



PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Giuseppe Andrea Fontanelli

XXXI Cycle

Training and Research Activities Report – Third Year

Tutor: Bruno Siciliano



1. Information

Giuseppe Andrea Fontanelli, MS degree in Automation Engineering, January 2014 with the thesis “Development of an 8 DOF Omnidirectional mobile robotic platform with integrated torque sensors”. Now PhD student, at 3rd year, XXXI-cycle in Information technology and electrical engineering at the University of Naples Federico II, under the supervision of the professor Bruno Siciliano. He received a grant from Ateneo Federico II.

2. Study and training activities

During my third year of PhD I spent 6 months abroad in the Hamlyn centre Imperial college of London. With my supervisor in London, Prof. Guang-Zhong Yang, I worked on the development of advanced strategies to assist the surgeon during the suturing procedure. Moreover, during the third year I participated in the following conferences:

- ICRA 2018 in Brisbane, Australia (2 CFU):
Paper presented 1: G.A. Fontanelli, M.Selvaggio, F. Ficuciello, L. Villani, B. Siciliano, “A New Laparoscopic Tool With In-Hand Rolling Capabilities for Needle Reorientation”, published on RAL 2018.
Paper presented 2: V. Lippiello, G.A. Fontanelli, F. Ruggiero “Image-Based Visual-Impedance Control of a Dual-Arm Aerial Manipulator”, published on RAL 2018.
- HSMR 2018 (1 CFU):
Paper presented 1: G.A. Fontanelli, L. Zhang, G. Z. Yang, B. Siciliano, “Interactive Wound Segmentation and Automatic Stitch Planning”.
Paper presented 2: M. Selvaggio, G.A. Fontanelli, F. Ficuciello, L. Villani, B. Siciliano, “Enhancing Dexterity with a 7-DoF Laparoscopic Suturing Tool”.

Finally, I had the opportunity to organize the workshop “Learning and Autonomy for Medical Robotics” held on June 24 during the Hamlyn Symposium 2018 in London.

3. Research activity

My research field is surgical robotics. Minimally Invasive Robotic Surgery (MIRS) holds a fundamental role in modern surgical procedures. In details, a better sense of visual immersion and comfort for the surgeon, the less post-operative pain and recovery time with respect to the classical open or laparoscopic surgery, are just some of the benefits of using robots in minimally invasive procedures.

During my third year, I had the opportunity to attend the International Conference on Robotics and Automation (ICRA) in Brisbane Australia and the Hamlyn Symposium on Medical Robotics in London during which I had the possibility to present four of my recent works.

During this year I also continued my collaboration with the University La Sapienza of Rome working on a new simulator for the da Vinci Research Kit based on V-REP. The results have been presented at the BioRob conference in France.

Moreover, I had the opportunity to continue my activity in the MUSHA project, (principal investigator Fanny Ficuciello) on the development of a multifunctional, miniaturized and underactuated hand for MIRS. The results have been submitted in the International Journal of Medical Robotics and Computer Assisted Surgery and the paper is under minor revision.

Finally, during the first six months of my third year, I worked abroad in the Hamlyn Centre of the Imperial College of London under the supervision of Prof. Guang-Zhong Yang. My working topic was the development of advanced assistive control techniques for suturing in MIRS. The results of this activity have been presented at IROS 2018 in Spain and at the Hamlyn Symposium of Medical Robotics 2018 in London.

More in details follows are reported the major activities of my third year:

- a)** Development of a new V-Rep simulator for the da Vinci Research Kit robotic platform. The simulator has been used for the testing of new control strategies and for education. This work has been conducted in collaboration with the University La Sapienza of Rome.
- b)** Continue the work on the trocar force sensor. The complete dynamical model has been produced and a comparison with other force estimation method, such as the use of a residual based approach and the robot dynamic model, have been conducted. Moreover, a simple and effective visual based force feedback method has been developed to give to the surgeon back the force information. The results have been submitted to the International Journal Transaction on Mechatronics and are under revision.
- c)** Continue the Mechatronic design of a multifunctional, miniaturized and underactuated robotic hand. The MUSHA project focus on the development of advanced devices human-inspired with the goal to improve the surgeon manipulation capabilities
- d)** Development of an algorithm for wound tracking in a surgical scenario. The Grab-Cut segmentation method and a spline-based model have been used to track the wound position and deformation online. Preliminary results have been presented at the

Hamlyn Symposium on medical robotics. This work was conducted during my period in the Hamlyn centre.

- e) Development of new assistive control methods for surgical suturing. A comparison of different control strategies (supervised, shared, virtual fixtures) has been proposed in a paper presented at IROS 2018. This work was conducted during my period in the Hamlyn centre.
- f) Writing the PhD thesis.

4. Products

a) Journal paper published:

1. M. Selvaggio, **G.A. Fontanelli**, F. Ficuciello, L. Villani, B. Siciliano, “Passive Virtual Fixtures Adaptation in Minimally Invasive Robotic Surgery”, *Robotics and Automation Letters*, Oct 2018, Presented at IROS2018
2. F. Ruggiero, A. Petit, D. Serra, A.C. Satici, J. Cacace, A. Donaire, F. Ficuciello, L.R. Buonocore, **G.A. Fontanelli**, V. Lippiello, L. Villani, B. Siciliano, “Nonprehensile manipulation of deformable objects: Achievements and perspectives from the RoDyMan project”, *Robotics and Automation Magazine*, Sept 2018
3. **G.A. Fontanelli**, M. Selvaggio, L.R. Buonocore, F. Ficuciello, L. Villani, B. Siciliano, “A New Laparoscopic Tool With In-Hand Rolling Capabilities for Needle Reorientation”, *Robotics and Automation Letters*, July 2018, Presented at ICRA 2018
4. V. Lippiello, **G.A. Fontanelli**, F. Ruggiero “Image-Based Visual-Impedance Control of a Dual-Arm Aerial Manipulator”, *Robotics and Automation Letters*, July 2018, Presented at ICRA 2018

b) Journal paper submitted:

1. **G.A. Fontanelli**, L. R. Buonocore, F. Ficuciello, L. Villani, B. Siciliano, “An External Force Sensing System for Minimally Invasive Robotic Surgery”, *IEEE Transaction on Mechatronics*, 2018, Under major revision
2. M. Selvaggio, **G.A. Fontanelli**, V.R. Marrazzo, U. Bracale, A. Irace, G. Breglio, L. Villani, B. Siciliano, F. Ficuciello, “The musha underactuated hand for robot-aided minimally invasive surgery”, *International Journal of Medical Robotics and Computer Assisted Surgery*, 2018, Under minor revision

c) Conference paper:

1. **G.A. Fontanelli**, G. Z. Yang, B. Siciliano, “A comparison of assistive methods for suturing in MIRS”, IROS 2018

Training and Research Activities Report – Third Year

PhD in Information Technology and Electrical Engineering – XXXI Cycle

Giuseppe Andrea Fontanelli

2. **G.A. Fontanelli**, M. Selvaggio, M. Ferro, F. Ficuciello, M. Vendittelli, B. Siciliano, “A V-REP Simulator for the da Vinci Research Kit Robotic Platform”, BioRob 2018.
3. **G.A. Fontanelli**, L. Zhang, G. Z. Yang, B. Siciliano, “Interactive Wound Segmentation and Automatic Stitch Planning”, HSMR 2018
4. M. Selvaggio, **G.A. Fontanelli**, F. Ficuciello, L. Villani, B. Siciliano, “Enhancing Dexterity with a 7-DoF Laparoscopic Suturing Tool”, HSMR 2018
5. **G.A. Fontanelli**, M. Selvaggio, F. Ficuciello, B. Siciliano, “The MUSHa hand: a New Three Fingered Underactuated Hand for Minimally Invasive Robotic Surgery”, SMITH 2017

d) Patent:

1. An Italian patent for a new “laparoscopic tool with in hand rolling capabilities” is **under second revision**.
2. An Italian patent for a new “Laparoscopic instrument able to manipulate tissues and reconfigure itself as surgical retractor” is **under submission**.
3. An Italian patent for a new “A robotic arm tool for handling packages” is **under submission**.

	Credits year 1							Credits year 2							Credits year 3							Total	Check			
	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4			5	6	Summary
Modules	20		6			8	7	21	10	3	3	2	0	0	5	13	0	0	0	0	0	0	0	0	34	30-70
Seminars	5	1,6	0		1	0	3,3	5,9	5	0	0,8	0,8	0	2	1,9	5,5	0	0	0	0	4	0	0	4	15	10-30
Research	35	8,4	4	10	9	2	2	35	45	7	6,2	7,2	10	8	3,1	42	60	10	10	10	6	10	8	54	131	80-140
	60	10	10	10	10	10	12	62	60	10	10	10	10	10	10	60	0	0	0	0	0	0	0	0	180	180