

## EMERALD International Summer School 2023 edition – brief overview

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Faculty of Industrial Engineering, Robotics & Production  
Management, Technical University of Cluj-Napoca, Romania  
Coordinator of the SEE - 21-COP-0019 - EMERALD project



# European Network For 3D Printing Of Biomimetic Mechatronic Systems



EMERALD project - European Network for 3D printing of Biomimetic Mechatronic Systems



EMERALD International Summer School on:

## Virtual e-learning platform experience in bio-mechatronics



28 AUGUST -  
4 SEPTEMBER  
2023

**WHO  
can apply**  
Bachelor students (BSc)  
Master students (MSc)  
PhD students

**SPECIALIZATIONS:**  
Manufacturing Engineering  
Bio-Mechatronics & Robotics  
Mechanical & Bio-Mechanical Engineering  
Computer Science & Automatics  
Science of Materials

More details  
[www.project-emerald.eu](http://www.project-emerald.eu)  
Registration until 18<sup>th</sup> of August 2023

Organized at the University of Agder, Norway  
by the EMERALD project consortium partners



### EMERALD International Summer School on virtual e-Learning platform experience in Bio-Mechatronics – 28 August - 4 September 2023

h	Monday 28.08.2023	Tuesday 29.08.2023	Wednesday 30.08.2023	Thursday 31.08.2023	Friday 01.09.2023	Saturday 02.09.2023	Monday 04.09.2023	h
10	Opening ceremony and EMERALD project presentation	VR programming and applications in bio-mechatronics	AR applications in bio-mechatronics	Mixed Reality applications in bio-mechatronics	Digital manufacturing and Digital testing	VR, AR and mixed reality applications made by the students for the EMERALD e-learning virtual platform	Finalizing progress report and preparing final presentation - working on smaller groups)	10
11	Participants' presentation and program guidelines of the summer school	VR Unity applications – laboratory on realizing programming in VR – part 1	AR Unity applications – laboratory on realizing programming in AR – part 1	Mixed reality experience – laboratory on realizing programming in Mixed Reality	Smart and Intelligent materials		Final test, final questionnaires and feedbacks fulfilled by the participants concerning the organized summer school + test corrections	11
12	Lunch & free time	Lunch & free time	Lunch & free time	Lunch & free time	Lunch & free time	Lunch & free time	Lunch & free time	12
13	Introduction to VR immersive technologies	VR Unity application – laboratory on realizing programming in VR – part 2	AR Unity application – laboratory on realizing programming in AR – part 2	EMERALD e-learning platform – concept presentation and Kuula presentation (basic concepts)	Digital factory - lecture Digital factory - seminar	Feedbacks provided regarding the content and functionality of the platform, sketching of potential scientific articles to be published by the EMERALD partners "in common"	Final student presentations, live demonstrations presenting and defining of common ideas of future diploma projects	13
14	Introduction to VR/AR and haptic technology integration in education	VR Unity application – laboratory on testing with VR goggles	AR Blender application – laboratory of programming for realizing apps in AR	Kuula seminar – working on the EMERALD e-learning platform (virtual laboratories updating)	Presentation on behalf of companies, themes and feedbacks received from the companies	Finalizing progress report and preparing final presentation - working on smaller groups	Final conclusions, future perspectives of continuing the directions and using of resources conceived within the EMERALD project	14
15	Presentation of case studies and dividing into smaller groups	Conclusions, feedbacks and progress report	Conclusions, feedbacks and progress report	Conclusions, feedbacks and progress report	Conclusions, feedbacks and progress report	Conclusions, feedbacks and progress report	Closing and final awarding ceremony	15

## Opening ceremony and project presentation



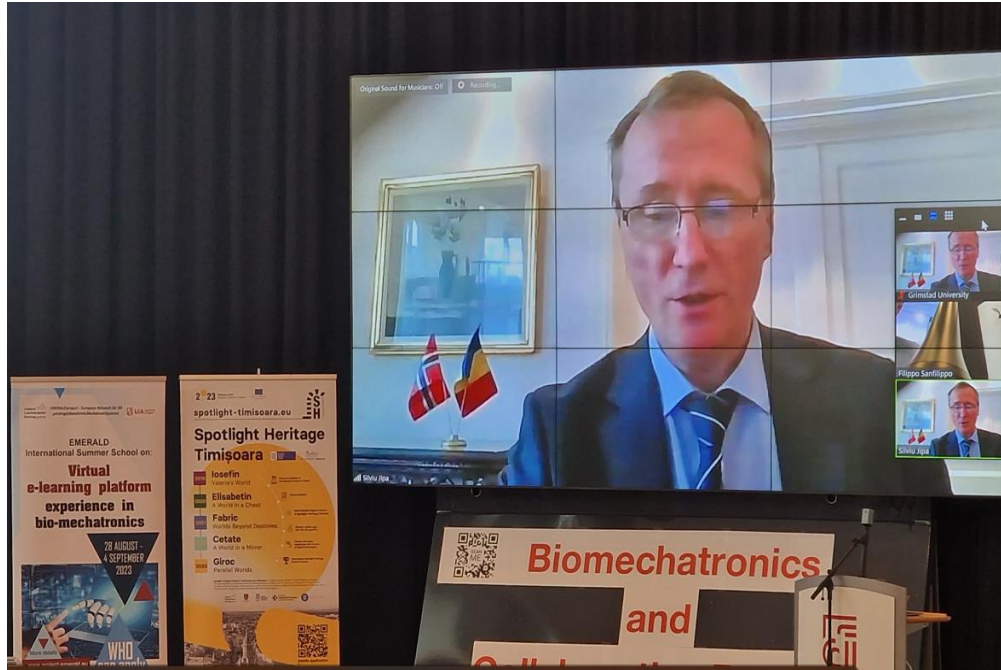
Welcoming speech of Prof. Filippo Sanfilippo – University of Agder (Norway)

## Opening ceremony and project presentation



Welcoming words addressed by Prof. Prof.dr.Hilde Inntjore – Vice Rector for Education, University of Agder (Norway)

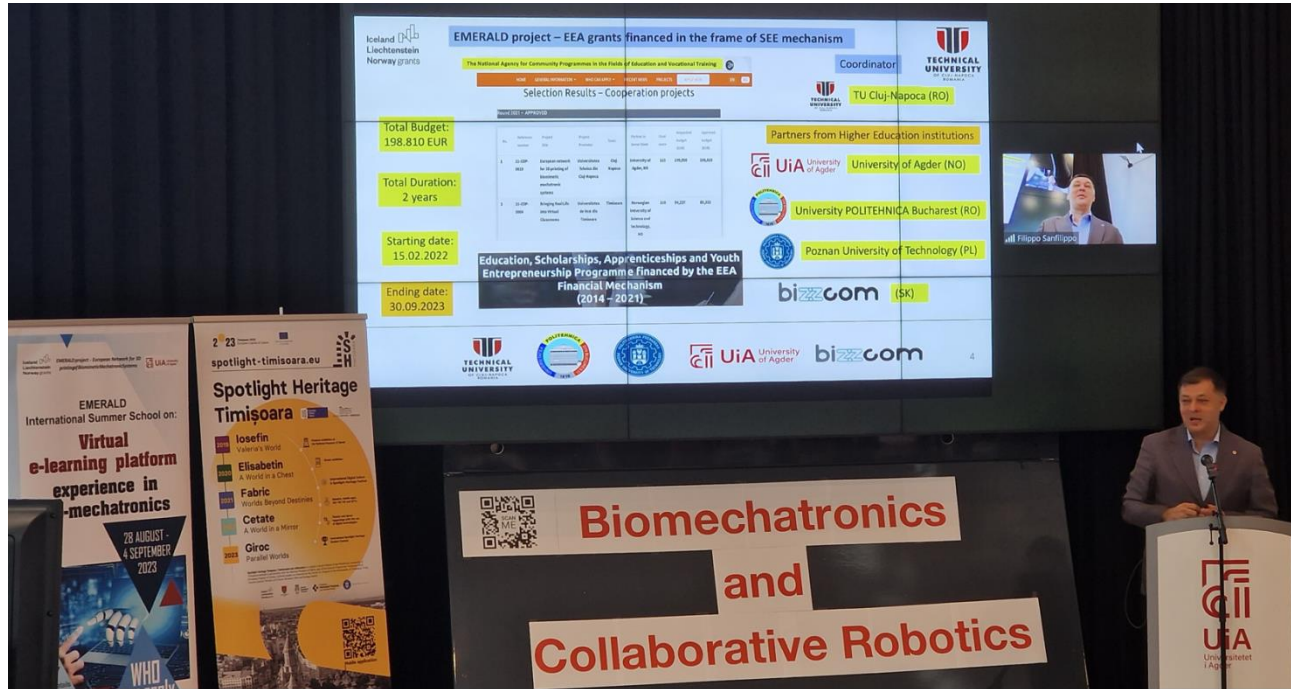
## Opening ceremony and project presentation



Remotely (online presentation) on behalf of Romanian Embassy in Norway, Mr. Silviu JIPA, Minister Counsellor

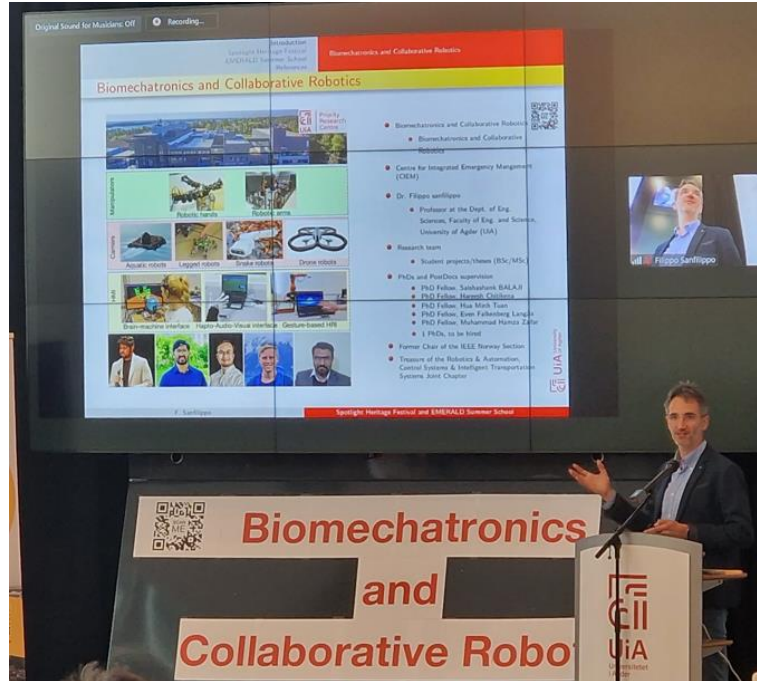
# European Network For 3D Printing Of Biomimetic Mechatronic Systems

## Opening ceremony and project presentation



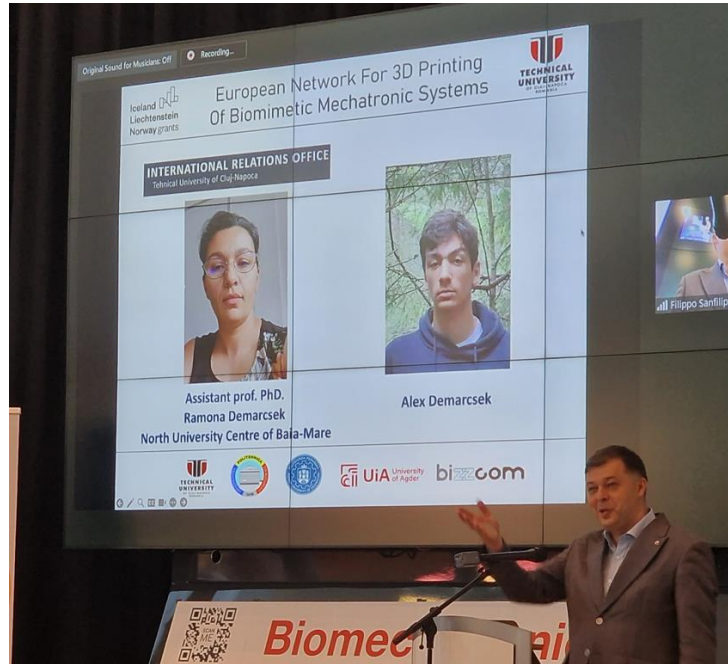
**Aims, actions, activities and achievements of the project – presented by Associate prof. dr.eng. Răzvan Păcurar (TUCN -Romania) – director of the EMERALD project**

## Participants' presentation



University of Agder (Grimstad, Norway)

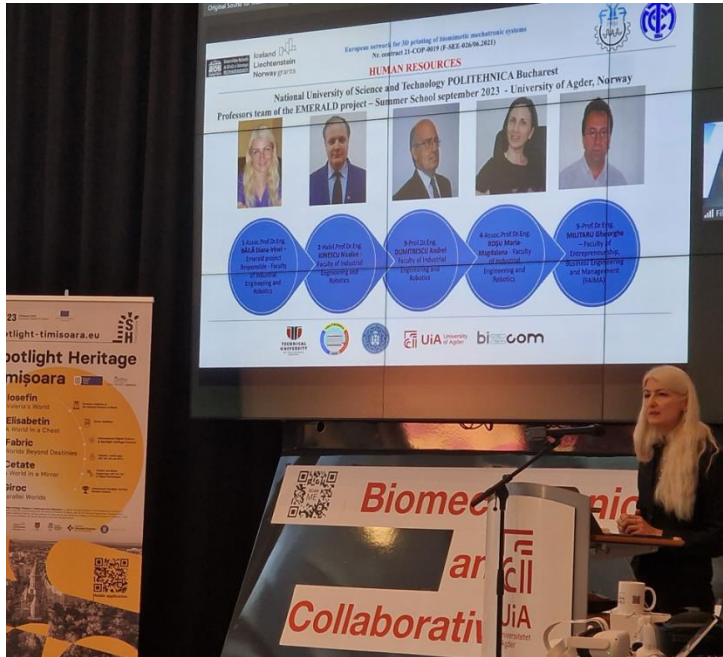
## Participants' presentation



Technical University of Cluj-Napoca (Romania) – leading partner of the EMERALD project



## Participants' presentation



University Politehnica of Bucharest (Romania)

## Participants' presentation



Poznan University of Technology (Poland)

## Participants' presentation



BIZZCOM s.r.o. company (Slovakia)

## Participants' presentation



**EMERALD International summer school – unique of life, cultural and scientific experience**

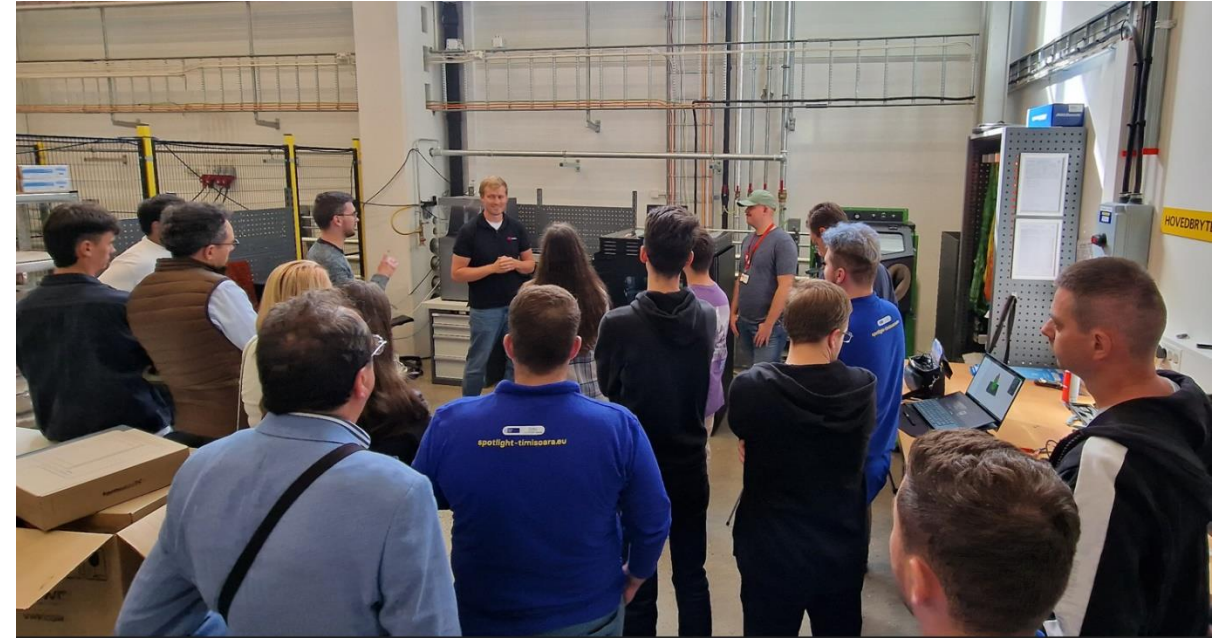
## Visiting of the UiA laboratories



Visiting of the MIL laboratory (University of Agder, Norway)

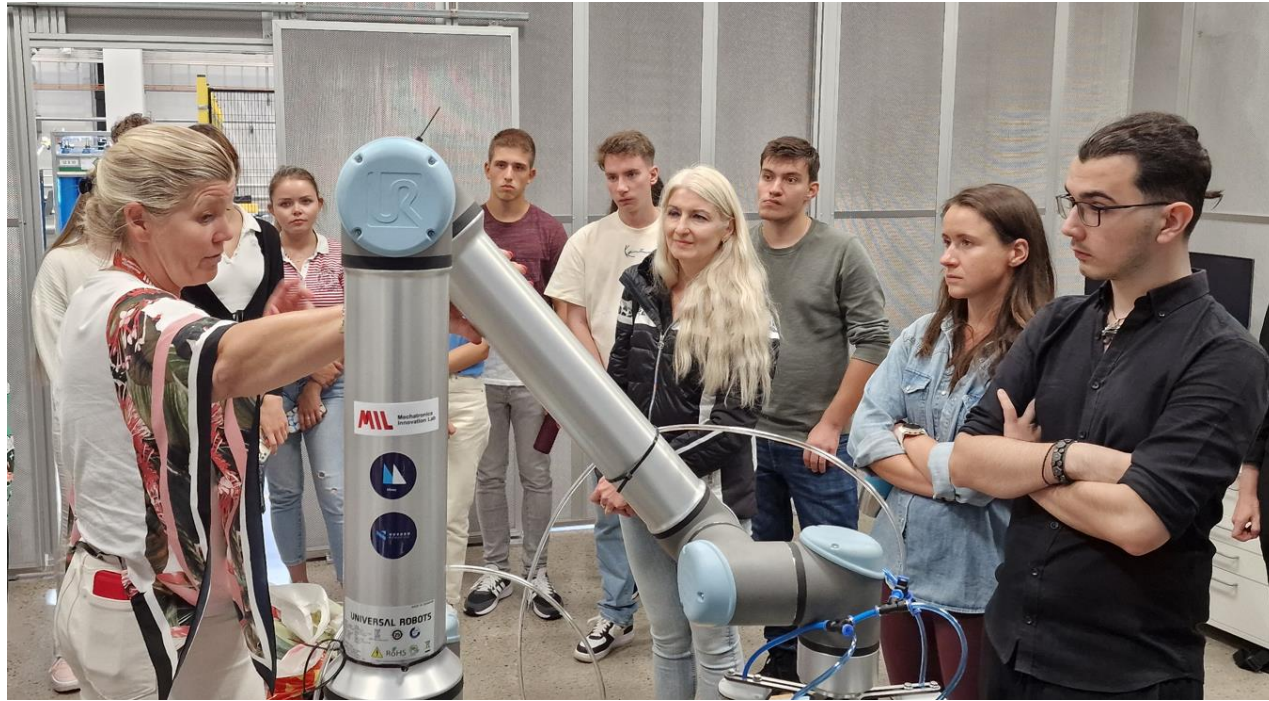
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## Visiting of the UiA laboratories



Visiting of the Brukertest LAB – usability lab (University of Agder, Norway)

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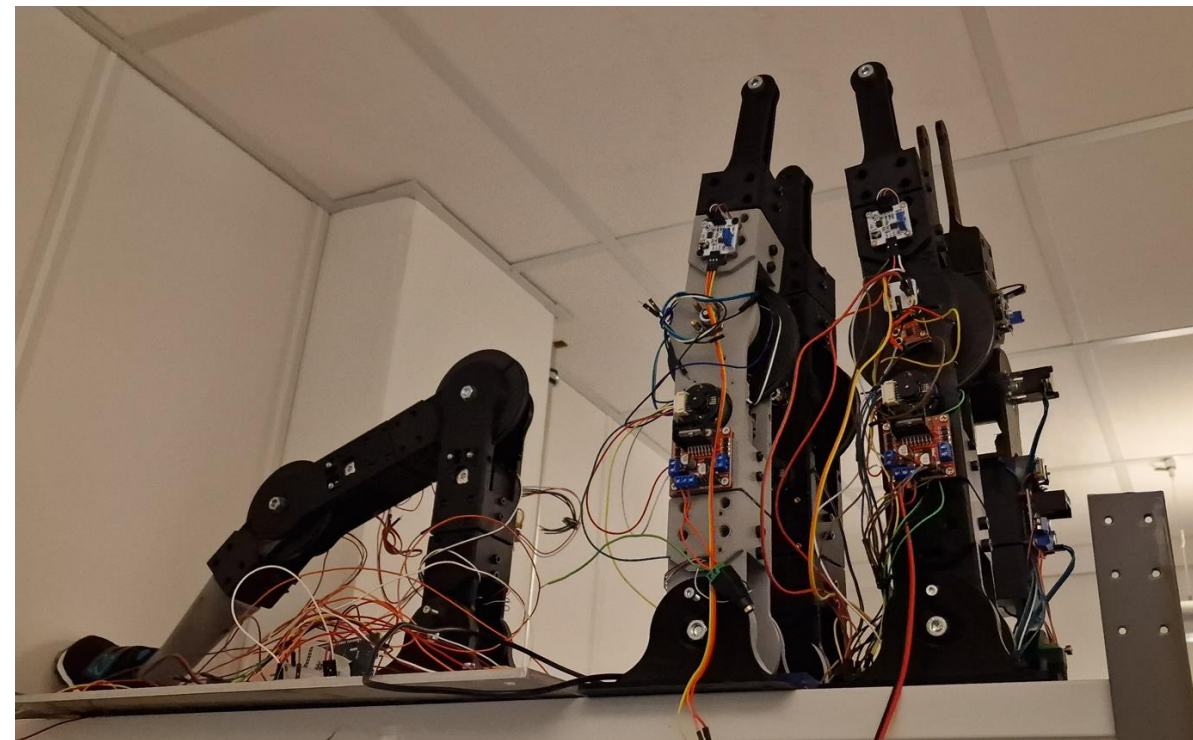
Visiting of the Top Research Center Mechatronics - TRCM - (University of Agder, Norway)

## Visiting of the UiA laboratories



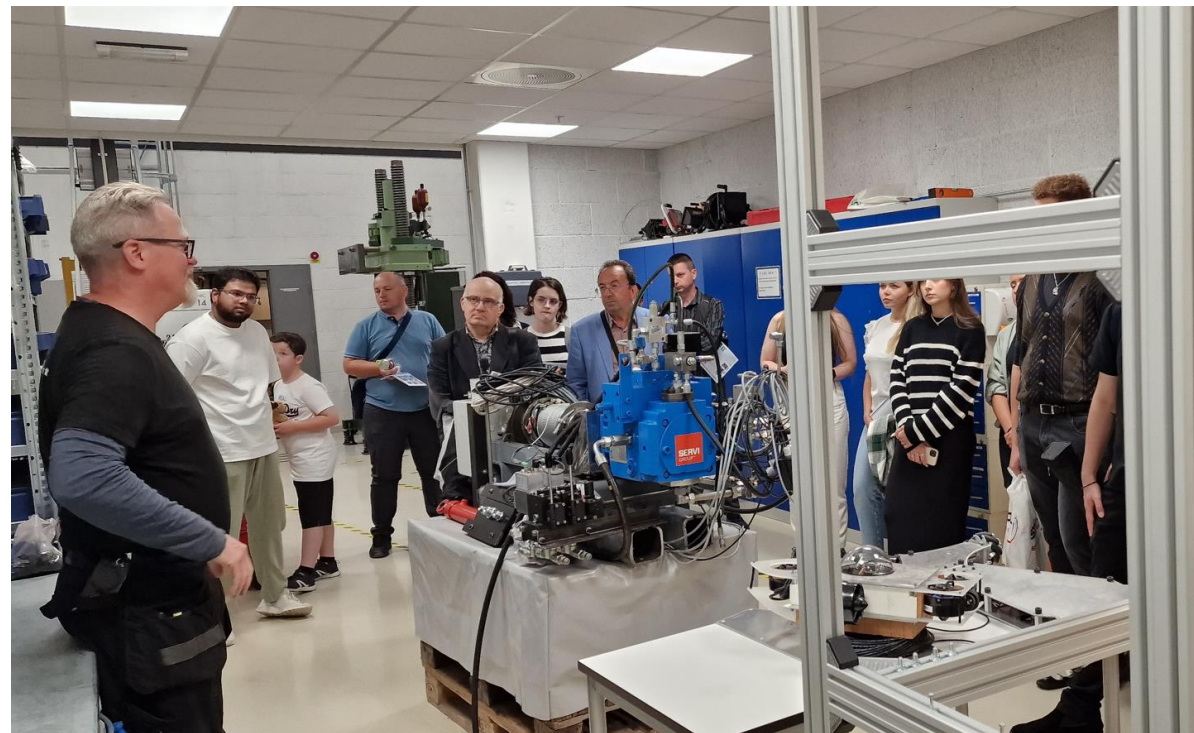
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## Lectures held by the EMERALD professors



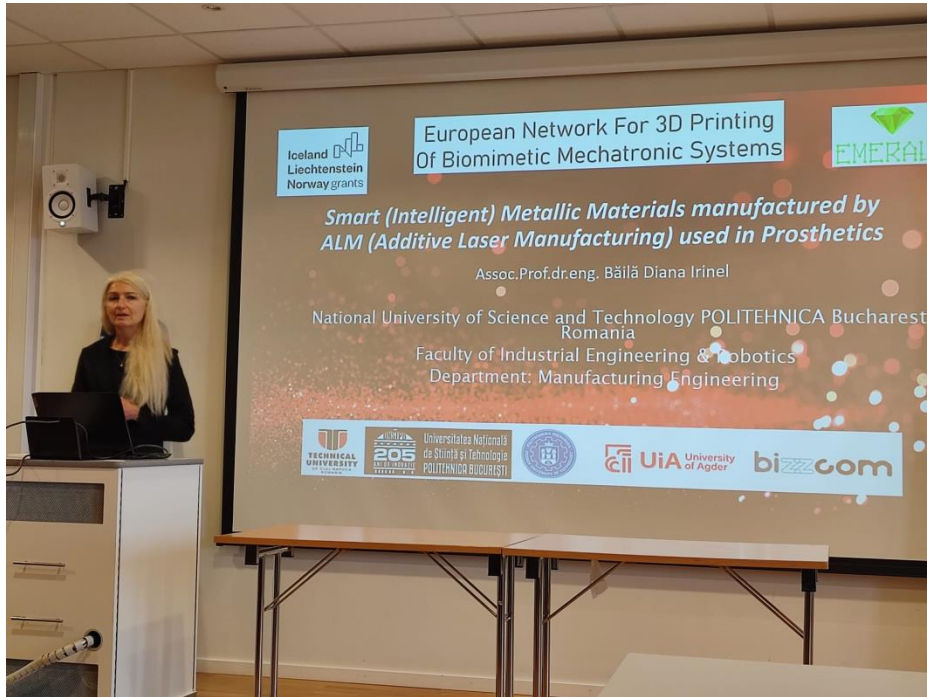
Introduction to VR/AR and haptic technology integration in education – prof. Filippo Sanfilippo (University of Agder - Norway)

## Lectures held by the EMERALD professors



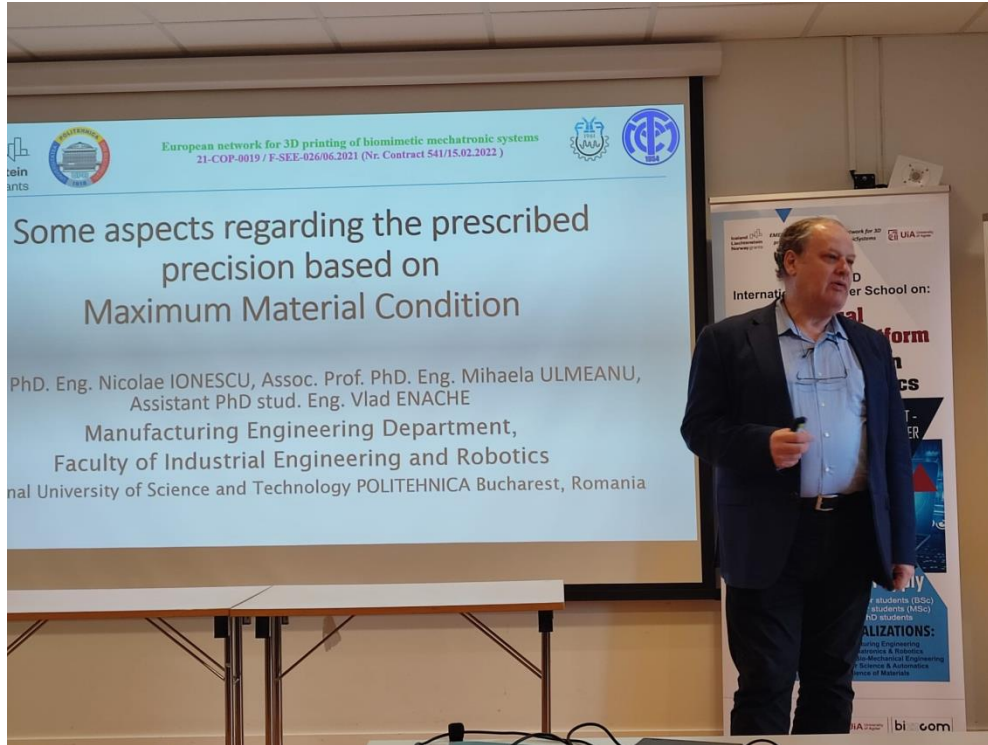
Automated design of 3D printed bio-mechatronic devices– Associate. prof. Filip Gorski (PUT - Poland)

## Lectures held by the EMERALD professors



Smart and Intelligent materials – Associate. prof. Diana Baila (UPB - Romania)

## Lectures held by the EMERALD professors



Precision and dimensional control – prof. Nicolae Ionescu (UPB - Romania)

## Lectures held by the EMERALD professors



Software instruments and project management – prof. Magdalena Rosu (UPB - Romania)

## Lectures held by the EMERALD professors



Plastics and product aesthetics— prof. Andrei Dumitrescu (UPB - Romania)

## Lectures held by the EMERALD professors



3D assets and VR applications – Lecturer Alin Plesa (TUCN - Romania)

## Lectures held by the EMERALD professors



Brain computer interfaces – Lecturer Alexandru Ianoși (TUCN - Romania)



## Lectures held by the EMERALD professors



Finite Element Analysis – Associate prof. Emilia Sabau (TUCN - Romania)

## Lectures held by the EMERALD professors



EMERALD virtual e-learning laboratory platform – Associate prof. Razvan Pacurar (TUCN - Romania)

## Companies presentations



Enterprise dynamics workshop + presentations of the Leycom company of Romania - provided by Associate prof.dr.eng. Diana Baila from University Politehnica Bucharest (Romania)

## Companies presentations



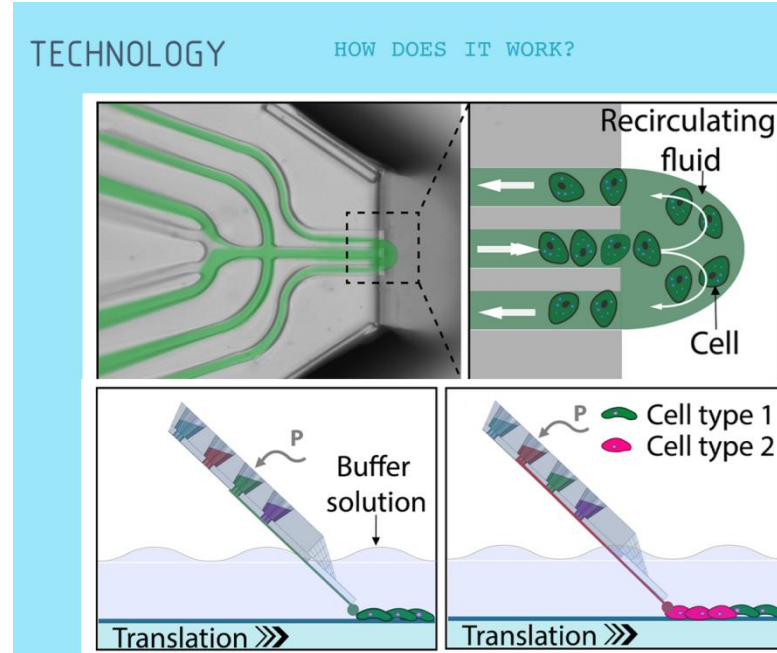
**Presentation made by Chief Business Developer and Sales Officer  
Nelson Khoo of Fluicell company from Goteborg (Sweden)**

## Companies presentations



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## Companies presentations



### INTRODUCTION

The discovery of novel and effective drugs is hampered by a low likelihood of acceptance (LOA) where more than 90% of all clinical drug candidates fail.<sup>1</sup> The selection of drug candidates is based on *in vitro* and *in vivo* experiments that largely fail to recapitulate the bona fide physiological effects in humans, calling for better predictive human surrogate models for drug discovery.

An important step in providing an alternative to 2D culture and animal models is the advancement of 3D models, where different cell types are combined in a 3D environment to mimic a tissue's extracellular matrix, biochemical and mechanical cues as well as cell-cell interactions seen *in vivo*.<sup>2</sup> More importantly, producing and combining multiple human tissue surrogate models that together demonstrate a biological system, eventually replacing animal models, is in line with the 3R principle (Reduce, Refuse and Replace the use of animals).

The non-alcoholic fatty liver disease (NAFLD) is a chronic disease that affects 20-50% of the population,<sup>3</sup> recognized by an abnormal accumulation of fat, which may eventually lead to liver failure and the need for liver transplantation.<sup>4</sup> Current models to target NAFLD include liver spheroids made by using ultraflow attachment plates and the seeding of cells,<sup>5</sup> applicable for high-throughput screening. However, the models are simple in nature by the lack of *in vivo* cell-microenvironment, and structural heterogeneity of the liver.<sup>6</sup>

Here, we present a novel application method to produce liver spheroids by using the Bioprinter bioprinting platform (Fluicell), carefully positioning cells in solution onto a substrate followed by gel encapsulation and culture (Figure 1). The method illustrates the potential to recreate the liver heterogeneity, with cell-cell contact prior to gel embedding, and tissue model maturation.

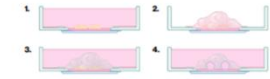


Figure 1. Illustration of the methodology. Cells are harvested from a standard 2D culture and seeded in a pattern of choice, embedded with gel and incubated over time. Images made using Fluicell software.

- #### Spheroid bioprinting - step by step guide
1. Bioprint suspended cells into cell culture dish containing PBS.
  2. Replace the PBS with Matrigel.
  3. Induce Matrigel gelification at 37°C for 20 min and add cell culture media.
  4. Mature the spheroid model for 6-7 days.

### SPHEROID FORMATION

Cells were reproducibly printed onto a substrate in squared patterns, aligned with preprinted sites of cell attachment agent, in similar cell number (Figure 2A and 2C). Consistent with a previously study using the same microfluidic based bioprinting technology,<sup>7</sup> CR cells did not attach to the substrate without the use of a cell attachment agent. The printed cells expanded in 3 dimensions into spheroid structures within 1 week time, showing a similar area given by perimeter measurements (Figure 2B and 2C). Until 4 days post-printing and gel embedding, the expanding spheroids were efficiently measured using phase microscopy (Figure 2A), measuring a height of 40 µm. Spheroids cultured for longer time were imaged using 2-photon microscopy, with a stack of 152 µm (2 µm increments) (Figure 2B).

### CONCLUSION AND DISCUSSION

The method of printing cells onto substrates while kept in solution (e.g., PBS or media) using Fluicell's microfluidic based bioprinter offers a novel way to produce spheroids with a defined starting point, here illustrated with cell number, architecture, and cell types. This provides a methodology to create advanced *in vivo* like tissue models, represented by spheroid or organoids, that may be dispersed into plates for larger throughput drug toxicity assays or combined to form complex biological systems to study systemic drug effects. For imaging, phase microscopy is an excellent option to monitor the initial 3D growth in this study, <40 µm height) while the models are in culture, whereas 2-photon microscopy is preferable for endpoint analysis, providing a high-resolution and z-stacking on thicker tissue models (in this study, <150 µm height).

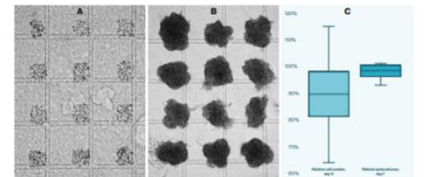


Figure 2. A) Phase microscopy images of spheroids at different time points. B) 2-photon microscopy images showing the internal structure of spheroids. C) Box plot showing the relative number of cells per printed square measured directly after printing and relative spheroid area measured after 7 days.

Presentation made by Chief Business Developer and Sales Officer  
Nelson Khoo of Fluicell company from Goteborg (Sweden) - bio-printing case studies / applications

## Companies presentations



Round table discussions between representatives of Fluicell company of Goteborg (Sweden) and professors of the EMERALD International summer school in Norway / signing of cooperation partnership agreements at the end of this session

# European Network For 3D Printing Of Biomimetic Mechatronic Systems

## Companies presentations



Super interactive and valuable interaction with representative of Fluicell company of Goteborg (Sweden) during the EMERALD International summer school in Norway 2023 edition



## Case studies launched by the EMERALD professors



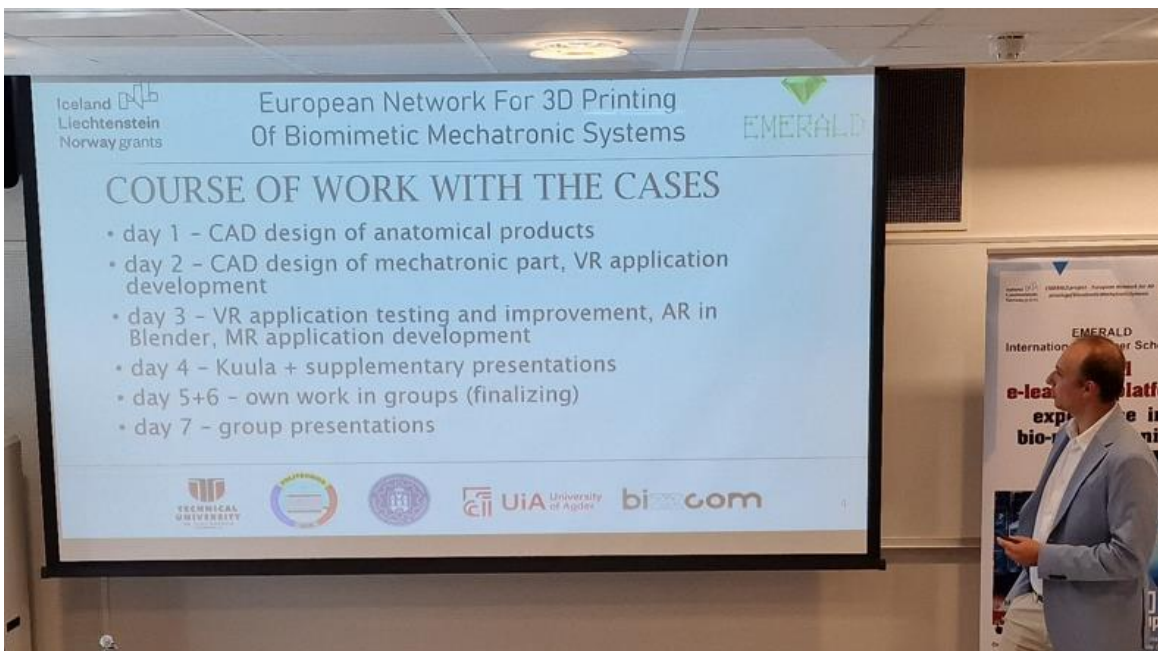
Case 1: bicycle prosthesis



Case 2: hand orthosis

Launching of case studies, tasks and working plan for the students in groups – Associate. prof. Filip Gorski (PUT - Poland)

## Tasks and plan for students' working in groups



Launching of case studies, tasks and plan for the students' working in groups – Associate. prof. Filip Gorski (PUT - Poland)

## Tasks and plan for students' working in groups



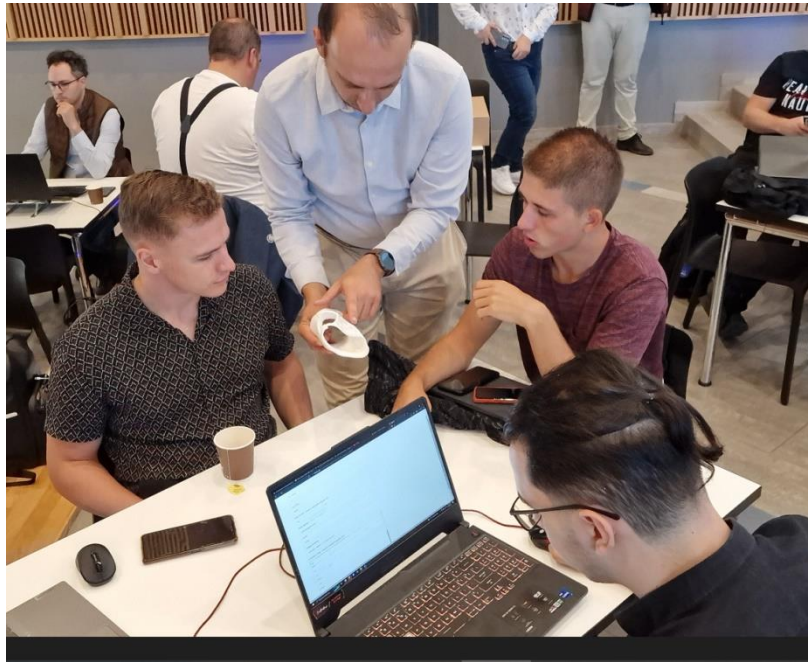
Launching of case studies, tasks and plan for the students' working in groups – Associate. prof. Filip Gorski (PUT - Poland)

## Working in groups with the students



Working on CAD and VR / AR topics based on case studies launched by associate prof. Filip Gorski (PUT - Poland)

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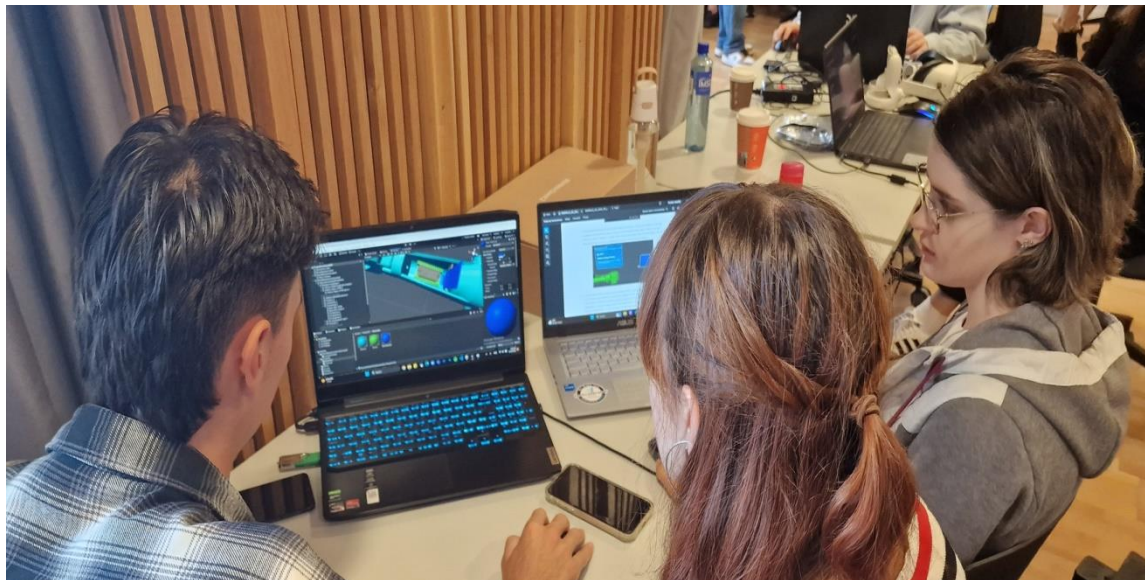
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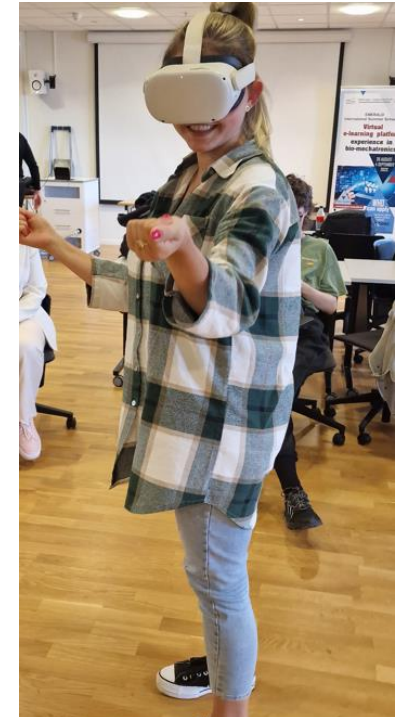
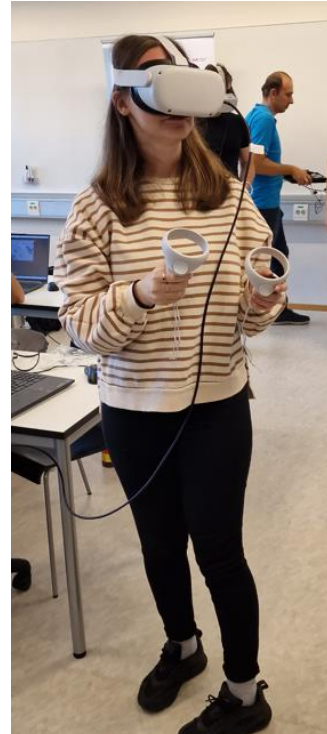
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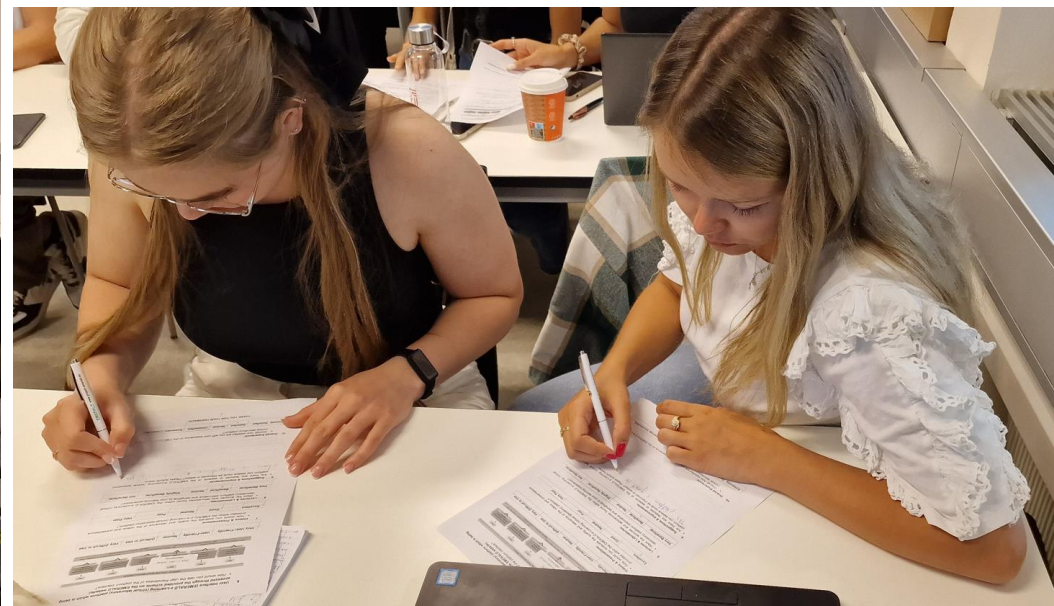
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## Final test defended by the students



Final test defended by the EMERALD students

## Final test defended by the students



Final test defended by the EMERALD students

## Feedbacks related to the EMERALD e-learning platform collected



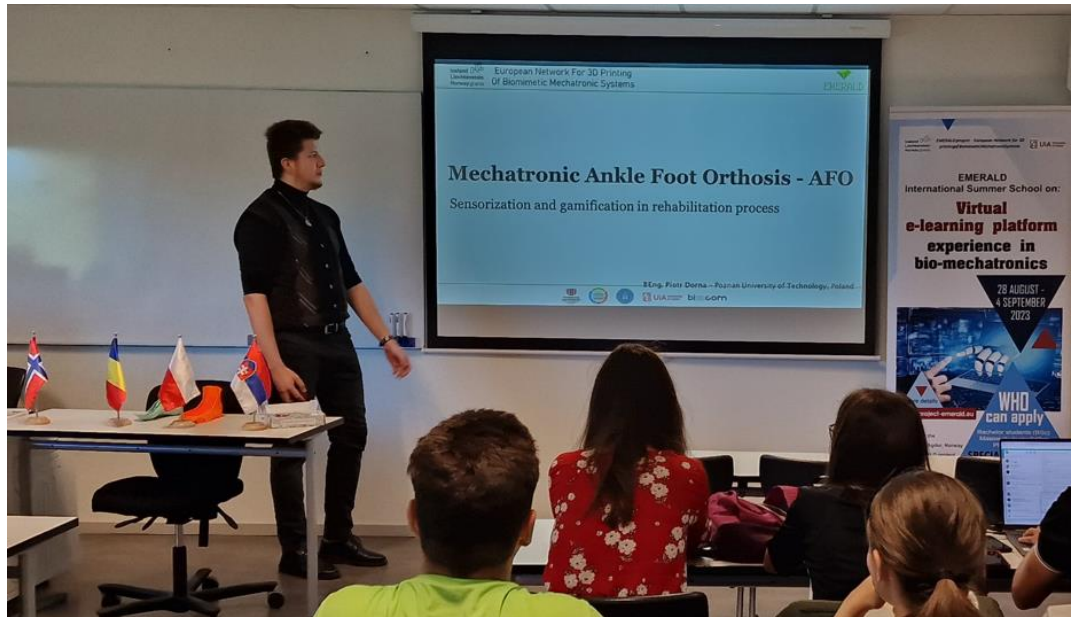
Feedbacks related to the EMERALD e-learning platform collected

## Final presentations realized by the students



Bachelor theses realized with support of the EMERALD co-supervised professors

## Final presentations realized by the students



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## Final presentations realized by the students



Bachelor theses realized with support of the EMERALD co-supervised professors

## Final presentations realized by the students



Feedbacks regarding the students' work and continuing of the ideas provided by the EMERALD supervising professors

## Final presentations realized by the students



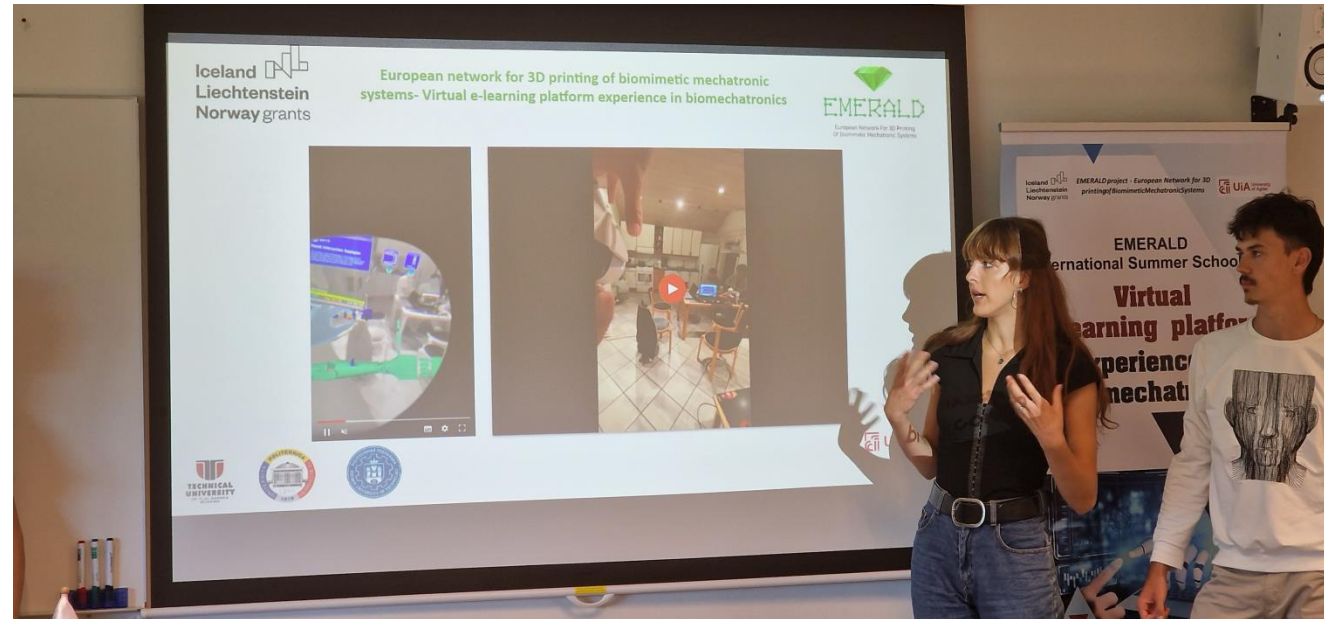
Final presentations realized by the students based on the work realized during the EMERALD international summer school

## Final presentations realized by the students



Final presentations realized by the students based on the work realized during the EMERALD international summer school

## Final presentations realized by the students



Final presentations realized by the students based on the work realized during the EMERALD international summer school

## Final presentations realized by the students



Final presentations realized by the students based on the work realized during the EMERALD international summer school

## Feedbacks provided to the students regarding their final presentations and awards



Final feedbacks received by the students on behalf of the EMERALD professors and final awards

## Certificates provided to all participants who have attended the summer school



Certificates provided to all participants who have attended the summer school



# European Network For 3D Printing Of Biomimetic Mechatronic Systems

**One last image of one super wonderful experience in Norway**



**Closing of the EMERALD international summer school 2023 edition**

## EMERALD project - contact details



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Assoc. Prof.dr.eng. Razvan Pacurar – [razvan.pacurar@tcm.utcluj.ro](mailto:razvan.pacurar@tcm.utcluj.ro)