

INTERUNIVERSITY PH.D. PROGRAM BETWEEN
POLITECNICO DI BARI AND UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO
IN INDUSTRY 4.0

Innovative Augmented Reality Interaction Techniques For Health Care In Industry 4.0

Augmented Reality Interface for the Precision Guidance of Surgical Tools

PhD candidate

Mine Dastan

Cycle

XXXVII

Tutors

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Description of the research program

The healthcare is evolving with the Industry 4.0 logic towards the digitization of processes and information (e.g. digital diagnostics and electronic medical records). The growing complexity of systems and data represents an important challenge for healthcare professionals that already overburdened by the terms of work shifts, psychophysical stress, bureaucracies and responsibilities.

In this era, robotics is not yet able to replace the human hand, and still there are areas in which even a minimal human error can have serious consequences on the patient's health (e.g. the destruction of bundles of nerves). Augmented Reality (AR) is one of the most promising solutions to this problem because it can provide a direct interface between technological systems, procedures and data, through personalized information and instructions in the visual field of the operator in the right place at the right moment.

The AR and with its recent evolutions in terms of resolution and tracking accuracy, can provide guides and visual aids that are able to reduce the risk of error and the stress of the surgeon that potentially reduce the postoperative recovery time of patient. This allows a considerable impact in economy, environment, humanity and society.

Therefore my research aims to find the novel idea using human in the centre approach, identifying strengths and weakness. One of the objective is to make the market analysis and carry out an in-depth review of the literature, and identify the most interesting medical areas in which to bring high-impact innovation. Once these have been identified, an activity will be carried out to identify the functional requirements and identify the criticalities. Questionnaires will be administered, for a holistic understanding and to collect qualitative and quantitative data.

The second objective is to provide the sterilize, fast and accurate solution. The design of the interface will be elaborated for the healthcare professionals. Innovating the interface for medical instrument utilization in the field of view of the surgical operator's and providing manual precision. This phase will make use of prototyping systems, theoretically with the modelling of scenarios, storyboards, personas (virtual users), and evaluated in Virtual Reality (using Unity 3D or similar) and subsequently applied in the field in AR. Experimental protocols will be defined and capable of acquiring user feedback directly and indirectly, the user will be fully involved in the solution of the implementation.

The third objective is to create interactive graphical information and guidelines for controlling the function of medical instruments (e.g. position in space, avoiding danger zones, milling torque control) and tools that reduce the human effort on the part of the operations team, exploring the effects and new methods of interaction of augmented reality for surgical processes in the literature.

This research has the potential to improve the surgical success, safety and general well-being of surgeons and patients. In addition, in the long run, it can have a positive impact on society, increase the productivity and effectiveness of the surgeon, give a higher quality of treatments to patients and provide a mutual profit. The effectiveness of the methodologies will be assessed qualitatively and quantitatively through preliminary simulations in virtual reality and subsequently in the augmented reality.

The effectiveness of the methodologies will be assessed qualitatively and quantitatively through preliminary simulations in virtual reality and subsequently in the augmented reality. Protocols and metrics (error rate, execution times, operator fatigue) will be defined for the experiments including questionnaires and / or interviews (SUS test, NASA TLX).

The impact will be providing better medical processes, lower error rates, and an improved quality of life for patients and doctors. From the point of view of scientific performance, the expected result is at least one international publication per year, with preference in a journal.

Schedule of the research activities

First academic year

	Description	Period	Activity abroad
First Research Activity	1. Analyses of State of the art in Medical and Industrial Field 2. Identify the functional requirements and criticalities	1-6	-
Second Research Activity	3. Design of innovative interface with Human Centred Design	1-6	-
Third Research Activity	4. Questionnaires and user surveys on surgeons 5. Analysis of the Collected Data		-
Fourth Research Activity	Individual research activity	12	-
Fifth Research Activity	Writing manuscripts for publications	12	-

Second academic year

	Description	Period	Activity abroad
First Research Activity	1.Improve interface prototype with user feedback (Living Lab approach) 2. Experiments and testing of interface	10	Technical University of Munich /Germany
Second Research Activity	Individual research activity	12	-
Third Research Activity	Writing manuscripts for publications	12	-

Third academic year

	Description	Period	Activity abroad
First Research Activity	Elaborating the results from previous stages	12	-
Second Research Activity	Individual Research activity	6	-
Third Research Activity	Writing manuscripts for publications	12	-
Fourth Research Activity	Writing final dissertation	12	-

Provisional training and research activities plan

First academic year

	Description	Period	Duration	CFU
PhD courses	Mixed Reality for data visualization in the Smart Factory	June 2022	20h	2
	New Technologies For Diagnosis In Medicine	October 2022	20h	2
	Smart Education for Industry 4.0	June 2022	20h	2
Master's degree courses	Materiali E Tecnologie Per La Bioingegneria	Second Semester	120h	12
Participation to seminars and international congresses or workshops	2022 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)	-	5 days	5
	SummAR Augmented Reality Workshop	June 2022	1 week	5
Presentation of research products at international congresses or workshops	Presentation of at least one international congress or workshop	-	-	2
	TOTAL OF CFU FOR TRAINING ACTIVITIES			30
Individual research activity	Individual Research activity	-	40h	20
Preparation of manuscripts for conferences or journals	Writing manuscripts for publications	-	250h	10
	TOTAL OF CFU FOR RESEARCH ACTIVITIES			30
	TOTAL OF CFU FOR YEAR I			60

Second academic year

	Description	Period	Duration	CFU
PhD courses	Fundamentals of Information Theory	-	-	2
	Emerging technologies and methodologies for the Cyber Security	-	-	2
	Percorsi Diagnostici Terapeutici Assistenziali	-	-	6
	Multidisciplinary Research Applications of 3D Printing	-	-	2
Master's degree courses	Dispositivi E Sistemi Di Test E Misure Biomedicali	Second Semester	60h	6
Participation to seminars and international	2023 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)	-	5days	5
	International Conference on Disability, Virtual Reality and Health Technology (ICDVRHT)	July 2023	1week	5

congresses or workshops				
Presentation of research products at international congresses or workshops	Presentation of at least two research at international congresses or workshops	-	-	2
	TOTAL OF CFU FOR TRAINING ACTIVITIES			30
Individual research activity	Individual Research activity	-	400h	16
Students' supervision	Tutoring students	-	100h	4
Preparation of manuscripts for conferences or journals	Writing manuscripts for publications	-	250h	10
	TOTAL OF CFU FOR RESEARCH ACTIVITIES			30
	TOTAL OF CFU FOR YEAR II			60

Third academic year

	Description	Period	Duration	CFU
PhD courses	-			
Master's degree courses	-			
Participation to seminars and international congresses or workshops	2024 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)	-	5 days	5
	Experimenting in Virtual Reality Summer School in Amsterdam	-	2 weeks	3
Presentation of research products at international congresses or workshops	Presentation of at least two research at international congresses or workshops	-	-	4
	TOTAL OF CFU FOR TRAINING ACTIVITIES			12
Individual research activity	Individual Research activity	-	350h	14
	Preparing the final dissertation	-	400h	16
Students' supervision	Tutoring students	-	100h	4

Preparation of manuscripts for conferences or journals	Writing manuscripts for publications	-	350h	14
	TOTAL OF CFU FOR RESEARCH ACTIVITIES			48
	TOTAL OF CFU FOR YEAR III			60
	TOTAL OF CFU FOR THE WHOLE PHD COURSE			180