PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Cristina Iacono

Cycle: XXXV

Training and Research Activities Report

Academic year: 2020-21 - PhD Year: Second

Cristina Iacono

Tutor: prof. Fanny Ficuciello

Fanny Ficuciello

Co-Tutor:

Date: October 21, 2021

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXV **Author: Cristina Iacono**

1. Information:

- **PhD student:** Cristina Iacono **PhD Cycle:** XXXV
- **DR number:** DR993899
- **Date of birth:** 23/06/94
- **Master Science degree:** Ingegneria dell'Automazione

  University: Università degli Studi di Napoli Federico II
- **Scholarship type:** UNINA
- **Tutor:** Fanny Ficuciello
- **Co-tutor:**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Deep learning-based localization of the biliary tract in laparoscopic images. Human-Robot Interactive Framework with a Remote Center of Motion Constraint and Forbidden Region Virtual Fixture	Research		10	1/11/20 - 31/12/21		
Robotica Medica (SSD: ING-INF/04)	Tutorship	8h		1/11/20 - 31/12/21		
Designing a Socially Assistive Robot for adaptive and personalized assistance to patients with dementia.	Seminar	1	0.2		PRISCA LAB	Y
Path planning and tissue interaction for automation of suturing procedures.	Research		8	1/01/21 - 28/02/21		
Robotica Medica (SSD: ING-INF/04)	Tutorship	4h		1/01/21 - 28/02/21		
Statistical data analysis for science and engineering research	Course		4	-/02/22	Prof. Roberto Pietrantuono	Y
Mathematics and Statistics for Life Sciences	Course		4	-/02/22	CBQ	Y

Robo Ludens: A game design taxonomy for human-robot interaction	Seminar	1	0.2	05/03/21	Silvia Rossi	Y
Emotions in Reinforcement Learning Agents	Seminar	1	0.2	17/03/21	Silvia Rossi	Y
Experiments with the KUKA ROBOT for the project BARTOLO	Research		3	1/03/21 - 30/04/21		
Robotica Medica (SSD: ING-INF/04)	Tutorship	12		1/03/21 - 30/04/21		
Upper Limb Prosthetic	Seminar	1	0.2	04/05/21	Fanny Ficuciello	Y
Workshop on Exoskeleton	Seminar	1	0.4	18/05/21	Fanny Ficuciello	Y
Introduction to legged robots and examples of IIT's dynamic legged systems lab	Seminar	1	0.4	26/05/21	Fabio Ruggiero	Y
Study on Reinforcement Learning applied to trajectory planning	Research		6	1/05/21 - 30/06/21		
Robotica Medica (SSD: ING-INF/04)	Tutorship	12		1/05/21 - 30/06/21		
Game Theory and Network Systems	Seminar	15	3	12-13-14/07/21	SIDRA 2021	Y
Soft Robots	Seminar	15	3	15-16-17/07/21	SIDRA 2021	Y
da Vinci Research Kit Robot Dynamic Model Identification for Sensor-less Force Estimation	Research		5	1/07/21 - 30/08/21		
Robotica Medica (SSD: ING-INF/04)	Tutorship	4		1/09/21 - 30/10/21		
Dynamic model estimation, Intuitive proposal for haptic interface	Research		8	1/09/21 - 31/10/21		
Strategic Orientation for STEM Research and Writing	Course		3.6	-/06/21 – -/09/21	Prof Chie Shin Fraser	Y

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1			10	0.32	10.32
Bimonth 2		0.2	8	0.16	8.36
Bimonth 3	8	0.4	3	0.48	11.88
Bimonth 4		1	6	0.48	7.48
Bimonth 5		6	5	0.16	11.16
Bimonth 6	4		8		12
Total	12	7.6	40	1.6	61,2
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

3. Research activity:

My primary research activity is the development of control methods that allow the automation of robot-aided surgical tasks.
The use of surgical robots significantly improves the execution of surgical tasks and enhances dexterity, ergonomics, motion scaling, and tremor filtering.
My research comprises two principal aspects necessary for the automation of surgical robot-assisted procedures:

- *Vision perception for robotics systems:*

  Perception is essential in a robotic system: in particular, in surgical robotics, vision perception plays a key role as it is the only feedback to the surgeon in the absence of force feedback, to characterize the surgical site.

- *Force feedback during robotic procedures:*

  Most of the currently available robotic surgery systems do not have haptic feedback capability. Studies on this topic show that haptic feedback could reduce unintentional injuries and learning time for novices. Moreover, force feedback would allow implementing advanced control algorithms (impedance/force control, adaptive virtual fixtures, bilateral telemanipulation control) to enhance the effectiveness and dependability of surgical robots.

To this end, during last year, my research focused on the following activities:

I. *Development of a deep learning-based method for the localization and segmentation of the biliary tract in laparoscopic images, to help the surgeon better visualize the biliary tract without the use of ICG. The laparoscopic cholecystectomy bears a higher risk for bile duct injury with an incidence in the range 0,3–1,5%. This work also includes the construction and annotation of an image database to train the deep learning algorithm.*
II. *Development of a control framework for human-robot interaction in medical applications that are characterized by an RCM constraint, such as surgical applications in which the tool is moved through the entry point into the patient's body. The method proposes a control strategy that ensures both the RCM kinematic constraint and repulsive VFs constraint in a human-robot*

interaction framework, in which the doctor guides the manipulator throughout the surgical application.

III. *Ex vivo testing of a miniaturized probe based on optical fiber sensor technology for prostate tissue characterization. The tests were conducted through indentation experiments on 33 real prostates obtained from radical surgeries of patients by moving the optical probe with a robotic arm (Robotic Arm, (KUKA LBR Med 7) with the aim to control the indentation depth. The indentation tests of each prostate in a large number of points allowed to construct a force measurement dataset, together with the results of the following histological examination.*

IV. *Da Vinci Research Kit Robot Dynamic Model Identification for sensor less force estimation. The work aims to identify the complete dynamical model of the Patient Side Manipulator (PSM) arm of the DVRK robot. The proposed model is tested using a residual based approach for external force estimation acting on the PSM end-effector.*

4. Research products:

Deep learning-based localization of the biliary tract in laparoscopic images acquired during surgical robotic procedures Cristina Iacono, Sara Moccia, Aldo Marzullo, Elena De Momi, Umberto Bracale and Fanny Ficuciello, I-RIM 3D, published

Participation to Intuitive Technology Research Grant Application
Participation to Maker Faire Rome 2021

5. Conferences and seminars attended

Attended Italian Institute of Robotics and Intelligent Machines (I-RIM) 3D 2020 to present the paper "Forbidden Region Virtual Fixtures for Surgical Tools Collision Avoidance", 10-12/12/20

Attended Italian Institute of Robotics and Intelligent Machines (I-RIM) 3D 2021 to present the paper "Deep learning-based localization of the biliary tract in laparoscopic images acquired during surgical robotic procedures", 8-10/10/21

6. Periods abroad and/or in international research institutions

None

7. Tutorship

During the academic year, I performed 40h of tutorship with the supervision of my tutor for the course Robotica Medica (Ingegneria Biomedica, SSD: ING-INF/04).
Theactivities are divided as follows:
- 8h of teaching assistance,
- 10h of tutorials,
- 22h of student assistance

8. Plan for year three

During the third year, my research activity will be focused on the automation of the suture task and in particular on the needle grasping and insertion phase. Passive set-point modulation and force sensing and estimation during surgical tasks will be further investigated to develop of control algorithms that include the interaction forces and haptic feedback to the surgeon.
This research activity will be also carried out during the period aborad. I program to spend the research period abroad to the Worcester Polytechnic Institute (WPI) and, in particular, to the Automation and Interventional Medicine (AIM) Robotics Research Laboratory at WPI, directed by Prof. Gregory Fischer.