Proceedings of BTS 2024

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1 INTRODUCTION

The summer school networking event took place during the "Breaking the Surface (BtS)" workshop, from September 29th until October 6th in Biograd na Moru, Croatia, and 198 people participated. The BTS is the international interdisciplinary workshop on robotics and maritime innovations that has been held for 16 years and serves as a meeting point for experts and students involved in marine robotics application areas. This year's BTS has been organized by the Faculty of Electrical and Computer Engineering of the University of Zagreb (UNIZG-FER) and served as a venue for strengthening links with potential end-users. The program was divided into four tracks (marine robotics, maritime biology, marine oceanography, and marine archaeology), and included 14 in-depth lectures, 3 company presentations, 11 tutorials including presentations of MBZIRC 2023 finalists, 10 demos, and the underwater localization challenge.

This deliverable describes the BtS 2024 organization, including the work program. The deliverable is accompanied with abstracts and presentations of the program presenters.

Dates: 29th September – 6th October 2024
Location: Biograd na Moru, Croatia
Website: https://bts.fer.hr/

2 ABOUT BREAKING THE SURFACE

Breaking the Surface - BtS workshop has been organized by UNIZG-FER (LABUST research group) for the last 15 years. Following the success of previous BTS workshops UNIZG-FER hosted the BTS 204 from September 29th to October 6th, 2024, in Biograd na Moru, Croatia. During the years, BtS served as a meeting place of experts and students of marine robotics and the marine robotics application areas such as marine biology, marine archaeology, marine security, oceanography, marine geology, and oceanology. This is the world's first successful, multi-year field training programme that combines academic topics in marine robotics and robotics application areas and hands-on working experience in the sea, doing remote sensing and sampling for various ocean sciences. The program is organized in the form of plenary talks, hands-on tutorials and demonstrations of marine technologies, e.g. marine robotics (MAROB), marine biology (MARBIO), maritime, nautical and ship archaeology (MARCH), oceanography (MAROCEAN), competitions for students, and company presentations.

BTS 2024 IN NUMBERS:

24 COUNTRIES 198 ATTENDEES 13 LECTURES 11 TUTORIALS 10 DEMOS 3 INDUSTRY TALKS

3 BTS ORGANIZATION STRUCTURE

3.1. Programme Committee

Ioannis Kyriakides
CMMI
Cyprus

Bridget Buxton
University of Rhode Island
USA

Fausto Ferreira
UNIZG FER
Croatia

Igor Radusinović
University of Montenegro, Faculty of Electrical Engineering
Montenegro

Massimo Caccia
Italian National Research Council (CNR)
Italy

Jeff Neasham
Newcastle University, School of Engineering
UK

Nuno Cruz
FEUP/INESC TEC
Portugal

Bill Kirkwood
Monterey Bay Aquarium Research Institute (MBARI)
USA

Irena Radić Rossi
University of Zadar
Croatia

3.2. Local Organizing Committee

Ana Golec
UNIZG FER
Croatia

Marina Loizidou
CMMI
Cyprus

Petra Kovačević
UNIZG FER
Croatia

Blanka Gott
UNIZG FER
Croatia

4 PROGRAMME

The BTS programme consisted of:

- lectures where the latest scientific research and results are presented,
- field demonstrations that showcase the latest technology achievements made by research groups and companies,
- tutorials that offer hands-on experience working with complex and modern underwater systems,
- company presentations with insight from company professionals about their company and company products,
- student competitions that serve as a platform for applying the knowledge acquired from BTS lectures and tutorials to address real-world challenges in marine robotics and blue economy.

Fig. 1. BTS Opening session

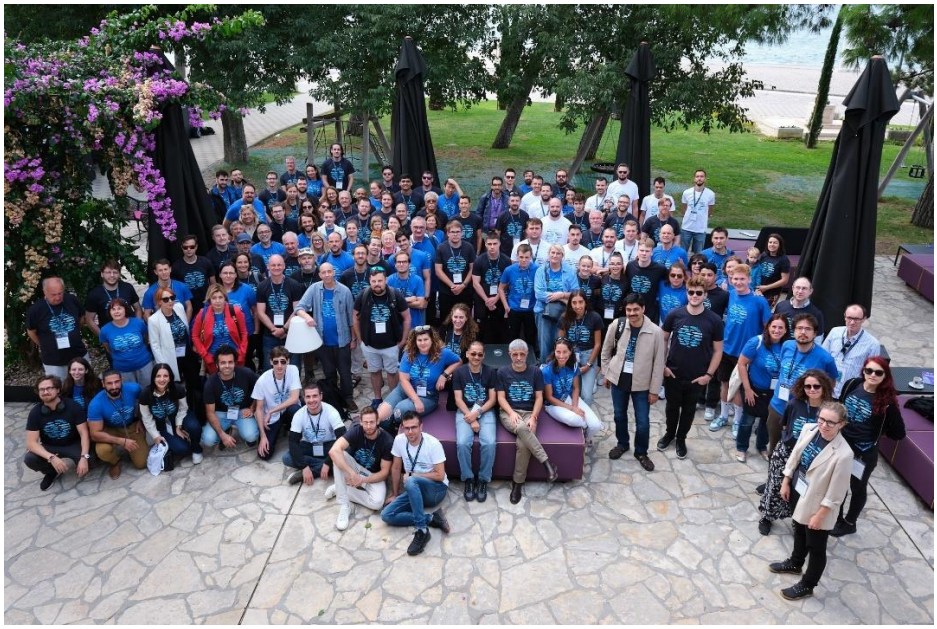


Fig. 2. Group photo of BTS 2024 participants

4.1 BTS Agenda

The daily lecture programme follows below with the list of talks and speakers and links to the abstracts, biographies and presentations of the lectures. The program is also available on the BTS 2024 website.

Day 1: 29th September		
Time	**Presentation title**	**Speakers**
16:30 - 18:00	Registration	
18:00 - 19:30	Welcome reception	Nikola Mišković, UNIZG-FER

Day 2: 30th September		
Time	**Presentation title**	**Speakers**
09:00 - 09:15	Opening session	Nikola Mišković, UNIZG-FER
09:15 - 10:00	Doing more with less – effective use of limited acoustic bandwidth (abstract)	Mandar Chitre, ARL, National University of Singapore
10:00 - 10:45	Expanding Ocean Observing Systems in time, space and the parameter dimensions for societal benefit (abstract)	Daniel Hayes, Cyprus Marine and Maritime Institute (CMMI)
10:45 - 11:15	Coffee break	
11:15 - 12:00	Technology and the Underwater Archaeology of the Southern Levant (abstract)	Gil Gambash, University of Haifa
12:00 - 12:45	Hear my ship. Discover the underwater radiated noise of various vessels: a new dataset and conclusions from the Adriatic (abstract)	Roee Diamant, University of Haifa
12:45 - 14:00	Lunch break	

14:00 - 14:45	TUTORIAL 1 INTRO: Uncovering the communication of sperm whales (abstract)	Guy Gubnitsky, University of Haifa
14:45 - 15:15	COMPANY PRESENTATION: DIVE IT d.o.o. (abstract)	Željko Pavlaković
15:15 - 16:00	Underwater localization challenge INTRODUCTION	Jeff Neasham, Newcastle University
16:15 - 17:45	T1 HANDS-ON: Uncovering the communication of sperm whales	Guy Gubnitsky, University of Haifa
16:15 - 17:45	Underwater localization challenge HANDS-ON	Jeff Neasham, Newcastle University
17:45 - 18:45	DEMOS DAY 1: AI ZEROCALIBER, SEA CRAS, DIVE-IT, CALIRAD, NUMAR, DEEP TREKKER	Company representatives/Project teams

Day 3: 1st October		
Time	**Presentation title**	**Speakers**
09:00 - 09:45	The effect of anthropogenic change and protection on fish movement patterns (abstract)	Jonathan Belmaker, School of Zoology, Faculty of Life Sciences & The Steinhart Museum of Natural History, Tel Aviv University, Israel
09:45 - 10:30	Technical advances to study effects of underwater noise exposure on hearing and behaviour of marine mammals (abstract)	Maria Morell, Institute for Terrestrial and Aquatic Wildlife Research (ITAW), University of Veterinary Medicine Hannover
10:30 - 11:00	Coffee break	
11:00 - 11:45	Funding the Gap in Ocean Technology (abstract)	Erika Montague, Schmidt Marine Technology Partners
11:45 - 12:30	Heterogeneous multi-agent systems for monitoring and preservation of marine environment (abstract)	Ivana Palunko, University of Dubrovnik, Laboratory for Intelligent Autonomous Systems (LARIAT)
12:30 - 13:45	Lunch break	
13:45 - 14:30	TUTORIAL 5 INTRO: Identifying Wrecks of the Deep (abstract)	Stephaine Blankshein, Felix Pedrotti, University of Southampton
14:30 - 15:15	TUTORIAL 7 INTRO: The SeaClear Project: A Use-case for Robotic Marine Litter Collection and Recycling Aspects (abstract)	Stefan Sosnowski, Technical University of Munich (TUM) Shahab Heshmati-Alamdari, Aalborg University Iva Pozniak, Matej Jelavić, University of Dubrovnik (LARIAT)
15:15 - 15:30	Break	
15:30 - 17:30	T5 HANDS-ON: Identifying Wrecks of the Deep	Kortney Opshaug - Blue Ocean Gear
15:30-17:30	T7 HANDS-ON: The SeaClear Project: A Use-case for Robotic Marine Litter Collection and Recycling Aspects	Stefan Sosnowski, Technical University of Munich (TUM) Shahab Heshmati-Alamdari, Aalborg University

		Iva Pozniak, Matej Jelavić, University of Dubrovnik (LARIAT)
15:30 - 18:30	Underwater acoustic challenge (Day 1)	Jeff Neasham, Newcastle University
17:30 - 18:30	DEMOS DAY 2: MASK, SEA CRAS, SEABER/MEPECO, dive-IT, AI ZEROCALIBER, CALIRAD, DEEP TREKKER, NUMAR	Company representatives/Project teams

Day 4: 2nd October		
Time	**Presentation title**	**Speakers**
09:00 - 09:45	Let's shrink it: Hydrobatic Underwater Robots for Confined Spaces (abstract)	Daniel Duecker, Technical University of Munich - Munich Institute of Robotics and Machine Intelligence (MIRMI)
09:45 - 10:30	Scalable Marine Robotics for a New Era of Ocean Exploration (abstract)	Giancarlo Troni, Monterey Bay Aquarium Research Institute (MBARI)
10:30 - 11:00	Coffee break	
11:00 - 11:45	Simulation-based smart testing of autonomous systems for digital assurance (abstract)	Stephanie Kemna, DNV
11:45 - 12:15	Company presentation: XYLEM (abstract)	Eloy Abscal Rob Thomson
12:14 - 12:45	Company presentation: DEEP TREKKER INC. (abstract)	Riccardo Caponi
12:45 - 14:00	Lunch break	
14:00 - 14:45	TUTORIAL 4 INTRO: Underwater photogrammetry systems: optical design, calibration and metrical performances (abstract)	Fabio Menna, Università Degli Studi Di Sassari
14:45 - 15:30	TUTORIAL 2 INTRO: Underwater optical 3D imaging (abstract)	Tomislav Petković, UNIZG FER
15:30 - 15:45	Break	
15:45 - 18:45	Underwater acoustic challenge (Day 1)	Jeff Neasham, Newcastle University
15:45 - 17:45	T4 HANDS-ON: Underwater photogrammetry systems: optical design, calibration and metrical performances	Fabio Menna, Università Degli Studi Di Sassari
15:45 - 17:45	T2 HANDS-ON: Underwater optical 3D imaging	Tomislav Petković, UNIZG FER
17:45 - 18:45	DEMOS DAY 3: XYLEM, DEEP TREKKER, dive-IT, SEABER/MEPECO, AI ZEROCALIBER, NUMAR	Company representatives/Project teams

Day 5: 3rd October		
Time	**Presentation title**	**Speakers**

09:00 - 09:30	INTRODUCTION TO MBZIRC TUTORIALS	Barbara Arbanas Ferreira, UNIZG FER
09:30 - 10:15	MBZIRC TUTORIAL 1 INTRO: Autonomous drones in GNSS-denied operation for search and object manipulation at sea by UNIZG-FER (abstract)	Barbara Arbanas Ferreira, UNIZG FER
10:15 - 11:00	MBZIRC TUTORIAL 2 INTRO: Operation of Heterogeneous UAV-USV system in a GNSS-denied maritime environment (abstract)	Shaoming He, Beijing Institute of Technology
11:00 - 11:30	Coffee break	
11:30 - 13:00	MBZIRC T1 HANDS-ON	Marijana Peti, Antun Ivanović, Jakob Domislović, Barbara Arbanas Ferreira, UNIZG FER
11:30 - 13:00	MBZIRC T2 HANDS-ON	Shaoming He
13:00 - 14:15	Lunch break	
14:15 - 15:00	MBZIRC TUTORIAL 3 INTRO: Autonomous catamaran in GNSS-denied operation for search and intervention at sea by UNIZG-FER (abstract)	Fausto Ferreira, UNIZG FER
15:00 - 15:45	MBZIRC TUTORIAL 4 INTRO: GNSS-denied over-water navigation for UAVs and USV by Nomagic Warsaw MIMotaurs (abstract)	Karol Pieniący, University of Warsaw
15:45 - 16:00	Break	
16:00 - 17:30	MBZIRC T3 HANDS-ON	Juraj Obradović, Matko Batoš, Natko Kraševac, Luka Mandić, Fausto Ferreira, Barbara Arbanas Ferreira, UNIZG FER
16:00 - 17:30	MBZIRC T4 HANDS-ON	
17:30 - 18:30	DEMOS DAY 4: XYLEM, NUMAR, AI ZEROCALIBER, dive-IT	Company representatives/Project teams

Day 6: 4th October		
Time	**Presentation title**	**Speakers**
09:00 - 10:15	Challenge presentations	
10:15 - 10:45	Coffee break	
10:45 - 11:30	Enhancing cetacean research through whale-watching tourism in the Mid-Atlantic (abstract)	Laura González García, Futurismo Azores Adventures / Institute of Marine Sciences - OKEANOS, Universidade dos Açores
11:30 - 12:00	MONUSEN Centre: Achievements in Underwater Sensor Networks and Marine Robotics (abstract)	Slavica Tomović, Igor Radusinovic, University of Montenegro, Faculty of Electrical Engineering
12:00 - 12:30	Company presentation: Fameline Energy (HMS) (abstract)	Fameline Energy

12:30 - 13:45	Lunch break	
13:45 - 14:30	TUTORIAL 6 INTRO: The Maritime Computer Vision Initiative (MaCVi): Use-Cases and Hands-On (abstract)	Janez Perš, University of Ljubljana Benjamin Kiefer, University of Tuebingen
14:30 - 15:15	TUTORIAL 3 INTRO: Integration of interdisciplinary data for landscape mapping of submerged ancient cities: the uBlueTec approach (abstract)	Jordy Moies, Jafar Anbar, Kalliopi Baika, Aix-Marseille University (AMU)
15:15-15:30	Break	
15:30- 17:30	T6 HANDS-ON: The Maritime Computer Vision Initiative (MaCVi): Use-Cases and Hands-On	Janez Perš, University of Ljubljana Benjamin Kiefer, University of Tuebingen
15:30-17:30	T3 HANDS-ON: Integration of interdisciplinary data for landscape mapping of submerged ancient cities: the uBlueTec approach	Jordy Moies, Jafar Anbar, Kalliopi Baika, Aix-Marseille University (AMU)
17:30-18:30	DEMOS DAY 5: NUMAR, ROADMAP, dive-IT	Company representatives/Project teams
19:30 - 20:00	Closing ceremony	
20:00 - 21:00	Gala dinner	

Day 7: 5th October	
Time	**Activity**
09:00 - 17:00	Field trip

5 Competitions for students and young researchers

5.1 Localisation challenge

The Underwater Localization Challenge at the BTS 2024 was vitally important for underwater exploration and data gathering. However, since radio waves are severely attenuated by sea water, researchers need to operate in a GPS denied environment. In contrast, underwater sound travels with much lower attenuation and they rely on acoustic systems to enable them to measure position. Whilst the slow speed of sound underwater is an advantage and enables us to measure propagation delays/distance very accurately, researchers must also overcome challenges posed by severe, time varying multipath effects (reverberation) and noise from many natural and man-made sources. This was an opportunity for teams to gain valuable, hands-on experience in how underwater acoustic systems work and collecting/processing acoustic data to estimate the location of a subsea device.

This year, 3 teams participated in the localization challenge, and were asked to locate a submerged miniature beacon using 1-way acoustic direction finding. The groups were given an acoustic recording system and 3 hydrophones that they could configure as they wish to form a receiving array. The 3 hydrophone channels were acquired simultaneously allowing time delays between signals arriving at each hydrophone to be estimated by correlating against the known signal transmitted by the beacon. Teams took the receiver

system out on a boat along with a GPS receiver and compass to gather georeferenced recordings from multiple locations. The teams then analysed the collected acoustic data offline (or even while on the boat) to estimate the position, presenting their results/method on the final day of the workshop. The teams competed on three aspects (1) a race to locate the beacon most quickly (2) the most accurate final position after post processing (3) the most innovative localization strategy. Experts accompanied the participating groups, during their preparation, data collection and analysis.

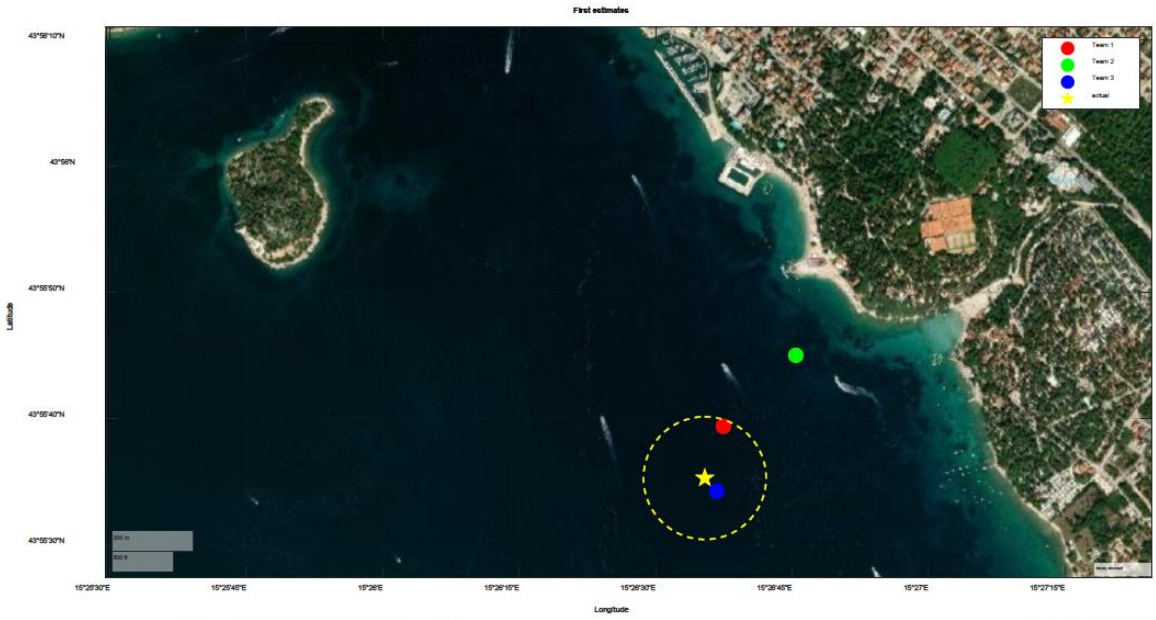
The challenge served not only as an intensive learning experience but also as a forum for emerging talents to showcase their capabilities in addressing real-world challenges. While the data showed varying degrees of success in meeting the challenge objectives, the event marked a significant step forward in both academic learning and practical skill development in underwater localization.

What is it?

- Locating a hidden device by acoustic positioning.
- Gain experience in acoustic data collection and processing.
- This year involved more **signal processing**.

Fig. 3. Localisation challenge introductory session and challenge description

First estimates



Final Estimates

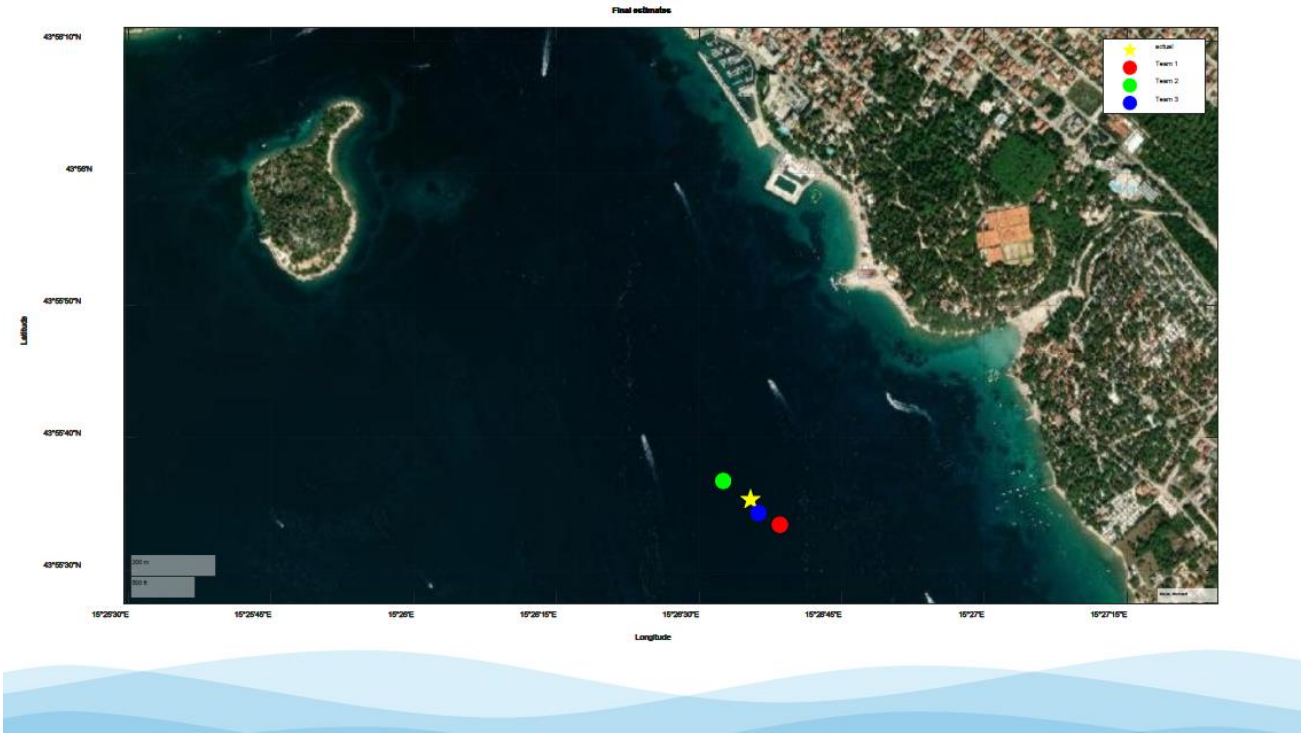
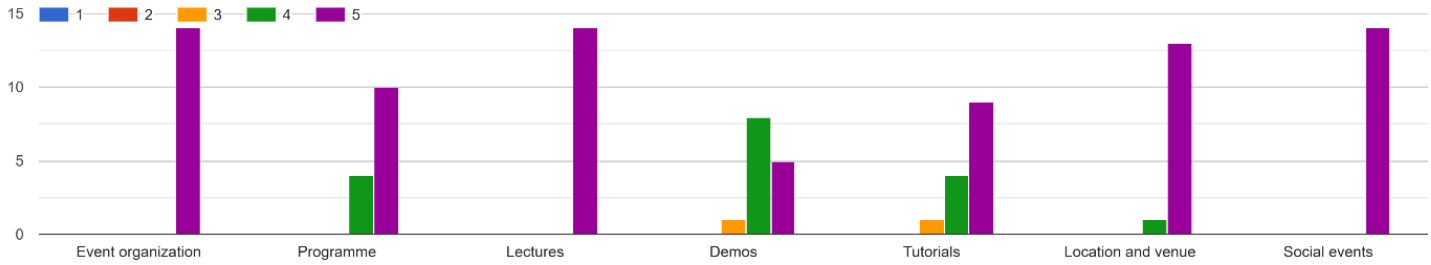


Fig. 4. Final localisation results

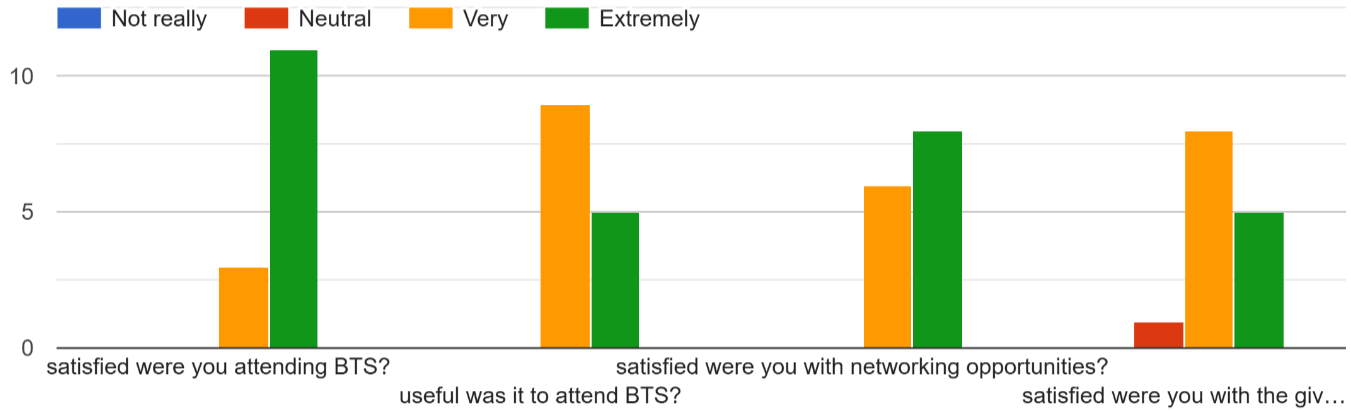
● 6. SURVEY RESULTS FROM PARTICIPANTS ON SUMMER SCHOOL EXPERIENCE

Below we present the results of survey focused on the summer school experience, which offers a detailed overview of the participants' perceptions and feedback.

How would you rate the following aspects of BTS (5 is the highest, 1 the lowest grade):



Overall, how...



Would you like to point anything out about these particular aspects of BTS?

(7 responses)

Overall very good. I would like to have a designated "chill" area for when there are lectures or demos that are not related to your field or interest so that you can go there and maybe meet up with other people for a chat.

I like more the prolonged hands-on activity like the localization challenge rather than the tutorials, because in 3-4 days it is easier to actually learn something useful rather than in just 2 hours of tutorial where you don't even have the time to understand the software.

Fantastic work keeping the event going, and organization is getting more and more smooth over the years.

Better projectors would be great.

The tutorials were all a little rushed, and some had materials that, if they had been shared a week before or so, we could all have downloaded and prepared for, but the info did not get to us in advance. I liked the opportunity to attend all tutorials, but an hour did not feel like enough to really learn much for many of the tutorials - I would recommend at least 2 hours for a good tutorial/workshop (and less time spent on intro - a 15min intro/teaser should also suffice). Also, many of the people participating in the UW challenge did not attend (and also skipped part of the lectures) - it might be useful to do the UW challenge on one day, separate from everything else, so as not to have people (especially students!) skip lectures and tutorials.

The localization challenge was very interesting and valuable! Would like to see a next challenge at BTS next year.

Maybe provide a 30-min session at the morning to outline all companies with their demos

What was the most interesting lecture for you?

(11 responses)

Doing more with less

Unfortunately I came too late for the lectures

Basically all of Thursday was very interesting.

Mandar Chitre Doing more with less – effective use of limited acoustic bandwidth

Maria Morell

Mandar Chitre

DOING MORE WITH LESS – EFFECTIVE USE OF LIMITED ACOUSTIC BANDWIDTH

Doing more with less – effective use of limited acoustic bandwidth

The Maritime Computer Vision Initiative (MaCVi): Use-Cases and Hands-On

Excellent content and presentations, cannot pick any particular

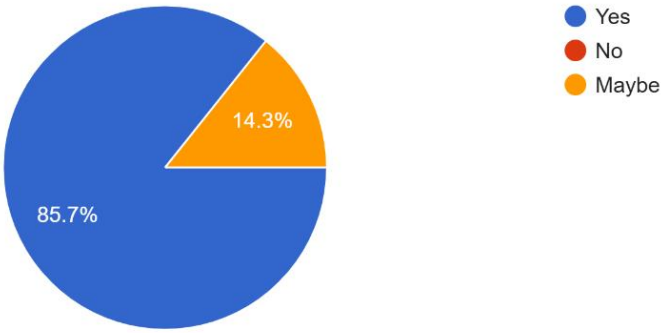
What topics would you recommend for lectures or tutorials next year?

(9 responses)

Maritime computer vision as a lecture?
I would like to have something about mechanical and electrical design challenges and system architecture for underwater robotics. And have a design show if there is some specific subsystem or architecture that they are particularly proud of.
Communication protocols, microplastic monitoring
Current selection of topics is great
Underwater robotics, autonomy, swarms, sensors: what's available (cameras, sonars, laser scanners etc.), advanced use of AI (ML/DL), positioning and navigation, communication, how to bring cost down and capabilities up.
Maritime Computer Vision
Autonomous surface vessels and Remote Sensing
-
Topics more AI oriented, computer vision, satellite images, remote sensing etc.

Would you like to attend BTS again?

14 responses



If you have any additional suggestions or comments, feel free to add them here:

(4 responses)

Would be good to encourage people to bring business cards or have a few buisness cards for each participant already printed out as part of the goody bag.

Keep up the great work!

Less parallel demos and better signage/info on tutorial/demos organization.

The localization challenge was very interesting and valuable. Kudos to the organizers. I hope there will be a next edition at BTS next year.