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~ MONtenegrin center for
Underwater SEnsor Networks ~

EXPERT VISIT 4

8 – 9 May 2024

UNIZG-FER

UCG
Univerzitet Crne Gore

ISTITUTO DI INGEGNERIA DEL MARE
INSTITUTE OF MARINE ENGINEERING

FER

UNIVERSITY OF ZAGREB
Faculty of Electrical
Engineering and
Computing

Newcastle
University

1. VENUE

Room 308, University of Montenegro, Faculty of Electrical Engineering (UoM)
Cetinjska 2, Podgorica 81000, Montenegro

2. PREREQUISITES FROM PARTICIPANTS

- Basic knowledge of robotics
- Basic knowledge of communication systems

3. SCHEDULE

Day 1: 8 May 2024 (Wednesday)

10:15 - 11:00	**Towards diver-robot interaction** by Assist. Prof. Đula Nađ
11:00 – 11:15	Break
11:15 - 12:00	**Towards diver-robot interaction** (cont.) by Assist. Prof. Đula Nađ
12:00 - 13:00	Break
13:15 - 14:00	**Uncovering the "language" of sperm whales** by Guy Gubnitsky, PhD candidate
14:00 – 14:15	Break
14:15 - 15:00	**Uncovering the "language" of sperm whales** by Guy Gubnitsky, PhD candidate
15:00 - 15:30	**Discussion**

Day 2: 9 May 2024 (Thursday)

10:15 - 11:00	**LiDAR-based docking and collision avoidance – MBZIRC 2023** by Matko Batoš, PhD candidate
11:00 – 11:15	Break
11:15 - 12:00	**Object detection at sea - Obstacle Detection Marine Computer Vision Challenge 2024** by Matej Fabijanić, graduate finalist

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4. EXPERT VISIT PLANNED OUTCOMES:

- Get an overview of different methods for diver-robot interaction
- Get theoretical and practical knowledge on acoustic detection of sperm whale communications
- Get introduced to LIDAR-based methods for docking and collision avoidance in a GPS-denied real scenario
- Get introduced and acquired knowledge on object detection at sea using cameras

5. LECTURE DESCRIPTION:

1. Towards diver-robot interaction

The lecture presents a high-level overview of building blocks in diver-robot interaction with focus on current research. Different interaction modalities for nonhumanoid underwater vehicles are reviewed. Wearable sensor technologies for enhancing interaction and collecting information about the diver are presented together with other elements in perception and control.

2. Uncovering the "language" of sperm whales

Recent advances in the field of neural networks enable translation between languages even in cases where no dictionary is available, such as ancient languages. The backbone of this capability is access to vast amounts of training data. Given this breakthrough, there has been a great deal of interest in recent years in the application of unsupervised machine translation (UMT) methods to decipher the communication of potentially intelligent animals, with most efforts focused on sperm whales, which have a unique communication system. However, to cope with the amount of data required for UMT, an automated tool to detect and annotate these signals is a prerequisite. In this talk, we will present a detector-based annotator for sperm whale communication signals. We will describe the main ideas and the theoretical formulation. Participants will then apply the annotation software to a sample recording of a short conversation between two whales. Finally, participants will be divided into groups and given time to try to match the annotated signals to their corresponding speaker based on the features extracted by the software. Teams that successfully complete this task will be able to uncover the "language-like" structure of sperm whales.

3. LiDAR-based docking and collision avoidance – MBZIRC 2023

LiDAR technology has become an integral part of autonomous navigation systems, especially in maritime applications, where precision and reliability are important. First, the ASV (Autonomous Surface Vehicle) uses LiDAR data to navigate to the target while maintaining a safe distance to avoid collisions with other nearby objects and ships. The system uses a sophisticated collision avoidance mechanism that dynamically assesses potential hazards by projecting future positions based on the ASV's current trajectory and speed, adjusting its course if necessary to avoid incidents. When approaching the docking target, the ASV switches to a refined LiDAR-based relative localization technique. In this phase, the point cloud data is clustered and tracked to accurately identify the target and determine a reliable relative position. The ASV then performs a series of maneuvers in which it adjusts its orientation and position relative to the target to prepare for the final docking phase.

4. Object detection at sea - Obstacle Detection Marine Computer Vision Challenge 2024

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Sharing of insights from a challenging obstacle detection competition in maritime environments, exploring the possibilities of employing computer vision techniques to detect obstacles from camera images amid dynamic water environments, and discussion of our approach that led to success in the competition.

6. DESCRIPTION OF THE PARTNER INSTITUTION:

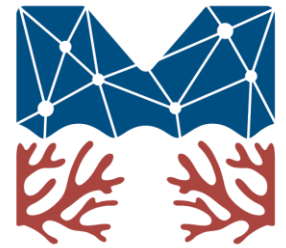**University of Zagreb, Faculty of Electrical Engineering and Computing (UNIZG-FER)**

Address: Unska 3
           Zagreb 10000
           Croatia

Website: https://www.fer.unizg.hr/en

Faculty of Electrical Engineering and Computing (UNIZG-FER) is part of University of Zagreb – the largest and oldest Croatian university. With 130 professors, 220 graduate teaching and research assistants, 4900 students enrolled in various programs, and operating in facilities of more than 35000 m2, UNIZG-FER is the largest technical high education institution and the leading educational and R&D institution in the fields of electrical and computer engineering and computer science in Croatia. UNIZG-FER is the highest-quality member of the University of Zagreb, with a large and modern infrastructure devoted to research-based education. UNIZG-FER is organised in 12 Departments which represent the focal points of education and R&D. Laboratory for Underwater Systems and Technologies (LABUST) is a research group within the Department of Control and Computer Engineering at the UNIZG-FER. At present, the Department consists of 14 professors and 60 researchers. LABUST (http://labust.fer.hr) research group has 17 members: 2 permanent staff, 1 professor emeritus, 1 senior researcher, 6 PhD students, 2 research engineers, 3 technical staff and 1 administrative person. The staff holds expertise in marine robotics: development and adaptation of marine vehicles (3 AUVs, 1 ASV); acoustic networks and sonars; identification, navigation, guidance and control of marine vessels; cooperative and coordinated formations of marine vehicles. LABUST is currently coordinating one national project, one ONR-G project and is a partner in one Horizon Europe project (MONUSEN). Recently they have coordinated two H2020 projects (Twinning EXCELLABUST and FET LaunchPad APAD) as well as two FP7 projects (FP7-ICT CADDY and FP7 CURE). In the last 5 years the group has participated in more than 20 international and national projects related to marine robotics. The LABUST group has experience in developing guidance and control software for industry. They have organised 13 annual field trainings "Breaking the Surface" with the purpose of conducting multidisciplinary research within marine biology, archaeology, and security.

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7. BIOGRAPHIES OF LECTURERS

Assist. Prof. Đula Nađ

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Email: dula.nad@fer.hr

Đula Nađ is an assistant professor at the Laboratory of Underwater Systems and Technologies (LABUST), part of University of Zagreb Faculty of Electrical Engineering and Computing. He received his PhD in 2017 on the topic of guidance and control of autonomous underwater agents with acoustically aided navigation. Over the past 13 years of his career, he has participated in over 15 international projects as a researcher. His research interest includes navigation, guidance, and control of underwater vehicles, underwater localization aiding, embedded control systems and diver-robot cooperation.
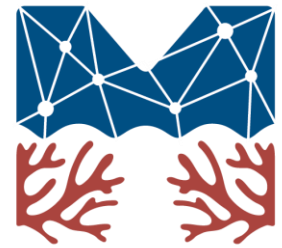

Guy Gubnitsky

Website: https://sites.google.com/edu.haifa.ac.il/anl/personnel

Email: ggubnits@campus.haifa.ac.il

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Guy Gubnitsky received his bachelor's degree in electrical engineering from Ariel University in 2018, specializing in electro-optics and medical imaging. In October 2019, he completed his master's degree at the Department of Marine Technologies at the University of Haifa, specializing in underwater signal and image processing. Guy is currently working on his PhD thesis, which deals with acoustic detection, classification and separation of sperm whale signals.

Matko Batoš

Website: https://www.fer.unizg.hr/matko.batos

Email: matko.batos@fer.hr

Matko Batoš, graduated in July 2022 with a master's degree in electrical engineering and information technology on the topic of "Unmanned aerial vehicle navigation based on magnetic field" at the Faculty of Electrical Engineering and Computing in Zagreb, Croatia. Part of the Laboratory for Underwater Systems and Technologies since 2023, with a focus on pursuing a PhD in data-driven modeling of maritime systems for prediction and fault detection.
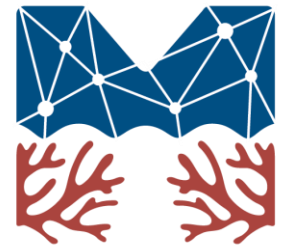

Matej Fabijanić

Email: matej.fabijanic@fer.hr

Matej Fabijanić is expected to graduate in July 2024 with a master's degree in software engineering and information systems on the topic of "Detection and classification of objects at sea using neural networks"

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at the Faculty of Electrical Engineering and Computing in Zagreb, Croatia. He is a part of the Laboratory for underwater systems and technologies since 2022, focused on working with computer vision related problems and researching neural networks for object segmentation and detection.

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