POLITECNICO DI MILANO

PhD in BIOINGEGNERIA / BIOENGINEERING - 38th cycle

PARTENARIATO PNRR Research Field: INTEGRATED IN VITRO AND VIRTUAL PLATFORMS TO SIMULATE PERCUTANEOUS PROCEDURES

Monthly net income of PhDscholarship (max 36 months)
€ 1250.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Transcatheter technologies allow for extending the treatment of lethal cardiovascular pathologies to fragile patients who are not eligible to standard cardiac surgery procedures. Yet, transcatheter approaches suffer from two critical limitations as compared to standard surgery: i) the catheter, the implantable device carried by it, and the anatomical structures are not directly visible; ii) often is not possible to compensate for errors in the procedure, when these occur. It is hence pivotal to develop technologies to allow operators for optimizing their learning curve in terms of time-expense and outcomes, without impacting on patients, as well as for optimizing the planning of procedures. On this basis, the research will have two objectives: O1 – developing a virtual simulator of transcatheter cardiovascular procedures devoted to training and pre-procedural planning. The virtual simulator will include i) the standardized generation of patient-specific anatomical models from medical imaging; ii) the physics-based and real time simulation of procedures; iii) an augmented reality (AR) interface to interact with the virtual model and the simulation.

	O2 – developing a hybrid simulator devoted to training in transcatheter procedures. The hybrid simulator will include i) the 3D printed replicas of the relevant anatomical structures, ii) the visualization of the pre-procedural imaging used to obtain the 3D printed models and of simulated intra-procedural imaging, iii) the AR visualization of the digital twin of the 3D printed anatomy and of the indications (e.g., in terms of catheter trajectory and catheter tip pose at the implant site) yielded by the previously simulated procedure. The virtual model will be co-registered on the 3D-printed one. The possibility to exploit the sensors embedded in the AR headset to quantify the performance of the trainee is also envisioned.
Methods and techniques that will be developed and used to carry out the research	Regarding objective O1, the following methodologies will be developed and implemented: - automated or semi-automated methods for image segmentation. AI-based methods will be considered; - finite element modeling to simulate the procedure; - AR applications designed through the Unity platform for the HoloLens2 headset by Microsoft Regarding objective O2, the following methodologies will be developed and implemented: - 3D printing and molding of complex anatomies, which will include the definition of a standardized protocol to obtain realistically models; - simulation of fluoroscopic and ultrasound imaging as if these were acquired on the in vitro simulator. This will include the need for designing an experimental set-up with a sensorized ultrasound probe and C-arm, which could be represented by physical mockups; - 3D reconstruction and co-registration techniques to allow for a consistent representation of the virtual model, of the simulated intra-procedural imaging and of the in vitro simulator. Activities will be carried out within the Biomechanics Research Group, leveraging on the infrastructures and the

	background available in the Department, namely in the Computational Biomechanics Laboratory and in the Laboratory of Experimental Micro and Biofluid dynamics. A collaboration with the 3D and Computer Simulation Laboratory at IRCCS Policlinico San Donato is envisioned, and some activities may be carried out in that structure. A tight collaboration with the innovative start-up company Artiness srl, which is a spin-off company of Politecnico di Milano devoted to developing AR applications for surgery, is also envisioned.
Educational objectives	Acquiring deep knowledge of transcatheter technologies. Becoming proficient in 3D printing technologies, in AR applications, and numerical modeling. Becoming able to design and implement complex numerical models. Becoming able to design and build complex and integrated in vitro simulators.
Job opportunities	The candidate will work on an interdisciplinary project and become proficient in a broad spectrum of technologies and methodologies, which will make him/her appealing for a broad spectrum of markets spanning from implantable surgical devices to metaverse.
Composition of the research group	2 Full Professors 5 Associated Professors 1 Assistant Professors 15 PhD Students
Name of the research directors	PROF. EMILIANO VOTTA - PROF. RICCARDO VISMARA

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--

Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	625.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The successful candidate will be based mostly at the premises of the Department of Electronics, Information and Bioengineering at Politecnico di Milano, where the candidate will have a personal desk and will be provided with the technologies needed to develop his/her research. The successful candidate may be asked to apply to calls for teaching assistantship in courses whose content will be deemed consistent with his/her research and educational activity.