

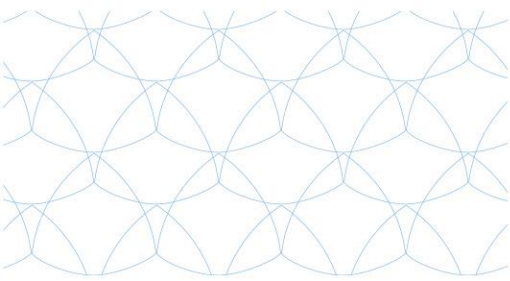
**EXCELLABUST**  
EXCELLING LABUST IN MARINE ROBOTICS

# TUTORIAL 3

## *Report*

18 - 20 January 2017

University of Limerick



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691980.



## 1. VENUE

TCR, University of Zagreb Faculty of Electrical Engineering (UNIZG-FER)  
Address: Unska 3, Zagreb, Croatia

## 2. SUMMARY

The expert visit to LABUST, University of Zagreb by researchers from MMRRC, University of Limerick has been very successful and executed according to plan. The first day started with Invited Lecture, presented by Dr Gerard Dooly, who initially provided an overview of research activities at UL, and then presented results from recent field trials with work-class ROV Holland 1.

The lecture on first day focused on modelling and simulation of marine craft, including kinematics and dynamics. Special attention has been devoted to quaternions and their role in vector rotations. Simulation models of open-frame ROVs, based on attitude representation with Euler Angles and Unit Quaternions, were gradually developed throughout the lecture. Full nonlinear 6 DoF dynamics model has been described, including nonlinear model of propulsion system dynamics and models of waves and ocean currents. Hands on exercises provided opportunity for students to implement and validate simulation models, introduced previously in theoretical sessions, in MATLAB/Simulink environment. Simulation model of generic open-frame ROV, based on attitude representation with Euler Angles, has been introduced first, highlighting singularity issues. Simulation model based on attitude representation with unit quaternions was introduced next, including transformation blocks to present attitude to users using conventional HMI. Finally, simulation model has been linked to Virtual Reality underwater scene to visualise ROV motion.

The lecture on second day focused on control aspects of a marine craft, including design and implementation of low-level controllers and fault-tolerant control system. Autotuning method for finding optimal gains has been described. The hybrid algorithm for control allocation, capable to find a feasible solution over the entire attainable input control space, was explained in detail. 3D visualisation of input and true control spaces was demonstrated, providing deep insight into geometry of underlying control allocation optimisation problem. Real-world applications of proposed algorithm have been presented. Hands on exercises provided more insight into control system for ROV/USV using demonstration platform - subsystem of OceanRINGS (smart technologies for subsea operations, developed by MMRRC, UL). Features include full 6 DoF motion of ROV/USV in presence of waves and ocean currents, range of control modes (from pure manual, over semi-manual to fully automated), autotuning, and dynamic positioning in absolute frame or relative to reference frame.

The lecture on third day focused on development of interface between control software and physical actuators (thrusters) using NI myRIO. Two approaches have been explained: (i) approach based on Express VI (RT only, without need to develop FPGA code), and (ii) approach based on RT & FPGA code development. Methods to overcome friction/dead zones for low speed rotations have been demonstrated for both approaches. The hands on practical session demonstrated how to use FPGA to generate PWM signals for high precision speed and direction control of Blue Robotics T200 thrusters.

The outcomes of the expert visit:

- Learn basic principles of modelling, simulation and control of marine craft, including transformation of reference frames, kinematics and dynamics equations of motion, disturbances, control allocation, and low-level motor control.
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- Explore tools for simulation, control design, and real-time control using MATLAB, LabVIEW, myRIO and ROV thrusters.

The tutorial allowed meeting many students, researchers and academic staff from University of Zagreb and University of Sarajevo, and exchange of ideas and research interests.

### 3. LIST OF PARTICIPANTS

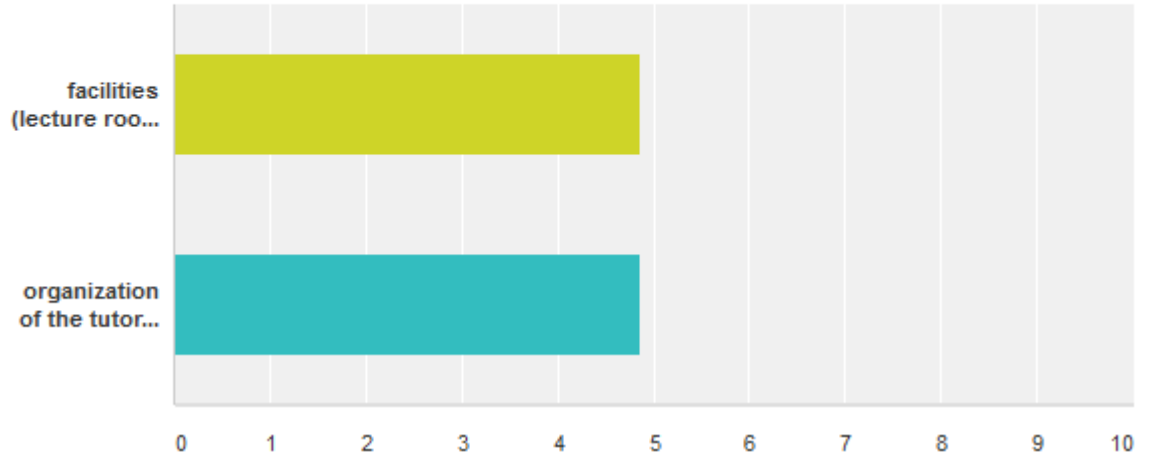
1. Anja Babić – PhD student; [anja.babic@fer.hr](mailto:anja.babic@fer.hr)
2. Nadir Kapetanović - PhD student; [nkapetanov1@etf.unsa.ba](mailto:nkapetanov1@etf.unsa.ba)
3. Ivan Lončar – PhD student; [ivan.loncar@fer.hr](mailto:ivan.loncar@fer.hr)
4. Filip Mandić - PhD student; [filip.mandic@fer.hr](mailto:filip.mandic@fer.hr)
5. Armin Dajić – PhD student - [adajic1@etf.unsa.ba](mailto:adajic1@etf.unsa.ba)
6. Stjepan Bogdan – Professor – [stjepan.bogdan@fer.hr](mailto:stjepan.bogdan@fer.hr)
7. Nikola Mišković – Professor – [nikola.miskovic@fer.hr](mailto:nikola.miskovic@fer.hr)

### 4. SURVEY RESULTS

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## How would you rate the quality of:

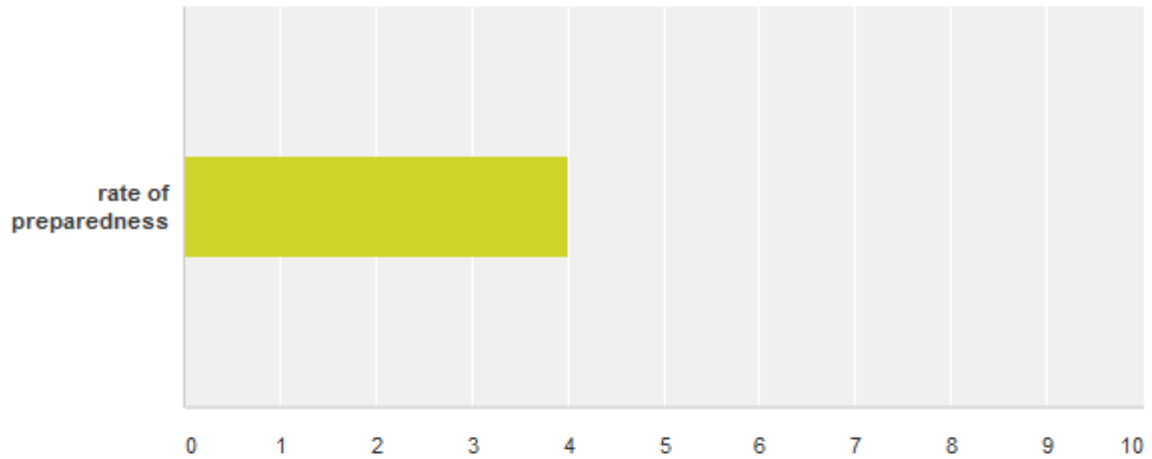
Answered: 7 Skipped: 0



	Bad	Below average	Average	Above average	Excellent	Total	Weighted Average
facilities (lecture room, wireless internet, etc.)	0.00% 0	0.00% 0	0.00% 0	14.29% 1	85.71% 6	7	4.86
organization of the tutorial (syllabus, breaks, etc.)	0.00% 0	0.00% 0	0.00% 0	14.29% 1	85.71% 6	7	4.86

## How would you rate your preparedness for the tutorial?

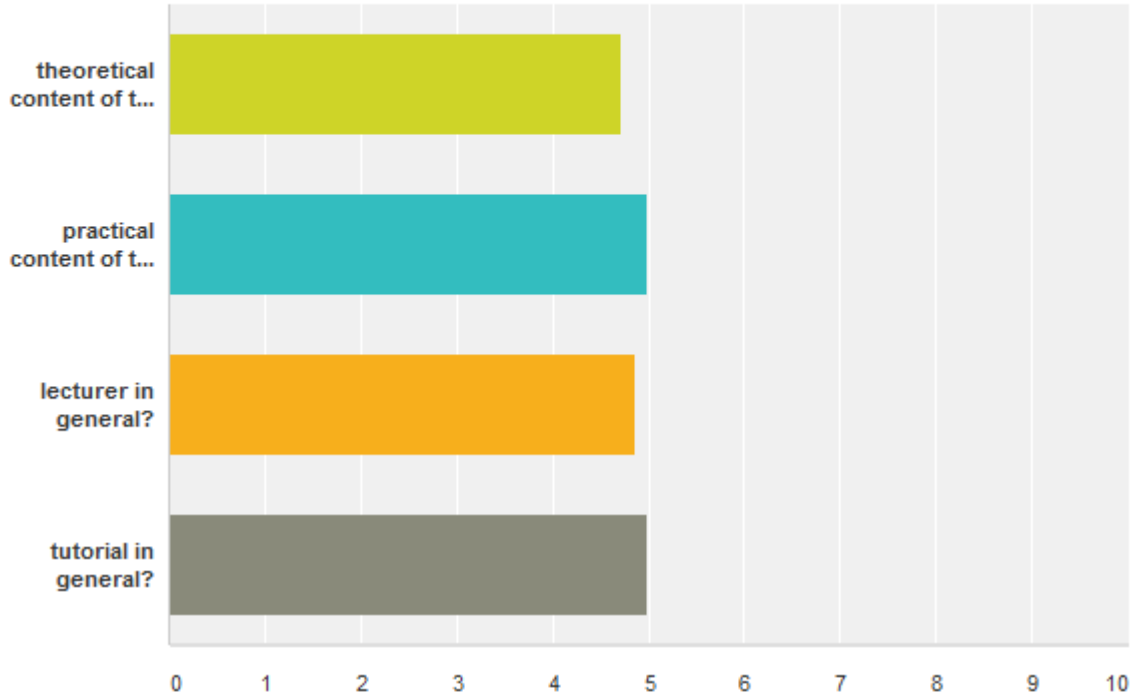
Answered: 7 Skipped: 0



	Bad	Below average	Average	Above Average	Excellent	Total	Weighted Average
rate of preparedness	0.00% 0	0.00% 0	28.57% 2	42.86% 3	28.57% 2	7	4.00

## How satisfied were you with the:

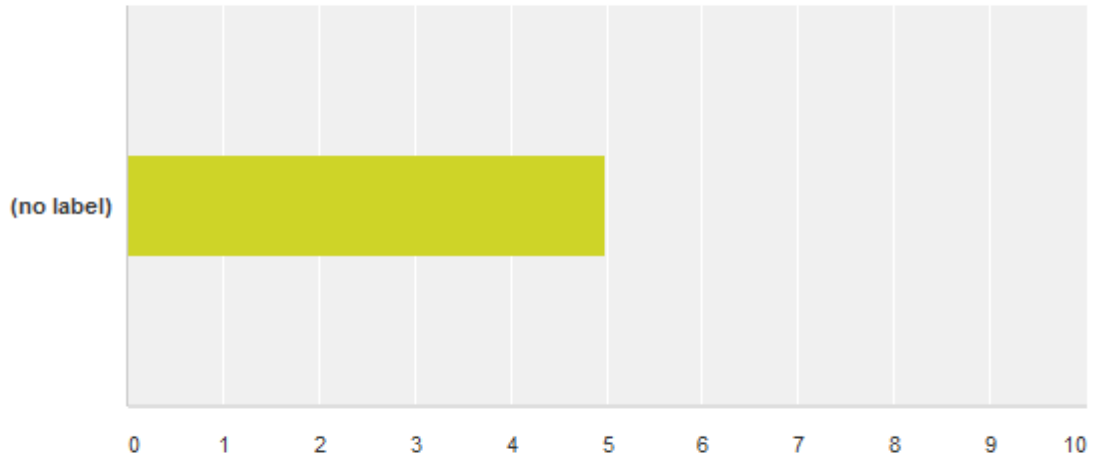
Answered: 7 Skipped: 0



	Bad	Below Average	Average	Above Average	Excellent	Total	Weighted Average
theoretical content of the tutorial?	0.00% 0	0.00% 0	0.00% 0	28.57% 2	71.43% 5	7	4.71
practical content of the tutorial?	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 7	7	5.00
lecturer in general?	0.00% 0	0.00% 0	0.00% 0	14.29% 1	85.71% 6	7	4.86
tutorial in general?	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 7	7	5.00

## How knowledgeable in the tutorial content was your lecturer?

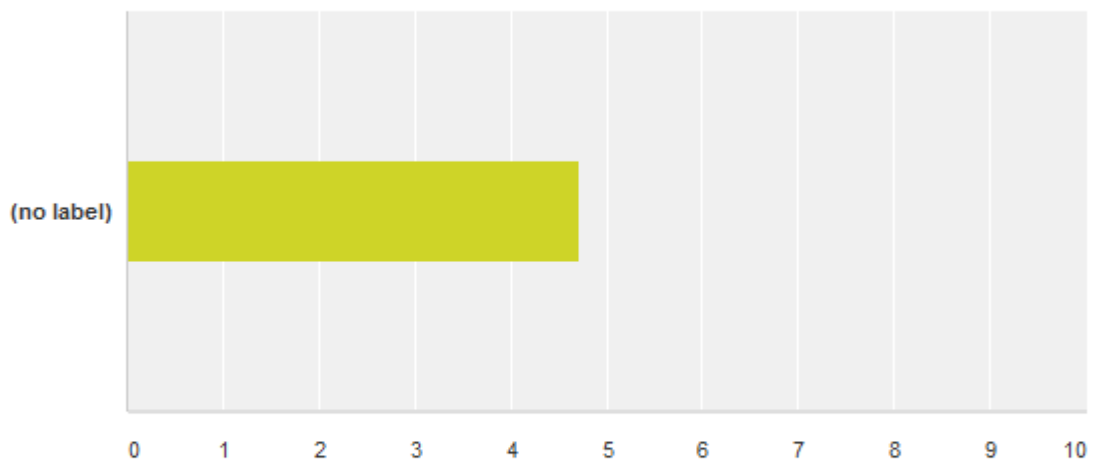
Answered: 7 Skipped: 0



	Bad	Below Average	Average	Above Average	Excellent	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 7	7	5.00

## Did the tutorial meet your expectations?

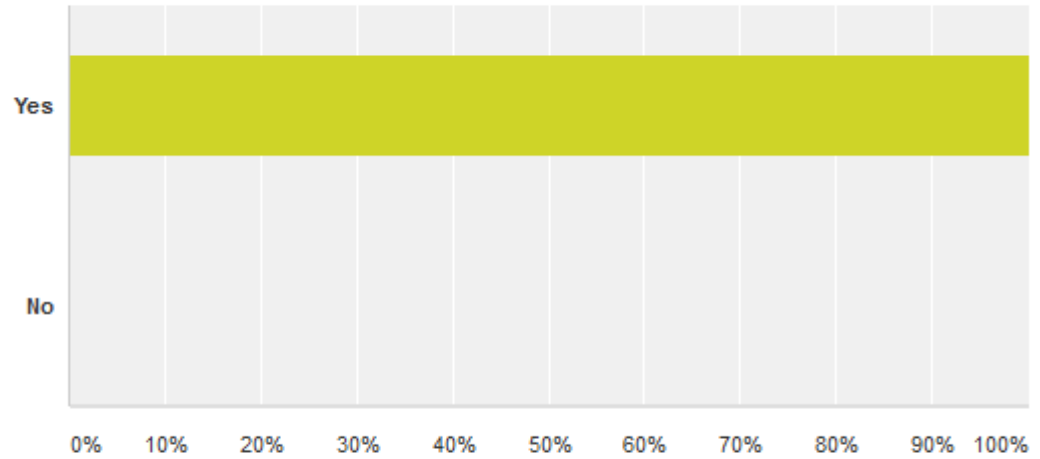
Answered: 7 Skipped: 0



	Bad	Below Average	Average	Above Average	Excellent	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	28.57% 2	71.43% 5	7	4.71

## Would you attend another tutorial organized within the scope of EXCELLABUST project?

Answered: 7 Skipped: 0

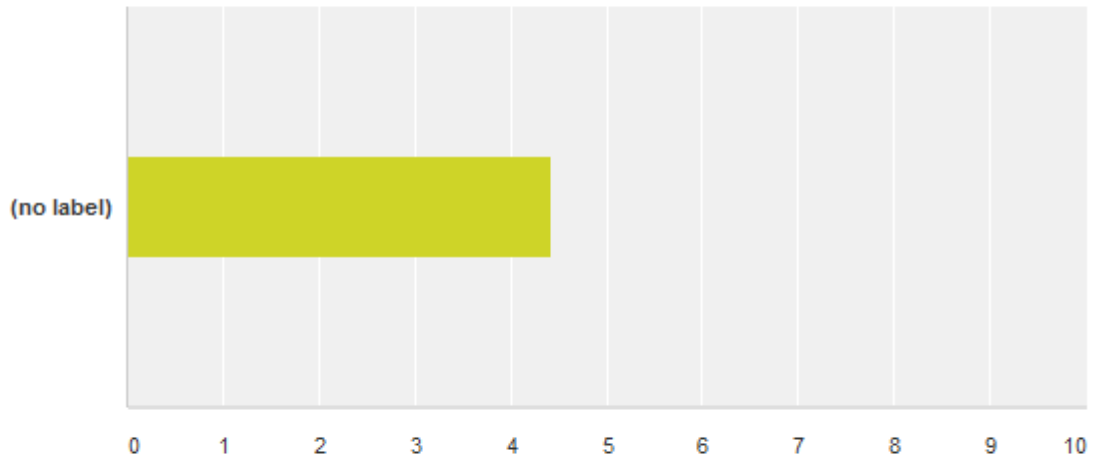


Answer Choices	Responses
Yes	100.00% 7
No	0.00% 0
Total	7



## How would you rate your level of knowledge about the topic of the tutorial after attending tutorial, compared with the knowledge you had about the topic before attending the tutorial?

Answered: 7 Skipped: 0



	Bad	Below Average	Average	Above Average	Excellent	Total	Weighted Average
(no label)	0.00% 0	0.00% 0	0.00% 0	57.14% 4	42.86% 3	7	4.43

## Which part of the tutorial did you find

Answered: 4 Skipped: 3

Answer Choices	Responses
<b>the MOST useful?</b>	<b>Responses</b> 100.00% 4

● Responses (4)
☁ Text Analysis
📁 My Categories

Categorize as...
Filter by Category
Search responses

Showing 4 responses

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Practical demo  
2/6/2017 9:19 PM [View respondent's answers](#)

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lecture related to quaternions  
2/6/2017 6:12 PM [View respondent's answers](#)

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Labview interfacing with myRIO, quaternions visualization, matlab model of the AUV  
2/6/2017 5:55 PM [View respondent's answers](#)

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LabView integration  
2/6/2017 4:39 PM [View respondent's answers](#)

Answer Choices	Responses
<b>the LEAST useful?</b>	<b>Responses</b> 50.00% 2

● Responses (2)
☁ Text Analysis
📁 My Categories

Categorize as...
Filter by Category
Search responses

Showing 2 responses

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all parts of the tutorial were useful  
2/6/2017 6:12 PM [View respondent's answers](#)

## Do you have any further comments/recommendation on the tutorial/lectures/organization?

Answered: 1 Skipped: 6

● Responses (1)   Text Analysis   My Categories

Categorize as...   Filter by Category   Search responses

Showing 1 response

Nice job Edin, just keep the good work!  
2/6/2017 5:55 PM   [View respondent's answers](#)

## 5. PHOTOS