PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Rocco Moccia

XXXIII Cycle

Training and Research Activities Report – First Year

Tutor: Prof. Bruno Siciliano – co-Tutor: Fanny Ficuciello, PhD

1. Information

I am Rocco Moccia, Ms.Sc in Mechanical Engineering – La Sapienza, Università di Roma, Department of Mechanical and Aerospace Engineering – January 2017. Master thesis title: "Design and Development of a Haptic Human-Robot Interface to study the effect of Co-Contraction Training on motor control", developed at Georgia Institute of Technology, in Atlanta, GA, United States of America. Currently PhD student in Information Technology and Electrical Engineering, XXXIII Cycle, at Università degli Studi di Napoli Federico II with a PON fellowship in collaboration with MMI S.p.A and University of Leeds, supervised by Prof. Bruno Siciliano and Fanny Ficuciello, PhD.

2. Study and Training activities

Courses

Lecture/Activity	Type	Credits	Certification	Notes
Green Economy and Management in Engineering projects	External Module	3	x	
Summer School on Control of Surgical Robots (COSUR 2018)	Doctoral School	3	x	
Image processing for computer vision	MS Module	9	x	
Geometric Theory of Soft Robots	External Module	4	x	

Seminars

Lecture/Activity	Type	Credits	Certification	Notes
EIT-Health Matchmaking Event 2018	Conference	3,2	x	
The Age of Human-Robot Collaboration	Seminars	0,4	x	
IBMQ: Building the First Universal Quantum Computers for Business and Science	Seminars	0,8	x	
How Does Mathworks Accelerate the Pace of Engineering and Science?	Seminars	0,2	x	
Domains of Attraction and Manifolds in Gear Model	Seminars	0,2	x	

3. Research activity

My primary research activity is the development of innovative control methods in minimally invasive surgery and microsurgery, exploiting the use of computer vision techniques.

The use of surgical robots significantly improves surgeons' technical capabilities, improving the accuracy of tissue manipulation tasks and the quality of surgical procedures. In Minimally invasive surgery, the da Vinci robot is the most used surgical robotic platform. Also, in microsurgical procedures the use of robots significantly enhances the surgeon's performances.

The research activity articulates in three parts:

- The use of computer vision allowing characterizing the surgical scene and track soft-tissues and surgical instruments, using a stereo camera as sensor;
- Development of new control algorithms allowing the surgeon working under less stressful conditions and performing the surgical procedures with more accuracy and safety;
- The development and the integration of new sensors and instruments in surgical robots.

During my first year, I worked in collaboration with Prisma Lab and ICAROS center. I studied basic computer vision techniques, attending the courses of Image processing and investigate the state of the art on the application of vision methods in surgical robots. I worked also with surgeons, attending different surgical procedures in the operative room in order to define the main difficulties and surgeons' needs. This allows me defining as main problems the tumor and polyp dissections, that require very precise operations and surgeon's high skills in region of interest identification and accurate path definition to perform the cutting procedure. Also, the reconstructive phase is a critical step, consisting of tissue's suturing after organ removal.

Shared control techniques such as virtual fixtures and active constraints, are identified as a concrete aid for the surgeon to perform precise operation, reducing its physical workload.

I focused on multiple aspects necessary for the development of assistive surgical procedure towards fully autonomy and the surgical robot:

I. The study of the state-of-the-art methods for automatic detection and segmentation of tumor and polyp. This study led to the development of a vision-based method for region of interest extraction directly from stereo images. The developed method has been applied on assistive polyp dissection. Starting from stereo endoscopic images, acquired from da Vinci Research Kit robot's endoscope, the method includes detection and segmentation of the tumor and

leads to the definition of accurate points needed in path planning for assistive/autonomous cutting and dissection.

II. The study of the state-of-the-art methods for 3D reconstruction of the surgical scene. This aspect is crucial for the correct visualization and rebuild of the scene to estimate the correct pose of the objects in the scene and the automatization of the surgical gesture. The study led to the development of methods for 3D reconstruction using stereo images from da Vinci Research Kit robot's endoscope, exploiting basic computer vision algorithms.

III. The study of shared control techniques and virtual fixture generation. This led to the definition of an accurate path planning for assistive/autonomous cutting. The generated path is used as virtual fixture, i.e a constraint that restrict the motion of the robot manipulator along the path through haptic guidance forces rendered to the user.

IV. Development of a vision-based virtual fixtures generation method for assistive polyp dissection in minimally invasive robotic surgery [1]. The work proposes a vision-based pipeline for assistive polyp dissection, exploiting the vision and virtual fixtures generation techniques developed.

Also, during my first year, I attended the summer school on Control of Surgical Robots (COSUR) in Verona. I took part of Maker Faire Roma 2018, presenting an augmented reality simulator of the da Vinci robot.

I visited the MIMESIS Research group of INRIA in Strasbourg, France (July 2018), under the supervision of Dr.Stephane Cotin and Antoine Petit, PhD. There, I investigated methods of real-time tracking of surgical instruments and deformable objects in minimally invasive robotic surgery, using the software SOFA.

Finally, I visited the Medical Micro instruments (MMI), S.p.A in Pisa. There, I studied the basic procedures of microsurgery and the hardware of the Pico robotic platform developed by MMI.

4. Products

Accepted Papers

[1] **R.Moccia**, M.Selvaggio, B.Siciliano, A.Arezzo, F.Ficuciello. "Vision-based Virtual Fixtures Generation for MIS Dissection Tasks" CRAS 2019 – 9th Joint Workshop on New Technologies for Computer/Robot Assisted Surgery, Genova, Italy, March 21-22, 2019.

Papers in Preparation (Titles are provisional)

[2] **R.Moccia**, M.Selvaggio, B.Siciliano, F.Ficuciello. "Vision-based Virtual Fixtures Generation for Polyp Dissection and surgical tools collision avoidance in colon-rectal surgery", in preparation.

[3] M.Selvaggio, **R.Moccia**, B.Siciliano, F.Ficuciello. "Autonomous Virtual Fixtures Generation and Adaptation in Minimally Invasive Surgery: A Survey", in preparation.

5. Activity abroad

19/07/2018-31/07/2018, MIMESIS research team, INRIA Institut National de Recherche en Informatique et en Automatique, Strasbourg, France. Work topic: tracking of surgical instruments and deformable objects in Minimally Invasive Surgery.

6. Tutorship

- Master Thesis:
  - Antonio Cristiano: 3D reconstruction of Endoscopic Video Frames in Minimally Invasive Surgery.
  - Pasquale Ferrentino and Alessia Molinaro: PrismaHand, sensor's design and control

7. Summary of credits

	Credits year 1								Credits year 2								Credits year 3									
		1	2	3	4	5	6			1	2	3	4	5	6			1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	20			3	3		13	19	11							0	0							0	19	30-70
Seminars	5	3,2	0,4	1			0,2	4,8	5,2							0	5							0	4,8	10-30
Research	35	5	6	6	6	6	6	35	45							0	60							0	35	80-140
	60	8,2	6,4	10	9	6	19	59	61	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	59	180

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	MODULES				
1	Green Economy and Management in Engineering projects	External Module	3	x	
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	SEMINARS				
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1	The Age of Human-Robot Collaboration	Seminar	0,4	x	
1	IBMQ: Building the First Universal Quantum Computers for Business and Science	Seminar	0,8	x	
1	How Does Mathworks Accelerate the Pace of Engineering and Science?	Seminar	0,2	x	
1	Domains of Attraction and Manifolds in Gear Model	Seminar	0,2	x	