as:

$$\mathbf{P}_{k+1}^B = \mathbf{J}_{1\odot}\mathbf{P}_k^B\mathbf{J}_{1\odot}^T + \mathbf{J}_{2\odot}\mathbf{P}_{q_i}^B\mathbf{J}_{2\odot}^T \tag{6}$$

3) Loop closing candidates: Each new pose of a scan is compared against the previous scan poses that are in the nearby area defined by a threshold. Whenever enough points are overlapping, a new scan matching introduce a constraint between the poses, updating the ASEKF. These constraints close the loops that correcting the whole trajectory and bounding the drift. Finally the scan matching result is used to update the filter.

4) Scan matching: In order to execute the pIC algorithm, given two overlapping scans (S_i, S_n) with their related poses $(\hat{\mathbf{x}}_i^B, \hat{\mathbf{x}}_n^B)$, an initial guess of their relative displacement is necessary. This initial guess $[\hat{\mathbf{q}}_i^{I_i}, \mathbf{P}_{q_i}^{I_i}]$ can be easily extracted from the state vector using the tail-to-tail transformation [15]:

$$\hat{\mathbf{q}}_i^{I_i} = \ominus\hat{\mathbf{x}}_i^B \oplus \hat{\mathbf{x}}_n^B \tag{7}$$

Since the tail-to-tail transformation is actually a non-linear function of the state vector $\hat{\mathbf{x}}_k^B$, the uncertainty of the initial guess can be computed by means of the Jacobian of the non linear function:

$$\mathbf{P}_{q_i}^{I_i} = \mathbf{H}_k \mathbf{P}_k^B \mathbf{H}_k^T \tag{8}$$

where

$$\mathbf{H}_k = \left. \frac{\partial \ominus \hat{\mathbf{x}}_i^B \oplus \hat{\mathbf{x}}_n^B}{\partial \mathbf{x}_k^B} \right|_{(\mathbf{x}_k^B = \hat{\mathbf{x}}_k^B)} \tag{9}$$

Moreover, as shown in [15], the Jacobian for the tail-to-tail transformation $\mathbf{x}_{a_c} = \ominus\mathbf{x}_{b_a} \oplus \mathbf{x}_{b_c}$, is:

$$\frac{\partial \ominus \mathbf{x}_{b_a} \oplus \mathbf{x}_{b_c}}{\partial (\mathbf{x}_{b_a} \mathbf{x}_{b_c})} = [\mathbf{J}_{1\oplus}\mathbf{J}_{\ominus} \quad \mathbf{J}_{2\oplus}] \tag{10}$$

where the $\mathbf{J}_{1\oplus}, \mathbf{J}_{2\oplus}$ and $\mathbf{J}_{\ominus}$ are the Jacobian matrices of the compounding and inverse transformations respectively.

Being in our case $\hat{\mathbf{x}}_{n_k}^B$ and $\hat{\mathbf{x}}_{i_k}^B$ components of the full state vector, the Jacobian of the measurement equation becomes:

$$\mathbf{H}_k = \frac{\partial \ominus \hat{\mathbf{x}}_{i_k}^B \oplus \hat{\mathbf{x}}_{n_k}^B}{\partial \mathbf{x}_k} = [\mathbf{J}_{2\oplus_{3x3}} \quad \mathbf{0}_{3x3(n-i-1)} \quad \mathbf{J}_{1\oplus}\mathbf{J}_{\ominus_{3x3}} \quad \mathbf{0}_{3x3(i-1)}]$$

Once the initial displacement guess is available, the pIC algorithm can be used to produce an updated measurement of this displacement.

5) State update: When two overlapping scans (S_i, S_n) with the corresponding poses $(\mathbf{x}_i^B, \mathbf{x}_n^B)$ are registered, their relative displacement defines a constraint between both poses. This constraint can be expressed by means of the measurement equation, which again in our case becomes:

$$\mathbf{z}_k = \ominus\hat{\mathbf{x}}_{i_k}^B \oplus \hat{\mathbf{x}}_{n_k}^B \tag{11}$$

where $\hat{\mathbf{x}}_{i_k}^B$ is the scan pose which overlaps with the last scan pose $\hat{\mathbf{x}}_{n_k}^B$. Now, an update of the stochastic map can be performed with the standard extended Kalman filter equations.

IV. Sparus AUV

Sparus AUV (fig. 4), was developed in the underwater robotics lab at Universitat de Girona (UdG) mainly for participating in the Student Autonomous Underwater Challenge - Europe (SAUC-E) 2010. After becoming the winning entry of the competition, Sparus has been used as a research platform to develop and test new algorithms as well as to collect datasets in real environments. Recently, in SAUC-E 2011, it achieved the second place [16].

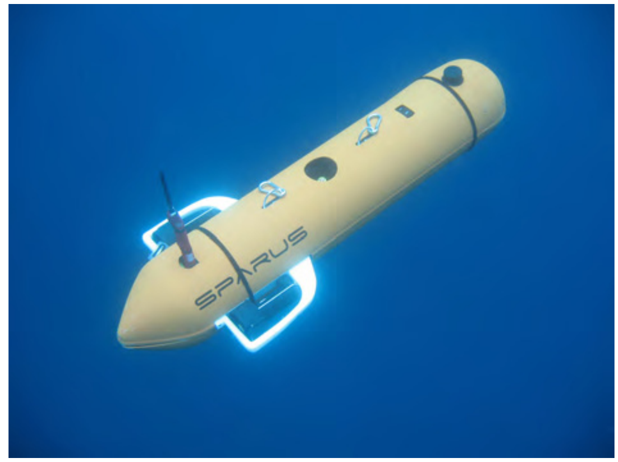


Fig. 4. Sparus, the AUV of the underwater robotics lab at UdG.

A. Mechanical design

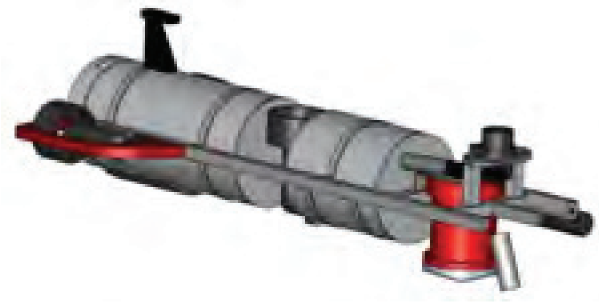
Sparus AUV, was designed with the main goal of having a small and simple torpedo-shaped vehicle with hovering capabilities. It has three DoF and the propulsion consists of three thrusters: two for the surge and yaw DoFs, one for the heave DoF and are integrated in a classical torpedo shape AUV. The mechanical structure and components are therefore organised around this configuration. The front of the vehicle contains all the sensors and the battery housing while in the back there is a second housing for the electronics, the computer and the inertial navigation system.

The main structure is made of aluminium profiles and stainless steel clamps that hold the two pressure housings (fig. 5a). The electronics and battery housings were made of aluminium, rated for $100m$ depth. To give the vehicle the required buoyancy, technical foam is distributed all over the top part of the vehicle in order to place the buoyancy centre at the same longitudinal position as the gravity centre but above it, assuring pitch and roll stability (fig. 5b). Finally, to reduce the water drag and to protect the components, a two-part ABS skin covers the AUV (fig. 5c). The final dimensions of the vehicle are 1.22 m length by 0.23 m diameter, and the weight is around 30 kg.

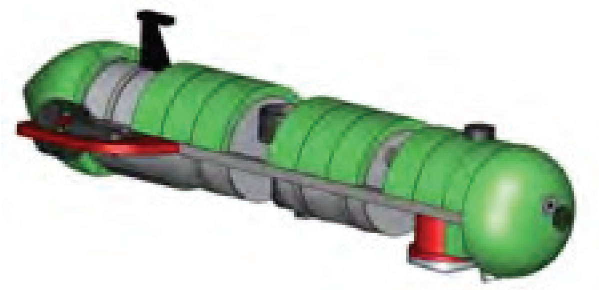
B. Hardware design

The vehicle's power module consists of one battery pack of 25.9 V and 34.4 Ah of nominal capacity, which allows for an autonomy of more than 6 hours. The pack is composed by 112 Lithium ion battery cells (18650 type, 3.7 V, 2150 mAh). Additionally, an umbilical cable can be connected to the vehicle's computer housing for external power and Ethernet access.

The on-board embedded computer has been chosen as a trade off between processing power, size and power consumption. The ADL945HD board together with the U2500



a)



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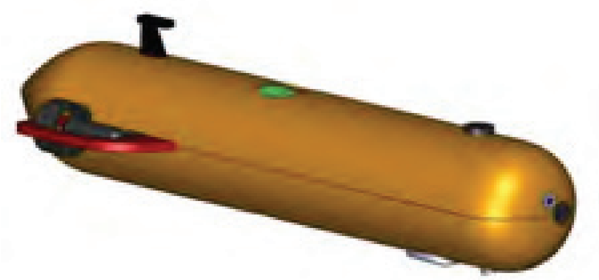


c)

Fig. 5. Sparus mechanical design. (a) Basic structure with the two aluminium housings. (b) Buoyancy distribution. (c) With the ABS skin.

processor at 1.2 GHz provides the processing power of a Core Duo architecture together with the Ultra Low Voltage (ULV) consumption and the 3.5" small form factor.

The vehicle is equipped with a complete sensor suite composed by two colour video cameras (forward-looking and down-looking), a MRU MTi from XSens Technologies, a Micron imaging sonar from Tritech, an echosounder, a pressure sensor and the NavQuest 600 Micro DVL from LinkQuest which also includes a compass/tilt sensor. Additional temperature, voltage, pressure sensors and water leak detectors are installed into the pressure vessels for safety purposes. Besides, the vehicle hosts on the top a WiFi and a GPS antenna covered with resin, which can be detached and placed in a float on surface, keeping the connection with the AUV via a 5 meter USB cable.

C. Software architecture

The software architecture currently running on Sparus was developed from scratch for the SAUC-E 2010, although is fully compatible with the previous robots in the underwater robotics laboratory. The COLA2 architecture (Component

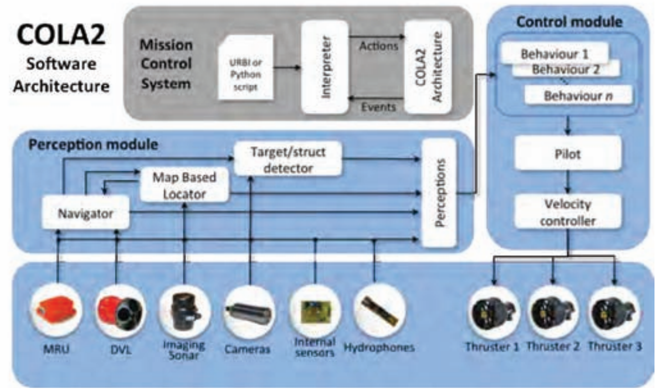


Fig. 6. Schematic of COLA2 software architecture.

Oriented Layer-based Architecture for Autonomy) is an hybrid control architecture divided in three layers, namely mission, execution and reactive layers. The reactive layer is composed by the Vehicle Interface, Perception and Control and Guidance modules (fig. 6) where the different software components (drivers, processing units, primitives, etc.) communicate using a custom-designed communication protocol. Over these three modules there is the Mission Control System which constitutes the mission and execution layers.

The implemented communication system is based in standard XML strings over TCP/IP connections, resulting in a lightweight protocol which allows to perform the component communication in a plain and simple way. By using this protocol, the architecture can be network-distributed among different computers allowing, for example, the execution of some components inside the vehicle's computer and some others in external PC's.

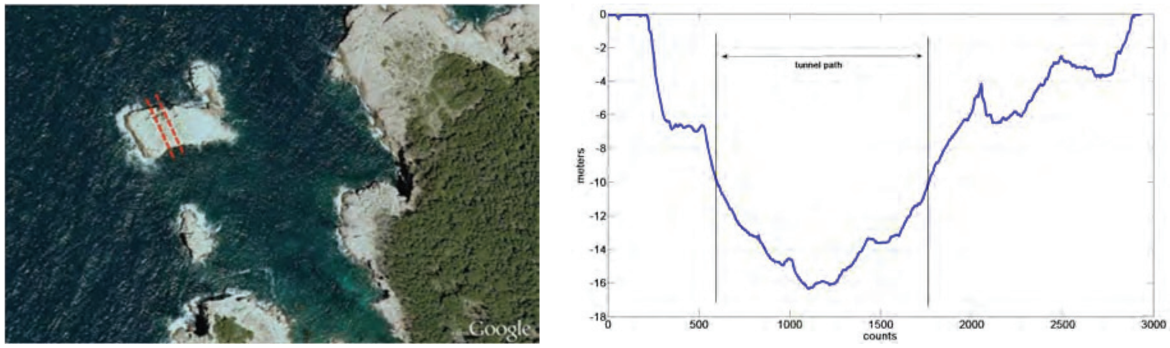
V. Experimental set-up and results

A. The dataset

The method described in section III, has been tested with a dataset obtained in a natural underwater tunnel located in the Costa Brava area, Spain (fig. 7a).

Although there is enough vertical information for a MSIS sensor, it is a challenging unstructured environment as the walls and the depth of the tunnel are uneven (fig. 7b). The entrance of the tunnel starts at around 10 m depth and reaches almost 18 m at the end of a 30 m corridor.

The survey mission was carried out using the Sparus AUV guided along a 150 m path. The MSIS was configured to scan the whole 360° sector and it was set to fire up to a 50 m range, with a 0.1 m resolution and a 1.8° angular step. Dead-reckoning was computed using the velocity reading coming from the DVL and the heading data obtained from the MRU sensor, both merged using the described EKF. Standard deviation for the MSIS sensor was set as it is specified by the manufacturer, 0.1 m in range and 1.8° in angular measurements.



a) b)

Fig. 7. Gathering the dataset: a) The underwater tunnel is pointed by the dotted red lines. b) The depth profile of the AUV trajectory.

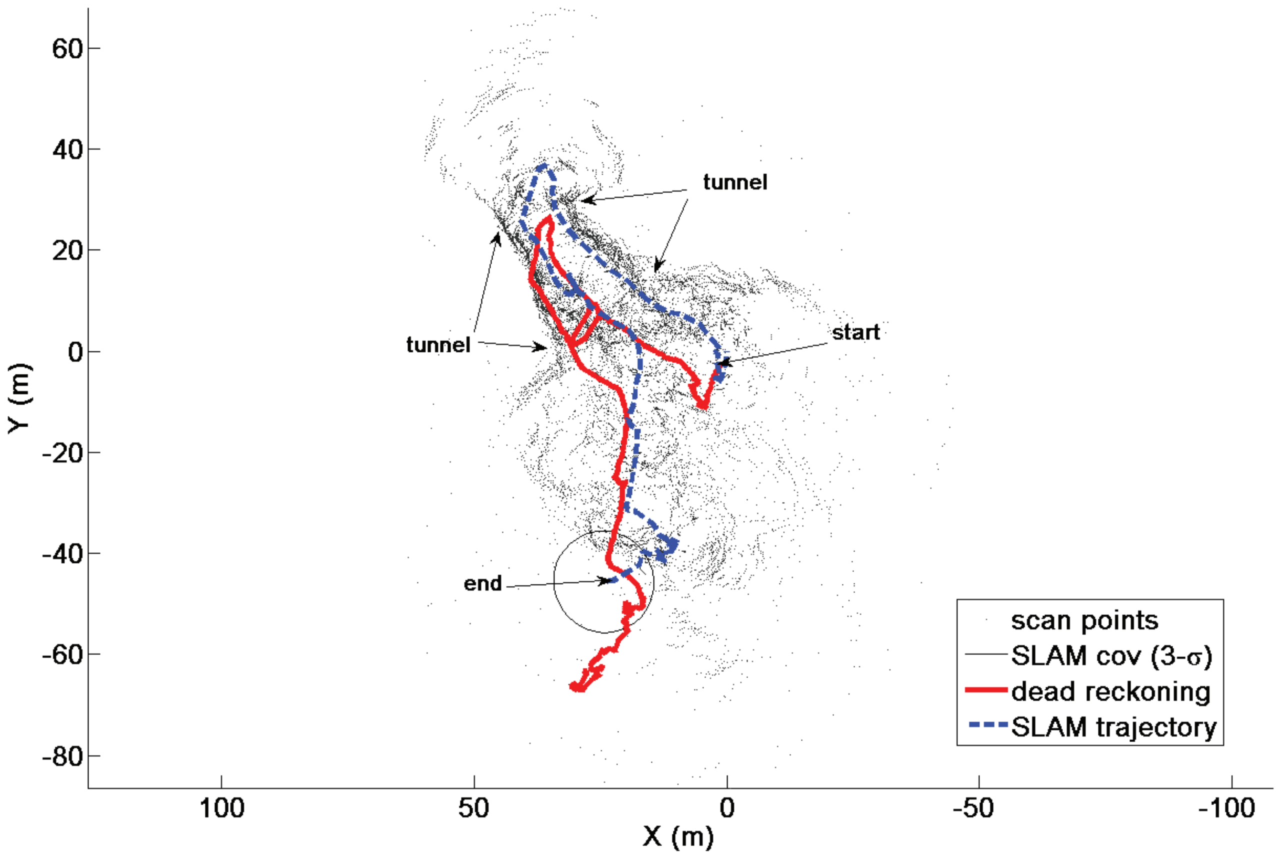


Fig. 8. SLAM Trajectory and map. In red (solid) line is the dead reckoning and in blue (dash) the trajectory estimated with the SLAM algorithm.

B. Results

The vertical beam width of the MSIS is 30°, which eliminate the vertical resolution on the sensor (2D scans). That was not introducing any problem in our previous work in the marina environment [5], as the man-made wall were straight vertical. In this natural dataset, the rough and unstructured walls, as much as the vertical extension of the tunnel, breaks the continuity of the sonar images from scan to scan. However, the proposed algorithm was able to cross-register 36 from the 102 scan poses. Figure 8, shows the trajectory and the map estimated with the proposed SLAM algorithm. As was expected, the dead-reckoning estimated trajectory suffers from a significant drift which is drastically limited by the proposed SLAM algorithm. Unfortunately, in such environment is very difficult to obtain a ground truth but this is included in our future list work, as is the only way to validate the results. The whole dataset was acquired in 23 min with the vehicle travelling at 0.2 m/s average speed and the off-line execution of the proposed algorithm, implemented in MATLAB, needs around 4 min at a Intel Core2 Quad @ 3.00 GHz CPU, which gives good possibilities for real time implementation.

VI. Conclusion

This paper proposes a pose-based algorithm to solve the full SLAM problem for an AUV, navigating in an unknown and possibly unstructured environment. A probabilistic scan matching technique using range scans gathered from a MSIS is used together with the robot dead-reckoning displacements. The proposed method utilizes two EKFs. The first, estimates the local path travelled by the robot while forming the scan as well as its uncertainty, providing position estimates for correcting the distortions that the vehicle motion produces in the acoustic images. The second is an augmented state EKF that fuse in-line the raw data from the sensors and estimates and keeps the registered scans poses.

The algorithm has been tested with the Sparus AUV, guided along a 150 m path within an underwater tunnel, which is a challenging unstructured environment. Although the vertical extension of the tunnel is difficult to be sensed with a MSIS, our proposed algorithm was able to cross-register 30% of the total poses, and constrain the dead reckning drift.

Acknowledgment

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2011 Distinguished Service Award

This year's recipient of the OES Distinguished Service Award is James T. Barbera. Mr. Barbera has been active in the management of OES for many years, serving on the ADCOM for a period of twelve years as a membership chair for five years, chapter chair for ten years, treasurer for four years, and President for four years. Jim is presently the Junior Past President. In addition, Jim served on the OES RECON Committee to select viable venues.

As treasurer, Mr. Barbera was responsible for the financial aspects of all the OES conferences. He was the treasurer for AUV 94, OCEANS 96, US Baltic Symposium 04 and 06. He was on the organizing committee for ESTS 05 and on the committee for 07. He has served as liaison on numerous CCEANS conferences held in Europe, Japan, and North American sites. He was Vice President of the IEEE Systems Council - Conferences and is a member if the ICEO board. He also served as an ADCOM member for the Sensors council.

Mr Barbera earned his Bachelor's Degree in Electrical Engineering at Villanova University in 1960. Further graduate work was performed at The Catholic University of America in Underwater Acoustics.

Mr Barbera is a Life Senior Member of the IEEE and a Life Member of the US Naval Institute and the National Defense Industrial Association (NDIA).

HF Ocean Radars Observe Tsunami Properties

Malcolm L. Heron

Two of the three Plenary Lectures at IEEE/MTS OCEANS'12 at Kona had the theme that some good can come from adversity. In the case of the Deep Horizon, Mike Utsler described how the scientific and engineering effort is bringing new insights on how to deal with the dispersion of emulsified oil in the water column.

Eddie Bernard spoke of the tsunami which originated off the coast of Japan on 11 March 2011, causing such destruction and tragedy in the Sendai region. One piece of new science to come from the Sendai tsunami, and confirmed at the OCEANS Conference, is the clear demonstration that HF ocean radars can be used to observe the time of arrival and magnitude of a tsunami onto a continental shelf. Papers have been published showing results on both phased-array and crossed-loop direction-finding systems at several places across the Pacific basin.

Tsunami events consist of a pulse of very long wavelength gravity waves normally produced by an earthquake or landslide. Wave periods are generally between 20 and 60 minutes, and because of that they comply with the shallow-water approximation for phase speed, even in the deepest abyssal oceans given by

$$c = \sqrt{gH},$$

where H is the water depth and g is the acceleration due to gravity. Plug in $H = 2000$ m for a typical ocean basin and you will get $c = 504$ kilometer/hour, which is almost the speed of a jet aeroplane. From this you can see that the speed of the tsunami waves will be refracted as the bathymetry (H) changes. The MOST (Method of Splitting: Tsunami) model does a good job in calculating the speed, and the focusing and defocusing effects of refraction across the world's oceans, and gives a good indication of the expected time-of-arrival at the edge of the continental shelf at any location. What MOST does not do so well is to follow the refraction effects across the shelf, where bathymetry becomes critically important (and dominates the dynamics at the shore). Put $H = 50$ m into the above equation and you will see that the phase velocity drops to the vicinity of 80 km/h on a typical continental shelf. Also the model requires a guesstimate of the surface disturbance at the source; the link between earthquake magnitude and tsunami amplitude remains a challenge. This is why the deployment of DART buoys to measure ocean depth by pressure gauges is so important.

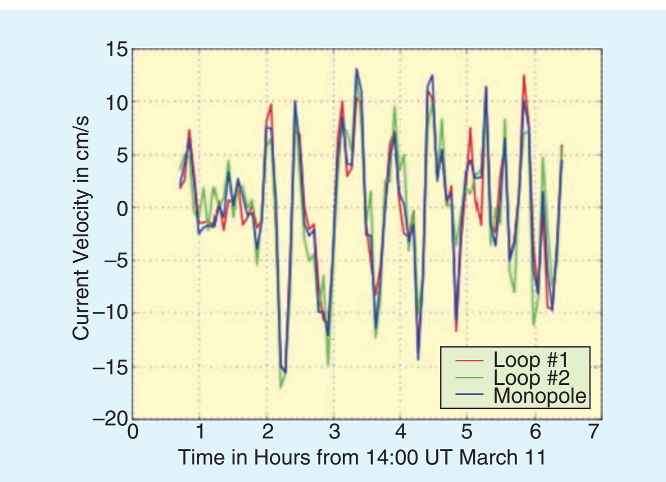

Fig. 1. Median radial currents in a set range annulus from a SeaSonde site at Commonweal, California. The tsunami signal commences at about 108 minutes on the time axis. The loop and monopole antennas are independent and are used for direction-finding at a later stage in the analysis. Source: CODAR Currents Newsletter Spring/Summer 2011. Figure courtesy Don Barrick.

The ability of HF ocean radars to measure the period and amplitude of tsunami waves on the shelf fills a critical gap in local monitoring of tsunami events.

CODAR crossed-loop HF radars picked up signals from the Sendai tsunami at several places around the Pacific including Japan and California. A record is shown in Fig. 1 of radial currents referenced to a radar station at Commonweal, 25 km north of the Golden Gate Bridge. It shows an onset of abnormal surface current at about 15:52 UTC on March 11 and subsequent fluctuations on an arc across the shelf. These fluctuations coincided with those on a tide gauge near the Golden Gate Bridge which had an onset at about 15:40 h on the same time scale. The time difference is explained by the offset of the locations and by the fact that the wave height at the shore lags the orbital current by 90 degrees.

WERA phased-array HF radars reported signals from Hawaii and Chile. A record is show in Fig. 2 from Lebu, Chile for a single station looking perpendicular to the lines of equal bathymetry. Here we see the radial component of surface current on a transect across the shelf. Starting at about 04:50 UTC the radial current at all ranges begins an anomalous negative excursion, followed by oscillations during the next hour and a half. The edge of the continental shelf is at about 24 km range. Note that there is a positive offset in the background current on the shelf which you can see before the tsunami records begins. Note also that there are corresponding fluctuations in surface currents beyond the edge of the continental shelf.

HF radars have great potential for local information about tsunami characteristics. Given the proven quality of the MOST model to predict arrival times at the edge of the continental shelf, HF radars can provide confirmation of the arrival and give important data on the magnitude of the imminent event at the shore. The challenge for HF radars will be to make the measurements as far from shore as possible, and preferably at the edge of the shelf. This will mean achieving

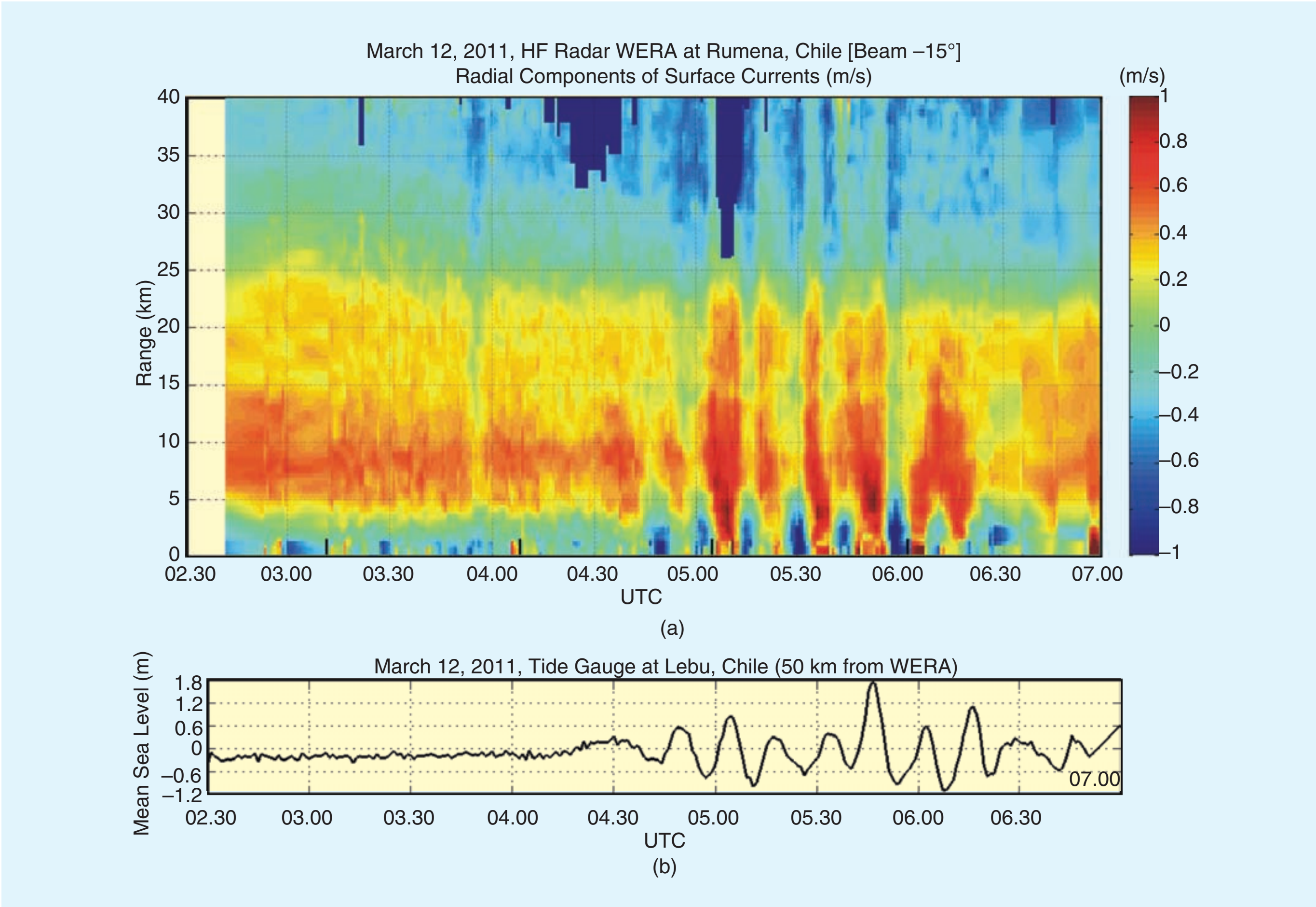

Fig. 2. Radial currents in a 15° sector across the bathymetry contours on the WERA radar at Rumena, Chile. The edge of the continental shelf is at about 24 km range and there is a pre-existing tidal current on the shelf underlying the tsunami signal. Source: Helzel Messtechnik Technical Notes June 2011. Figure courtesy Klaus-Werner Gurgel.

the best signal-to-noise ratio in order to maximize the range of observation.

Further reading

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2. *Japan Tsunami Current Flows Observed by HF Radars on Two Continents*, B, Lipa, D. Barrick, S_I. Saitoh, Y. Ishikawa, T. Awaji, J. Largier and N. Garfield, Remote Sens., 1663–1679, 2011, doi:10.3390/rs3081663.

James McFarlane Receives Lifetime Achievement Award

Dr. James McFarlane, ISE, receiving the DCBC Lifetie Achievement Award from Mr. Jonathan Chappie, DCBC, and Dr. Phil Nuytten, Nuytco Research.

Dr. James R. McFarlane, founder and president of International Submarine Engineering Ltd received the Diver Certification Board of Canada's Lifetime Achievement Award for 2011 for his significant contributions to the underwater industry.

The award was presented to Dr. McFarlane by Mr. Jonathan Chappie, DCBC's incoming Chairman and Senior Manager, Military and Professional with Aqua-Lung Canada Ltd at the Canadian Underwater Conference Awards Banquet on October 24th 2011. Dr. McFarlane was also a keynote speaker at the conference. "Jim's underwater-oriented technical contributions to Canada and the world are almost beyond compare." says David Parkes, Chief Executive Officer, DCBC. "In just one field of underwater work, Jim has been part of engineering teams that have designed and built over 400 robotic manipulators and over 200 vehicles."

Dr. McFarlane started ISE in 1974 and has been involved with the design, construction, and operation of manned, tethered and untethered Remotely Operated Vehicles as well as subsystems of these vehicles including manipulators and computer control systems. In 2009, ISE was inducted into the Offshore Energy Center Hall of Fame and was also named as one of Canada's top 40 defence companies.

Dr. McFarland is the author of many papers on submarines, manned submersibles, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), including the world's first automobile refueling system for Shell. He has also made keynote presentations in Europe, India, Japan, China, Korea, USA and Canada. Two notable presentations include the inauguration of the India Chapter of IEEE, Oceanic Engineering Society at the National Institute of Ocean Technology (NIOT) in 2008, and most recently at the Institute of Industrial Science, at The University of Tokyo in 2010.

Dr. McFarlane has served on many committees for international meetings and has been honored as guest speaker at many conferences around the globe. He has also received numerous awards including the Officer of the Order of Canada, BC Science Council Award for Industrial innovation, the BC Science and Engineering Gold Medal, and the IEEE Vancouver Centennial Award this past August.

About the Diver Certification Board of Canada

The Diver Certification Board of Canada is a federally incorporated not-for-profit body which operates under the authority of a number of agreements with the National Energy Board, the Canada-Newfoundland Offshore Petroleum Board and the Canada-Nova Scotia Offshore Petroleum Board. Originally set up to replace the offshore diver certification regime of the National Energy Board and the offshore petroleum boards, the Diver Certification Board of Canada is the only national body which certifies offshore and inshore commercial divers in Canada.

International Submarine Engineering Ltd.

During the last 37 years ISE has built Remotely Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs), manned submersibles, robotic manipulators, semi-submersibles and unmanned surface vessels.

Based just outside Vancouver, Canada, ISE has delivered more than 240 vehicles and over 400 robotic manipulators to more than 20 countries around the world. ISE has a robotics capability, having built underwater manipulators for a variety of functions and land based robotic systems including an automated car refueling station and the Canadian Space Agency robotic manipulator training system.

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Nonlinear Random Seaway Synthesizer for Marine Vehicle Performance Modeling

Frederick H. Maltz Independent Research Professional

Abstract

Numerically fast, stable and statistically robust seaway synthesizers are explored in this paper for application to marine-vehicle sea-keeping models and time domain simulations. A new approach to polynomial functional expansions is developed for accelerating convergence and increasing the efficiency of the computing procedures. This new approach uses a probabilistic representation instead of a phenomenological description that deals directly with the air-sea interface physics.

Introduction

In this paper we develop explicit Wiener and Volterra models for the rapid synthesis of distinctly nonlinear random seaways. Our purpose is to derive numerically fast, stable and statistically robust synthesizers for marine vehicle sea-keeping models and time-domain simulations. The seaway synthesizer provides the excitation or input to the Force-Transfer-Functions in standard Computational Fluid Dynamics (CFD) software packages such as WAMIT, VERES and SEAWAY. SEAWAY for Windows is now available for desktop computers. With the improved CFD software and detailed statistical description of the sea surface plus higher computing speeds, it is becoming possible to obtain vehicle dynamic performance predictions under more realistic operating conditions.

The weakly nonlinear case was treated previously Ref [1] by employing a near Gaussian sea surface model using a Volterra Series Expansion (VSE) along with multi-dimensional Fourier Transforms. For that case a low order VSE for sea surface displacement in time was given implicitly as a function of the bispectrum. These kinds of expansions have been known to require considerable computation for all but the simplest cases. Specialized block forms of the general VSE model have been used in the controls field in an attempt to reduce computational complexity for more general cases Ref [2]. There has also been some important recent work on implicit Wiener Series Expansions (WSE) Ref [3] and integrating the VSE in its stochastic form with the WSE. This latter approach re-casts the problem as one of polynomial regression analysis.

Alternatively, the approach we take is to derive a compact WSE explicitly from a Probabilistic Functional Representation (PFR) of the seaway, using a Markov assumption and a conditional Cumulative Distribution Function (CDF). In the stochastic setting, there are an infinite number of functional representations related to one another by measure preserving transformations. This PFR that we use is unique in that it is derived from a CDF and by definition CDFs are unique monotonic non-decreasing functions. In this sense this PFR is optimal in that it yields a compact WSE. The WSE by definition has orthogonal polynomial basis functionals. We use the classical method of obtaining the coefficients relying on this important property. Though this is computationally fairly intensive, it is done only once for each particular statistical type of seaway. The WSE gives the companion stochastic VSE by simple rearrangement of terms. This stochastic VSE is robust and can express non-trivial nonlinearities as those associated with near shore processes, abnormal seas in the deep ocean and similar phenomena.

Compact Series Expansions

Of necessity we must use a slightly high order VSE and it becomes necessary to improve the numerical efficiency. We start by examining block-oriented VSE subclasses, namely the Schetzen Ref [4], Wiener, projection-pursuit and Uryson models. The Uryson model is a WSE with $P = 1$ and r the degree of nonlinearity and P the (diagonal) order of the expansion dimensionality. In certain simple cases, it suffices to use a simple filter of non-Gaussian White Noise Ref [5]. We extend this to $P > 1$ and obtain an optimal trade-off between r and P. Also, a new type of the VSE is developed here and is referred to as a Sparse VSE or SVSE. This SVSE uses quantized coefficients in a factored form VSE and it is an alternative to the dimensionality reduction device using the implicit WSE model mentioned above. Coefficient quantization is computationally intensive but it is only done once for each particular statistical type of seaway. The best choice of dimensionality reduction device depends on the particular application. The generalized Uryson model is a P-diagonal subclass of the conventional VSE and WSE and is the focus of this paper.

Probabilistic Functional Representation

Let us consider a homogeneous seaway profile (line transect) of surface height displacements z_k in the x direction. Denote the vector of equally spaced positions $x_{1,m} = (x_1, x_2, x_3, \ldots x_m)$ and corresponding vector of surface height $z_{1,m} = (z_1, z_2, z_3, \ldots z_m)$. We use the convention that the process evolves to the left (negative index values). This is not the standard convention but it simplifies notation. It will be reversed in the sequel. Homogeneity implies that $z_{1,m}$ and $z_{1+k,m+k}$ are identically distributed for arbitrary shift k. Let us assume that the process is Markov of order $m-1$ so that z_1 depends only on the vector $z_{2,m} = (z_2, z_3, \ldots z_m)$. With these two properties all statistical properties of the process $z_{-\infty,+\infty}$, linear or otherwise, are described by the statistical properties of $z_{1,m}$. We assume that a joint probability density function $p(z_{1,m})$ exists, so that we can write the conditional probability density function using Bayes Rule as follows:

$$p_1(z_1 | z_{2,m}) = p(z_{1,m}) / \int_{-\infty}^{+\infty} p(z_{1,m})\, dz_1$$

We then calculate the conditional Cumulative Distribution Function (CDF) as follows:

$$F(z_1 | z_{2,m}) = \int_{-\infty}^{z_1} p(z | z_{2,m})\, dz$$

Regarding $Y_1 = F(z_1 | z_{2,m})$ as a random variable, it is well known that Y_1 is uniformly distributed between 0 and 1. Likewise for a standard Gaussian random variable ε_1 having mean 0, variance 1 and G as its CDF so that $Y_1 = G(\varepsilon_1)$. If the function F is monotonically increasing it can be inverted so that we have:

$$
\begin{aligned}
z_1 &= f_1(\varepsilon_1, z_{2,m}) = F^{-1}(G(\epsilon_1)) \\
z_2 &= f_1(\varepsilon_2, z_{3,m+1}) \\
&\vdots \\
z_m &= f_1(\varepsilon_m, z_{m+1,2m-1})
\end{aligned}
$$

By functional recursion, we find after n iterations that $z_1 = f_n(\varepsilon_1, \varepsilon_2, \varepsilon_3, \ldots, \varepsilon_N)$ where n is chosen so that N is sufficiently large. By ignoring the remaining z_i arguments we incur an error. Therefore, the required number of iteration is subject to numerical validation. This validation can be performed using the method outlined in Ref [1] for calculating the Higher Order Spectra from the VSE coefficients. By homogeneity this yields the Probabilistic Functional Representation (PFR) as follows:

$$z_i = f_n(\varepsilon_i, \varepsilon_{i+1}, \varepsilon_{i+2}, \ldots, \varepsilon_{i+N-1})$$

This is converted to the conventional form as follows:

$$\zeta_i = f_n(w_i, w_{i-1}, w_{i-2}, \ldots, w_{i-N+1})$$

where $\zeta_i = z_{-i}$ and $w_i = \varepsilon_{-i}$. The process ζ_i evolves in the direction of positive index values and w_i is a standard Gaussian White Noise process.

This can be thought of as a virtual nonlinearly driven system or plant with input-output relationship having w_k as the input. This virtual input-output relationship gives the correct statistics and circumvents the need for a phenomenological description that deals with the intricacies of the actual air-sea interface. In the sequel, without loss of generality, we use $z_1 = f_n(\varepsilon_1, \varepsilon_2, \varepsilon_3, \ldots, \varepsilon_N)$ for purposes of discussion.

Subclass Volterra and Wiener Series Derivations

The truncated WSE or any of its subclasses approximates $f_n(\varepsilon_1, \varepsilon_2, \varepsilon_3, \ldots, \varepsilon_N)$ in least mean square error sense. The stochastic VSE is equivalent to the WSE. It differs from the WSE only in the arrangement of terms in the expansion. To demonstrate this, we start by first defining two index vectors, namely $j = (j_1, j_2, \ldots, j_p)$ and $k = (k_1, k_2, \ldots, k_p)$. We then form the basis functionals for the P-diagonal subclass of the stochastic VSE and WSE respectively as follows:

$$
\begin{aligned}
A^{(p)}(j,k) &= \varepsilon_{j_1}^{k_1} \cdot \varepsilon_{j_2}^{k_2} \ldots \varepsilon_{j_p}^{k_p} \\
B^{(p)}(j,k) &= H_{k_1}(\varepsilon_{j_1}) \cdot H_{k_2}(\varepsilon_{j_2}) \ldots H_{k_p}(\varepsilon_{j_p}).
\end{aligned}
$$

where $H_{k_i}(\varepsilon_{j_i})$ with $i = 1, 2, \ldots, p$ are the ortho-normal (ON) Hermite polynomials. Using these basis functionals, we have

$$z_1 = \sum_P \sum_j \sum_k a^{(p)}(j,k) \cdot A^{(p)}(j,k) \qquad \text{(VSE)}$$

$$z_1 = \sum_p \sum_j \sum_k b^{(p)}(j,k) \cdot B^{(p)}(j,k) \qquad \text{(WSE)}$$

The index p ranges over the (generalized Uryson) order of dimensionality P, that is $1 \le p \le P$. The index vector j ranges over $1 \le j_1 < j_2 < \ldots < j_p \le N$. The index vector k ranges over total degree of nonlinearity, that is $1 \le (k_1 + k_2 + \cdots + k_p) \le R$. where R is the degree of nonlinearity. If we take $P < R$ then there can be considerable reduction in the size of the expansion. For example if $R = 5$ and $N = 256$, the full expansion has on the order of 10^{12} terms as compared to 10^5 terms in the $P = 2$ subclass expansion having the same degree of nonlinearity and functional dimension.

The coefficients $a^{(p)}(j,k)$ are obtained from the coefficients $b^{(p)}(j,k)$ by the Gram-Schmidt orthogonalization procedure. This can be done simply by collecting terms of the same degree. The latter coefficients are obtained from the WSE by projection (cross -correlation or input-output coherence) as follows:

$$b^{(p)}(j,k) = E[B^{(p)}(j,k) \cdot z_1]$$

The above expression is numerically evaluated by Monte Carlo integration. This is computationally fairly intensive (but nonetheless feasible for the subclass) so the coefficient sets are archived in a database for reuse. For a statistically robust seaway synthesizer, a large number of these coefficients is generally required. An obvious remedy for this demanding requirement is to quantize the coefficient values. This involves ordering values and collecting like values for factoring purposes. The ordering of values can be done efficiently by a quick-sort routine. The reason for organizing the computations this way is to reduce the number of multiplies in the exercising of the synthesizer. Considerable computer resources generally are required to form this database of quantized coefficient sets since all the coefficients for each type of seaway are required to do this.

Series Compression

Raising the order of dimensionality (diagonal order P or otherwise) increases the computational complexity exponentially. Thus, P must not be too large. This burden is further mitigated by quantizing the series coefficients. The quantization procedure is as follows:

(1) Form new coefficient vector C (with like values identified after ordering and quantizing).
(2) In performing step (1), save table J (for ordering elements) and K (for counting like values).
(3) For each seaway realization, form new basis vector B with the aid of tables J and K.
(4) Obtain the compressed WSE as the inner product of the vectors B and C.

Steps (1) and (2) are performed once for each statistical type of random seaway and the coefficient vector C and associated metadata (tables J and K) are stored in a database. Ordering is done using a quick-sort routine using the binary search method. Step (3) is performed for each realization and does not require any multiplications. The computational savings using this procedure is further increased by using a similar compression technique in the extended Fourier Transform (FT) domain associated with the VSE and WSE. This produces sparse multidimensional FFTs and IFFTs after FT coefficient quantization. Thus the effective dimensionality reduction carries over to the extended transform domain.

Special Case

Consider an ordinary Uryson model obtained by letting $P = 1$. For this case, further assume that the coefficients are of the form $a_{j,k} = g_j \cdot h_k$, so that we have the Hammerstein model: $z_1 = \sum_j g_j \cdot u_j$ where u_j is non-Gaussian White Noise defined by it's cumulants. It has been shown that for this case there is a simple mapping between the input and output cumulants Ref [5]. This property allows the joint fitting of spectrum and first order surface displacement probability distribution. This special model is useful for modeling the well known cnoidal waves that occur in shallow water.

Conclusion

A unique virtual input-output relation for the seaway model has been derived that efficiently represents moderately rough random sea surfaces including non-trivial nonlinearities. The method is based on a probabilistic description of surface displacements. This facilitates the explicit development of a stochastic Volterra series approximation having a minimal number of terms. Use of a generalized Uryson model produces a highly tractable and possibly further reduced form of this series approximation. Also, a numerical compression technique is introduced for mitigating the well known computational complexity associated in general with these types of multidimensional polynomial approximations. By extending the notion of Fourier Transforms to the extended expansion forms resulting from the (elevated dimensionality) VSE and WSE, it is possible to achieve further efficiencies, producing a numerically fast, stable and statistically robust seaway synthesizer.

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The Lighthouse

Henry Wadsworth Longfellow

The rocky ledge runs far into the sea,
and on its outer point, some miles away,
the lighthouse lifts its massive masonry,
A pillar of fire by night, of cloud by day.

Even at this distance I can see the tides,
Upheaving, break unheard along its base,
A speechless wrath, that rises and subsides
in the white tip and tremor of the face.

And as the evening darkens, lo! how bright,
through the deep purple of the twilight air,
Beams forth the sudden radiance of its light,
with strange, unearthly splendor in the glare!

No one alone: from each projecting cape
And perilous reef along the ocean's verge,
Starts into life a dim, gigantic shape,
Holding its lantern o'er the restless surge.

Like the great giant Christopher it stands
Upon the brink of the tempestuous wave,
Wading far out among the rocks and sands,
The night o'er taken mariner to save.

And the great ships sail outward and return
Bending and bowing o'er the billowy swells,
And ever joyful, as they see it burn
They wave their silent welcome and farewells.

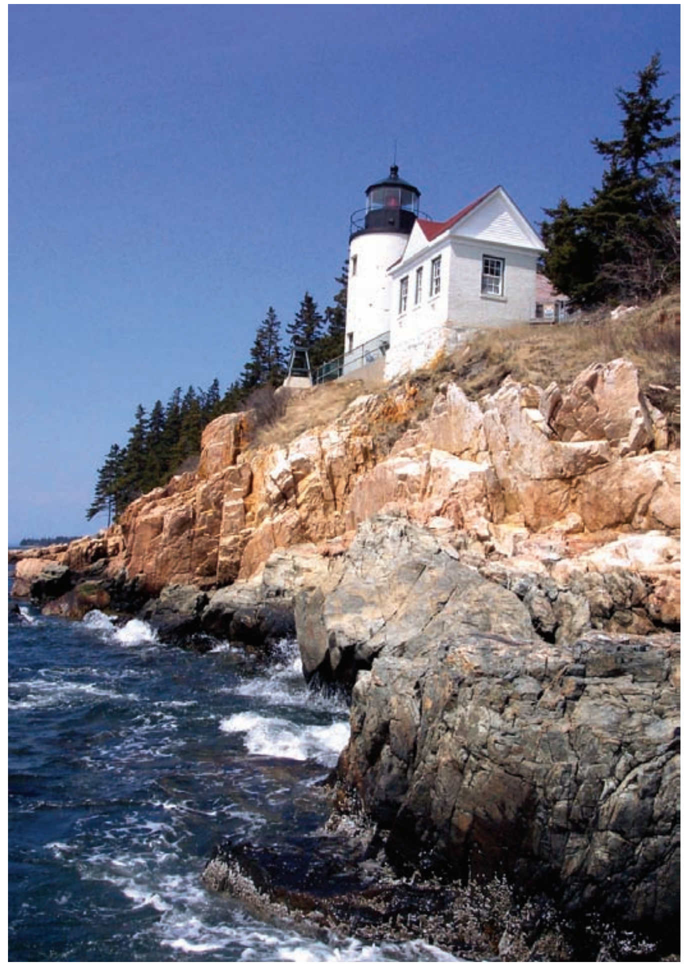
They come forth from the darkness, and their sails
Gleam for a moment only in the blaze,
And eager faces, as the light unveils
Gaze at the tower, and vanish while they gaze.

The mariner remembers when a child,
on his first voyage, he saw it fade and sink
And when returning from adventures wild,
He saw it rise again o'er ocean's brink.

Steadfast, serene, immovable, the same,
Year after year, through all the silent night
Burns on forevermore that quenchless flame,
Shines on that inextinguishable light!

It sees the ocean to its bosum clasp
The rocks and sea-sand with the kiss of peace:
It sees the wild winds lift it in their grasp,
And hold it up, and shake it like a fleece.

The startled waves leap over it; the storm
Smites it with all the scourges of the rain,



And steadily against its solid form
press the great shoulders of the hurricane.

The sea-bird wheeling round it, with the din
of wings and winds and solitary cries,
Blinded and maddened by the light within,
Dashes himself against the glare, and dies.

A new Prometheus, chained upon the rock,
Still grasping in his hand the fire of love,
it does not hear the cry, nor heed the shock,
but hails the mariner with words of love.

"Sail on!" it says: "sail on, ye stately ships!
And with your floating bridge the ocean span;
Be mine to guard this light from all eclipse.
Be yours to bring man neared unto man.

OCEANS '12 MTS/IEEE YEOSU

The Living Ocean and Coast
Diversity of Resources and Sustainable Activities

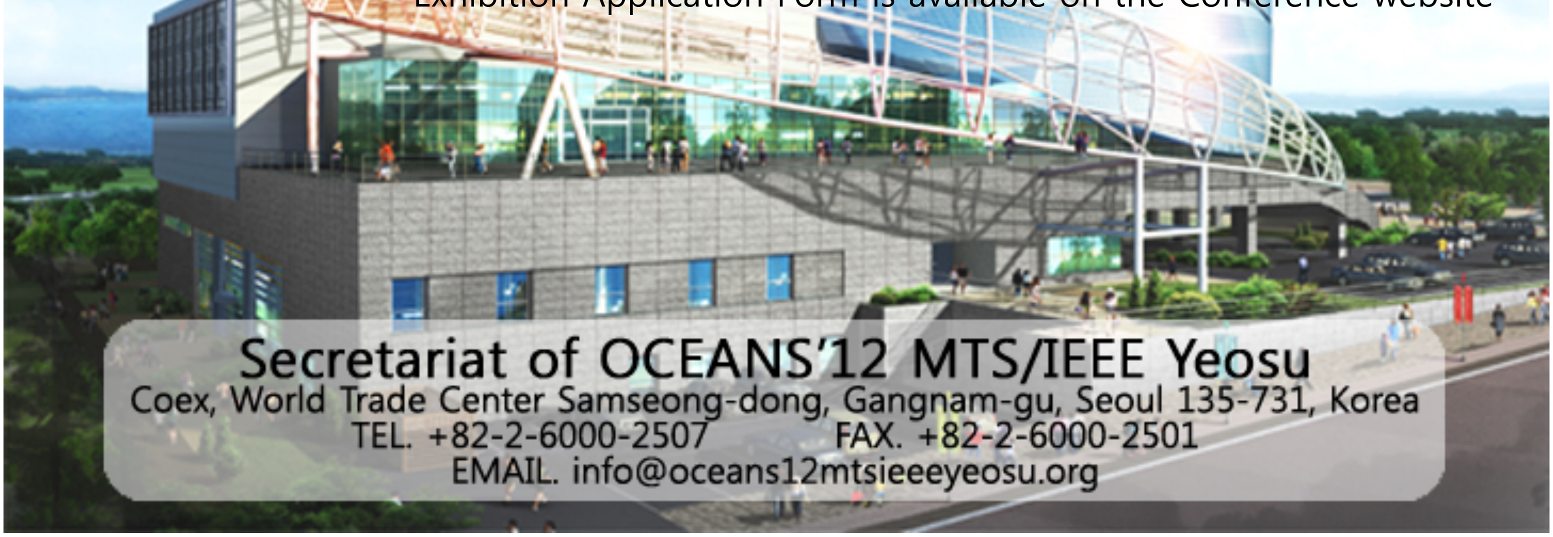
Overview

Title: Oceans'12 MTS/IEEE Yeosu
Date: May 21(Mon.) ~ 24(Thu.). 2012
Venue: The Ocean Resort, Yeosu, Republic of Korea
*The conference will be held during the 2012 YEOSU EXPO period.
Co-Sponsored by: MTS, IEEE/OES, KAOSTS
Website: www.oceans12mtsieeeyeosu.org

Exhibition Details

Participation Fee	Early Bird : USD 2,700/ Booth (Until Feb 25, 2012) Regular : USD 2,900/ Booth (From Feb 26, 2012)
Application Due	April 30(Mon), 2012
Exhibition Date	May 22(Tue) ~ 24(Thu), 2012

Exhibition Application Form is available on the Conference website



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