BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

MUR DM 117/Logos - Development of advanced simulation systems in ultrasonography by augmented reality and artificial intelligence

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Context of the research activity	The proposed activity focuses on the integration of virtual and augmented reality (VR/AR) with artificial intelligence (AI) elements to develop an innovative simulation system in clinical echography. AI will be used to reproduce virtual projections of the neck-head district and will generate echographic images with a known degree of pathology. The integration of the AI-based generation system in a VR/AR environment will allow the virtual execution of a sonographic examination with no need for physical phantoms or for ultrasound equipment. Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23001930004

	The use of simulation systems for the training of medical personnel is gaining importance, as it allows for instructing future practitioners prior of having a direct contact with patients. Simulation has already been widely used in training surgeons for more than a decade, but nowadays also in the field of radiology and sonography, simulation has started to be used to teach the trainees the semantic and semeiotic of the bioimages. Particularly critical is the training of sonographers, as ultrasounds examinations are referred as user-dependent, underlining that the sonographer operatively conducts the examination by manually scanning parts of the human body. Currently, most of the available ultrasound simulation systems basically just

Objectives	simulate the patient, and thus require the massive use of phantoms and the presence of an ultrasound scanner (with one or more probes). Beside being a cumbersome setup, with little portability and versatility, such systems usually train sonographers on how to properly set the scanner, but they are not suitable for teaching the semantic and semeiotic of the ultrasound image. The proposed research activity focuses on the development of a completely virtual simulation environment, specifically tuned for the simulation of thyroid echography images. The combination of AI and VR/AR will be used to allow trainees on a double level: 1) on appreciating the effect of the different scanner settings on the ultrasound image and 2) on recognizing/observing simulated images with a known type or degree of pathology. The PhD project has the following main objectives which the candidate will be required to do: - Develop innovative generative AI strategies to simulate ultrasound B-Mode images. - Integrate the AI generative architecture into a VR/AR framework simulating the entire examination (i.e. scanner, probe type, probe position, etc …). - Explore the possibility of integrating into the system a chatbot for the real-time guidance and correction of trainees. The candidate will focus on developing an AI generative engine to reproduce ultrasound thyroid images with different characteristics, ranging from normal to highly pathological. Tissue degeneration, tissue inflammation, as well as different types of focal thyroid lesions will be simulated. The AI core will be inserted into a VR/AR environment that will communicate the gestures of the trainee, so that a movement in the VR world will cause a change in the generated image. The VR/AR integration will be done in collaboration with the Company Logos Centro Studi Srl, that has a wide experience of VR solutions in education. It is expected that, at the end of the PhD activity, the candidate will be able to propose a complete framework for the completely virtual simulation of thyroid ultrasound images.
Skills and competencies for the development of the activity	The candidate must have a Master Degree, preferably in Biomedical Engineering, and with previous experience in medical image and data analysis, better if on a multi-scale level(i.e. ranging from cellular to total body). The successful candidate has a strong and documented expertise in these topics: • Artificial intelligence for image analysis • Use and analysis of 3D simulated human avatars in clinics and should demonstrate the knowledge of the more advanced generative AI tools in the field of medical imaging. Expertise using AI for image denoising, enhancement, segmentation and classification are also important skills the candidate should already possess.