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

Year: First

Cristina Iacono

Tutor: prof. Fanny Ficuciello *tutor signature*

Date: October 21, 2020

1. Information:

- **PhD student:** Cristina Iacono
- **DR number:** DR993899
- **Date of birth:** 23/06/94
- **Master Science degree:** Ingegneria dell'Automazione
  University: Università degli Studi di Napoli Federico II
- **Doctoral Cycle:** XXXV
- **Scholarship type:** no scholarship
- **Tutor:** Fanny Ficuciello

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Fundamentals of Deep Learning for Computer Vision	Seminar	2	0,4	16/10/19	DIETI	Y
Study of vision-based pose estimation of surgical tools, hand-eye calibration, Virtual Fixtures (VFs), impedance control	Research		10	1/11/19 - 31/12/19		
Numerical Methods for modeling, simulation and control for soft robots or robots in interaction with deformable environment	Seminar	1	0,2	14/01/20	Prof. Fanny Ficuciello, DIETI	Y
Study on VFs generation and adaptation, visual servoing	Research		10	1/01/20 - 28/02/20		
Matlab Fundamentals	Course	20	2	20/02/20 - 23/03/20	DIETI	Y
Study on vision techniques for robotics applications	Research		7,4	1/03/20 - 30/04/20		
Robotica Medica (SSD: ING-INF/04)	Tutorship	20		1/03/20 - 30/04/20		
Innovation management, entrepreneurship and intellectual property	Course	18	5	05/05/20- 19/06/20	Prof. Pierluigi Rippa, DII	Y
Robot Interaction	Msc		6	03/20 -	Bruno	Y

Control	Course			06/20	Siciliano, DIETI	
Visione per Sistemi Robotici	Msc Course		6	03/20 - 06/20	Luisa Verdoliva, DIETI	N
Robotics Lab	Msc Course		6	03/20 - 06/20	Vincenzo Lippiello, DIETI	Y
Large Scale Training of Deep Neural Networks	Seminar	2	0,4	06/05/20	DIETI	N
Exoskeletons and wereable robotics	Seminar	4	0,8	04/05/20–06/05/20	Fanny Ficuciello, DIETI	Y
Robotics in Surgery	Seminar	2	0,4	08/05/20	Fanny Ficuciello, DIETI	Y
Design e Nuove tecnologie. Possibili scenari per fronteggiare l'emergenza	Seminar	1	0,2	11/05/20	Innovation Village 2020	Y
La programmazione europea e la ricerca	Seminar	2	0,4	13/05/20	Innovation Village 2020	N
Health 4.0 – La rapidità della medicina e la velocità del cambiamento del nostro mondo	Seminar	2	0,4	14/05/20	Innovation Village 2020	N
Realtà Virtuale e salute reale. Health 4.0 - Dal bit alla mente: spazivirtuali per la salute	Seminar	1	0,2	15/05/20	Innovation Village 2020	N
Virtual Seminars on Sensing	Seminar	4	0,8	20/05/20	Plasmonica Prof. Carlo Forestiere, DIETI	Y
Bias from the wild	Seminar	2	0,4	26/05/20	CVPL - Associazione Italiana per la ricerca in Computer Vision, Pattern recognition	N

					e machine Learning	
Adversarial Attacks on Image Classifiers	Seminar	2	0,4	10/06/20	CVPL - Associazione Italiana per la ricerca in Computer Vision, Pattern recognition e machine Learning	N
Exploring autonomy in Robotic Flexible Endoscopy	Seminar	2	0,4	12/06/20	Fanny Ficuciello, DIETI	Y
Study of the state of the art of automatic suturing in MIRS, segmentation techniques for surgical images.	Research		2	1/05/20 – 30/06/20		
Robotica Medica (SSD: ING-INF/04)	Tutorship	10		1/05/20 – 30/06/20		
Machine Learning	Course	20	3.2	06/07/20-17/07/20	Carlo Sansone, DIETI	Y
Study on detection techniques for laparoscopic images. Study on set point modulation and proof of passivity of the system. Study on dual quaternions for the description of the robot kinematics.	Research		5	1/07/20 – 31/08/20		
Robotica Medica (SSD: ING-INF/04)	Tutorship	5		1/07/20 – 31/08/20		
	Research		0,6	1/09/20 – 31/10/20		
Robotica Medica (SSD: ING-INF/04)	Tutorship	5		1/09/20 – 31/10/20		

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	0	0,4	10	0	10,4
Bimonth 2	0	0,2	10	0	10,2
Bimonth 3	2	0	7,4	0,8	10,2
Bimonth 4	23	4,8	2	0,4	30,2
Bimonth 5	3.2	0	5	0,2	9,2
Bimonth 6	0	0	0,6	0,2	0,8
Total	28,2	5,4	35	1,6	70,2
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

During my first year, I worked in collaboration with Prisma Lab and ICAROS center.
My research activity is focused on automation of robot-assisted surgical procedures.
The use of surgical robots significantly improves the accuracy of tissue manipulation tasks and enhances dexterity, ergonomics, motion scaling, and tremor filtering.
In Minimally Invasive Robotic Surgery (MIRS), the da Vinci robotic system (Intuitive Surgical Inc., Sunnyvale, CA) is the most used surgical robotic platform. The surgeon performs tasks in teleoperation mode using only visual information of the surgical scene provided by a 3D stereo viewer.
Remote manipulators, such as the da Vinci, belong to a broad field of robotics called telerobotics. In [1], the authors present a classification of telerobots with respect to control architecture and user interaction. Depending on the degree of user interaction, three categories are defined: direct or manual control, shared control and supervisory control robotic systems. In direct control the surgeon operates the slave robot directly through the master console, leaving no autonomy on the slave. Apparently, this mode has the most surgeon involvement. At the other end, in supervisory control the procedure is executed solely by the robot, which acts according to a computer program, while the surgeon (supervisor) gives high-level directives. Finally, in shared control the surgeon and the controller share the command of the manipulator and work together in order to carry out a task. Obviously, shared control combines the intelligence of the surgeon and the robot, thus the robot presents a limited autonomy. [2]
My research activity has focused on multiple aspects necessary to for the automation of surgical robot-assisted procedures:

1) *Study on the existent literature on the automation of suturing sub-tasks:*
   Automation of repetitive tasks can improve laparoscopic surgical procedures by unloading surgeons and reducing duration, trauma, and expense. Driven by these motivations, I investigated the prior works on automation of suturing sub-gestures, such as grasping of suturing needle, knot-tying, needle insertion, etc.

2) Vision techniques for robotics systems:
Still, it is difficult to program a robot to execute an automatic surgical procedure because human tissues are variable, delicate, dynamic, and deformable. In this context, visual sensory feedback can give a major contribution on improvement of the control architecture of the surgical robot. For this

reasons, during this year I studied state of the art techniques for robotics applications, such as detection segmentation and localization. In particular, I applied them on the problems of vision-based pose estimation and tracking of surgical tools, hand-eye calibration and 3D reconstruction.

3) *Shared control techniques :*
   Given that surgeries involve critical and delicate tasks, automated surgical procedures should be carried out under the supervision and correction of the surgeon. Shared control architectures have proved functional to allow the human operator to supervise automated task execution [3]. In robot-assisted teleoperated surgeries, shared-control architectures have been used to apply Virtual Fixtures (VFs) that are force fields that guide the movement of the human operators [4] and also for collaboration between human operators and autonomous agents [5]. During the year, I studied the state of the art of shared control techniques and I focused on the VFs generation and adaptation. I applied this methodologies to develop a vision-based virtual fixture collision avoidance algorithm for surgical tools.

[1] Siciliano, Bruno, and Oussama Khatib, eds. Springer handbook of robotics. Springer, 2016.
[2]Moustris, George P., et al. "Evolution of autonomous and semi-autonomous robotic surgical systems: a review of the literature." The international journal of medical robotics and computer assisted surgery 7.4 (2011): 375-392.
[3] Kang, Hyosig, and John T. Wen. "Autonomous suturing using minimally invasive surgical robots." Proceedings of the 2000. IEEE International Conference on Control Applications. Conference Proceedings (Cat. No. 00CH37162). IEEE, 2000.
[4] O'Malley, Marcia Kilchenman, and Abhishek Gupta. "Passive and active assistance for human performance of a simulated underactuated dynamic task." 11th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 2003. HAPTICS 2003. Proceedings.. IEEE, 2003.
[5] Shamaei, Kamran, et al. "A paced shared-control teleoperated architecture for supervised automation of multilateral surgical tasks." 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2015.

4. Research products:

[J1] R. Moccia, C. Iacono, B. Siciliano and F. Ficuciello, "Vision-Based Dynamic Virtual Fixtures for Tools Collision Avoidance in Robotic Surgery," in IEEE Robotics and Automation Letters, vol. 5, no. 2, pp. 1650-1655, April 2020, doi: 10.1109/LRA.2020.2969941.

Paper published on RA-L and presented at ICRA 2020.

5. Conferences and seminars attended

- *2020 International Conference on Robotics and Automation, ICRA 2020, virtual conference, 31/05/20-30/06/20*

  RA-L paper presented at ICRA2020 conference (Vision-Based Dynamic Virtual Fixtures for Tools Collision Avoidance in Robotic Surgery).

- *2020 Conference on New Technologies for Computer and Robot Assisted Surgery, CRAS 2020, virtual conference, 28/09/20-30/09/20*

  Extended abstract presented at CRAS 2020.

6. Activity abroad:

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). The activities are divided as follows:

- *12h of teaching assistance,*
- *6h of tutorials,*
- *22h of student assistance.*