Robotic Innovations in Support of the Healthcare Workers against COVID-19 DIH-HERO perspective



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- ETF Robotics Laboratory
- School of Electrical Engineering
- University of Belgrade





- Established 1808 (213 years)
- ~100.000 students
- 4.800 academic staff
- 31 faculties, 12 research institutes
- ranked between 401st and 500th place (Shanghai University Ranking)



http://www.bg.ac.rs/



- Established 1948 (73 years)
- 4.000 students
- ~180 academic staff (105 with Ph.D.)
- ~160 SCI indexed journal papers annually
- ~24.000 graduated students
- B.Sc. 500, M.Sc. 300, Ph.D. 20
 (male: female ratio = 70%: 30%)
- >50 company donations annually



https://www.etf.bg.ac.rs















Research interests: Physical Robot Collaboration, Robot Modeling and Control, Soft Robots











TOP 3 journal papers in last 2 years:

- M.Trumic, K. Jovanovic, A. Fagiolini, "Decoupled Nonlinear Adaptive Control of Position and Stiffness for Pneumatic Soft Robots", *International Journal of Robotics Research (IJRR)*, 2020, pp. 1-19.
- Fagiolini, M.Trumic, K. Jovanovic, "An Input Observer-Based Stiffness Estimation Approach for Flexible Robot Joints", *IEEE Robotics and Automation Letters (RA-L)*, Vol5(2), 2020, pp. 1843-1850.
- B. Lukic, K. Jovanovic, T. Sekara, "Cascade Control of Antagonistic VSA an Engineering Control Approach to a Bioinspired Robot Actuator", *Frontiers in Neurorobotics*, Vol 13(69), 2019, pp. 1-15.

TOP 3 ongoing projects:

- "Mechanical Impedance Estimation and Planning for Next Generation Collaborative Robots", Funded by Science Fund - Republic of Serbia, Call: Program for excellent projects of young researchers (PROMIS). 8/2020 – 7/2022
- "Digital Innovation Hubs in Health Care Robotics", Funded by *EU Horizon 2020*, 1/2019 6/2023
- "A Pan European Network of Robotics DIHs for Agile Production", Funded by EU Horizon 2020, 1/2019 6/2023



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http://robot.etf.rs/

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Project coordinator: Prof. Stefano Stramigioli

UNIVERSITY OF TWENTE.

- **Project duration**: January 2019 Jun 2023
- Main project goals:

Support to SMEs in healthcare robotics innovations

Create sustainable network of stakeholders in healthcare robotics

www.dih-hero.eu





Project partners:

























FUNDACJA ROZWOJU KARDIOCHIRURGII















Cascade Funding for SMEs

Provide funding and mentoring for European SMEs in the open calls.

Technology Offering prototyping, research & development, and/or manufacturing expertise to speed-up the development of healthcare robotics.

Business Capital & Incubation

Providing access to public and private funding to help transform innovative ideas into market-ready products.

Certification & Standardization Helping innovators understand customer segments, regulations and value chains to create a perfect market entry strategy.

Testing
Facilities
& Test
Center

Enabling product testing, service testing and validation in specialized labs and/or realistic environments.

Training & Education Services

Providing healthcare professionals and robotic developers access to knowledge resources for competence building.



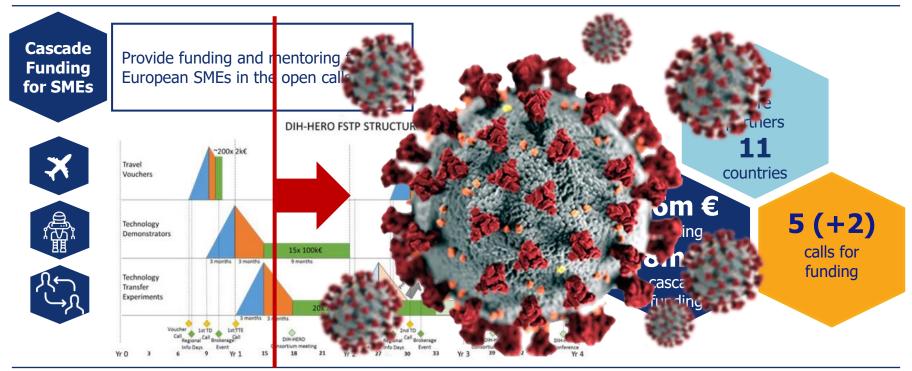
Cascade Provide funding and mentoring for **Funding** European SMEs in the open calls. for SMEs Core partners DIH-HERO FSTP STRUCTURE Proposal Collection ~200x 2k€ ~200x 2k€ Project Execution Travel countries Vouchers 0,8 M€ 16m € 5(+2)Technology funding Demonstrators calls for 15x 100k€ 8m € 10x 100k€ 3,5 M€ 10x 100k€ funding Technology cascade Transfer Experiments funding 20x 200k€ 3 M€ 1st TD 1st TTE

DIH-HERO

DIH-HERO Conference

DIH-HERO





29.06.2021 | The 30th Int. Conf. on Robotics in Alpe-Adria-Danube Region, RAAD 2021 | Presenter: Asst. Prof. Kosta Jovanović, Uni. of Belgrade - ETF

Transient to COVID-19 pandemic



population lockdown

reduced capacities in factories

non-Covid-19 hospitals closed

clinical rehabilitation imposible

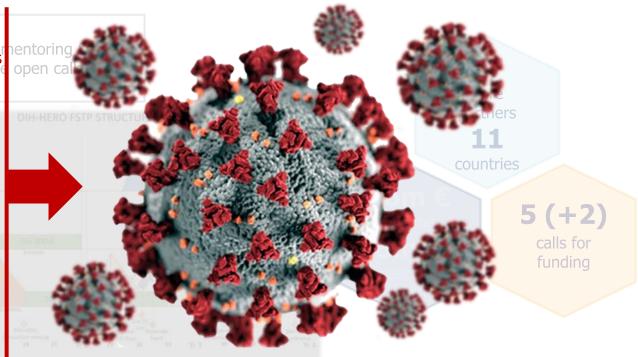
surgeries canceled

mental challanges due to social distancing

everyday activities went digital

home = office

human-human / human-machine interaction challanges



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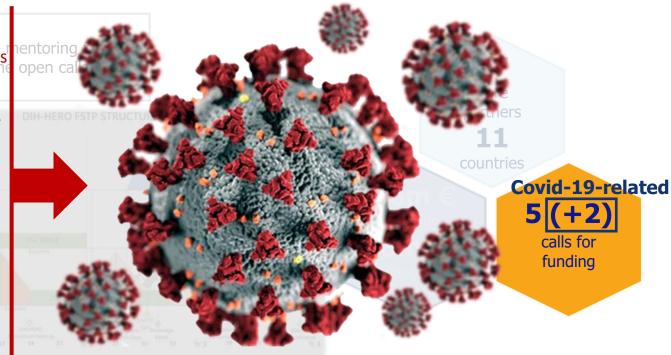
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DIH-HERO open call for industrial projects for robots fighting COVID-19



- Up to 10 projects 100.000€ funding per project (100% funding rate)
- Call opening: April 10th 2020
- Call deadline: April 17th 2020 (only 1 week!)
- Duration of project: maximum 2-3 months
- 2 main requests from the proposed robotic solutions:

Must clearly state the relevant clinical demand and the healthcare problem related to COVID-19 to be solved by the intended robotic solution

Must be an already existing technology that is in the later stages of development and deployable by the healthcare end-users in the fight against COVID-19 in project timeframe

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146 applications

from 30 different **European countries**

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- Call opening: A
- Call deadline:
- Duration of pro
- 2 main reques

Must clearly stat problem related solution

Lesson learned:

technology pull + emerging scenario are key drivers to innovations

ons

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Major application domains



Diagnostic Robotics

human function analysis and signal monitoring; automated medical imaging; AI-based decision making

Interventional Robotics

surgical robotics; doctor and patient side interfaces

Rehabilitation Robotics

exoskeletons; stationary or mobile training devices; prosthesis and orthosis

Robotics supporting patients

robot assistants; functional support robots; communication and social robots Robotics supporting healthcare professionals

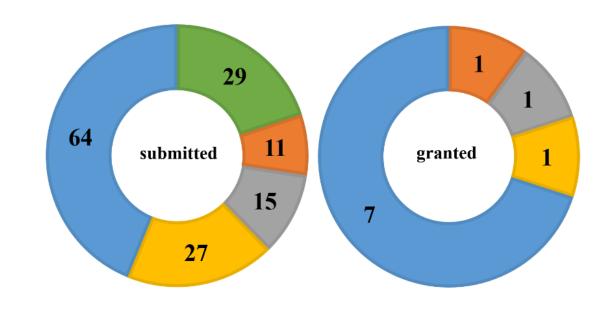
cleaning and disinfection robots; robots in logistics and hospital workflow optimization



- Diagnostic Robots
- Rehabilitation Robots
- Robots supporting Healthcare Professionals
- Interventional Robots
- Robots supporting Patients



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COMPANY	PRIMARY APPLICATION DOMAIN	PROJECT TITTLE
ACCREA Engineering (PL)	Robotics supporting Healthcare Professionals	DISInfecting RoboT (DisiRT)
Akara Robotics (UK)	Robotics supporting Healthcare Professionals	Disinfectant RObots to Protect Against COVID (DROPAC)
F&P Robotics (CH)	Robotics supporting Patients	Autonomous Sanitiser and Assistant Lio
Hocoma (CH)	Rehabilitation Robotics	Sensor-based arm and hand functional tele-rehabilitation with Armeo®Senso (Tele-AX)
Jonker-Makis Robotics (NL)	Robotics supporting Healthcare Professionals	Autonomous mobile disinfection robot SAM-Air
KELO Robotics (DE)	Robotics supporting Healthcare Professionals	Autonomous robots for disinfection (ARODIS)
MetraLabs (DE)	Robotics supporting Healthcare Professionals	Portable and agile autonomous disinfection robot (STERY)
PAL Robotics (ES)	Robotics supporting Healthcare Professionals	Fast Deployment of AVs in Hospitals
Rubedo Sistemos (LT)	Robotics supporting Healthcare Professionals	Unmanned Disinfection Solution (UDS)
Voxdale (BE)	Interventional Robotics	Robot for Intradermal Drug Delivery (ROB-ID)

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Diagnostics robotics in COVID-19



Expected applications:

- autonomous operations of the diagnostic equipment
- robotic laboratory setup (diagnostic samples handling)
- robots for vital signs monitoring

Prospective impact to healthcare:

- reduce workload of healthcare professionals
- increase performance
- reduce physical interaction

	Prevention	Diagnosis	Hospital Admission Respiratory 1		Intervention	Rehabilitation	
impact to COVID-19 treatment timeline:	Symptoms		Isolation Severe Covid-1		peutics 'imeline	Recover	y
				Diagnostic	Robots		

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29 applications
0 grants

	Prevention	Diagnosis	Hospital	Admission	Respiratory Intervention			Rehabilitation
impact to COVID-19	Symptoms		Isolation	Thera	peutics	!	Recovery	
treatment timeline:	Severe Covid-19 Treatment Timeline							
				Diagnostic	Robots			

Interventional robotics in COVID-19



Expected applications:

- robotics surgery
- robotics vaccination
- (semi-)automated ventilation

Prospective impact to healthcare:

- less invasive surgery
- shorten recovery time
- reduce physical interaction (remote interventions)
- reduced pressure to hospitals

• reduced pressure to n	ospitais							
•	Prevention	Diagnosis	Hospital Admission Respiratory Inter		ory Interv	ention	Rehabilitation	
impact to COVID-19	Symptoms		Isolation	Therap	eutics	 	Recovery	
treatment timeline:	Severe Covid-19 Treatment Timeline							
	Interventional Robots				Interventi	onal Robots	S	

Interventional robotics in COVID-19



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impact to COVID-19 treatment timeline:

Prevention Diagnosis

Symptoms

Hospital Admission

Respiratory Intervention

Rehabilitation

Recovery

Severe Covid-19 Treatment Timeline

Therapeutics

Interventional Robots

Interventional Robots



Isolation

Rehabilitation robotics in COVID-19



Expected applications:

- home training and rehab devices
- tailored exercise programs and devices with remote monitoring
- training for recovery of severe COVID-19 patients

Prospective impact to healthcare:

- prevention of the virus spreading at rehabilitation centers
- continuation of the rehabilitation activities in lockdown conditions
- continue to overall health, rehabilitation and prevention and reduce

pressure to hospitals
impact to COVID-19
treatment timeline:

Diagnosis

Hospital Admission
Respiratory Intervention
Rehabilitation
Recovery

Severe Covid-19 Treatment Timeline

Rehabilitation Robots

Rehabilitation robotics in COVID-19



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impact to COVID-19 treatment timeline:

Diagnosis **Hospital Admission** Prevention **Respiratory Intervention** Rehabilitation Symptoms Isolation Therapeutics Recovery Severe Covid-19 Treatment Timeline Rehabilitation Robots Rehabilitation Robots

Robotics supporting patients in COVID-19



Expected applications:

- social robots for isolated patients and nursing homes
- robots for personal assistance / logistics

Prospective impact to healthcare:

- improve emotional well-being of isolated individuals/patients
- reduce workload of healthcare professionals
- reduce physical interaction and virus spreading

	Prevention	Diagnosis	Hospital Admission		Respirator	y Intervention	Rehabilitation
impact to COVID-19	Symptoms	Symptoms Isolation Therapeutics		Recov	rery		
treatment timeline:	Severe Covid-19 Treatment Timeline						
			Robots su	pporting patients			

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Prospective impact to healthcare:

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impact to COVID-19 treatment timeline:

Robots supporting patients



Expected applications:

- cleaning and disinfection robots
- hospital logistics robots
- healthcare professional assistance robots

Prospective impact to healthcare:

- reduce workload of healthcare professionals
- reduce virus spreading

	Prevention	Diagnosis	Hospital Admission		Respirator	y Intervention	Rehabilitation
impact to COVID-19	Symptoms		Isolation Therapeutics		Reco	very	
treatment timeline:	Severe Covid-19 Treatment Timeline						
			Robots supporting	healthcare profe	essionals		

















impact to COVID-19
treatment timeline:

 Prevention
 Diagnosis
 Hospital Admission
 Respiratory Intervention
 Rehabilitation

 Symptoms
 Isolation
 Therapeutics
 Recovery

Severe Covid-19 Treatment Timeline

















impact to COVID-19 treatment timeline:

 Prevention
 Diagnosis
 Hospital Admission
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 Symptoms
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Severe Covid-19 Treatment Timeline

















impact to COVID-19 treatment timeline:

 Prevention
 Diagnosis
 Hospital Admission
 Respiratory Intervention
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 Symptoms
 Isolation
 Therapeutics
 Recovery

Severe Covid-19 Treatment Timeline





Lesson learned:

Technology adoption depends on the trust of the users much more than the confidence of the technology providers



habilitation

impact to COVID-19 treatment timeline:

Symptoms

Isolation

Therapeutics

Recovery

Severe Covid-19 Treatment Timeline

















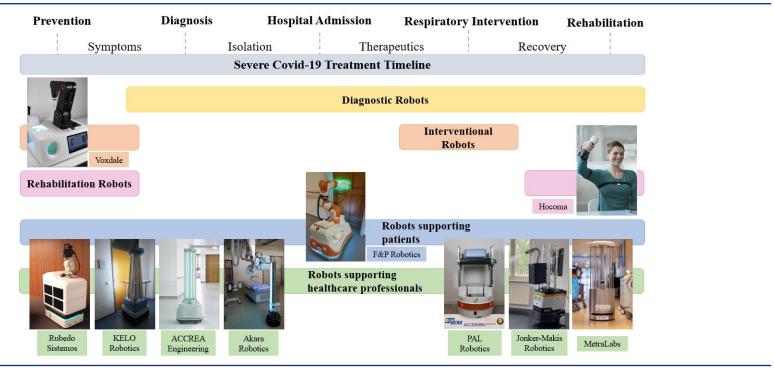
impact to COVID-19 treatment timeline:

 Prevention
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 Symptoms
 Isolation
 Therapeutics
 Recovery

Severe Covid-19 Treatment Timeline







Prevention Diagnosis Hospital Admission Respiratory Intervention Rehabilitation Lesson learned: Robotic technologies are already mature enough to quickly adapt and contribute to all stages of disease treatment: prevention, diagnosis, hospital admission, intervention, rehabilitation. Rubedo KELO Jonker-Makis ACCREA Akara PAL MetraLabs Sistemos Robotics Robotics Robotics Robotics Engineering

Robotics has made impact to COVID-19 and vice-versa



Robotics innovations and applications never seen (or seen less important) before COVID-19:

- identification and disinfection of critical environments
- detecting the disease (swab sampling, detecting chemical indicators)
- monitoring social/physical distancing
- providing and monitoring remote care and rehabilitation
- promoting social interaction for isolated patients
- supporting remote work and telepresence
- delivering automated vaccination
- delivering medical supplies to hospitals and goods to persons at remote home

Lessons learned



Application of robots in COVID-19 emerging scenario (reduced-barrier scenario) showcased:

- technology pull + emerging scenario are key drivers to innovations
- technology that requires immediate human-robot interaction can not be quickly deployed with current safety and regulation measures
- technology adoption depends on the trust of the users much more than the confidence of the technology providers
- robotic technologies are already mature enough to quickly adapt and contribute to all stages of disease treatment: prevention, diagnosis, hospital admission, intervention, rehabilitation.
- robots deployment in everyday living environments and operation with unskilled general population, impose challenges that need to be resolved
- robots in the regulated fields of healthcare and public safety raise ethical, safety, and reliability concerns that also need to be carefully considered

Related reading materials



- K. Jovanovic *et al.*, "Digital Innovation Hubs in Health-Care Robotics Fighting COVID-19: Novel Support for Patients and Health-Care Workers Across Europe", *IEEE Robotics & Automation Magazine*, vol. 28, no. 1, pp. 40-47, March 2021, doi: 10.1109/MRA.2020.3044965.
- A. Di Lallo, R. Murphy, A. Krieger, J. Zhu, R. H. Taylor and H. Su, "Medical Robots for Infectious Diseases: Lessons and Challenges from the COVID-19 Pandemic", *IEEE Robotics & Automation Magazine*, vol. 28, no. 1, pp. 18-27, March 2021, doi: 10.1109/MRA.2020.3045671.
- ➢ G. Z. Yang et al., "Combating COVID19-The role of robotics in managing public health and infectious diseases [Editorial]", Science Robotics, vol. 5, no. 40, March, 2020. doi: 10.1126/scirobotics.abb5589.
- L. Marques, R. Murphy, K. Althoefer, S. Tadokoro and C. Laschi, "Robotics Responds to the COVID-19 Outbreak [From the Guest Editors]", *IEEE Robotics & Automation Magazine*, vol. 28, no. 1, pp. 16-17, March 2021, doi: 10.1109/MRA.2020.3048866.

Should you have any further questions, please do not hesitate to contact me!



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