Two Post-Doc Positions in Robotic Surgery, Four PhD Positions in Robotic Surgery and Five PhD Positions in Technologies for Industry 4.0, University of Verona

- **Positions within the project ARS**

1. Two full time PhD students (3-year fully-funded positions).

The specific research topics are:
a. **Machine learning techniques to extract robotic surgery models from data sets**.
This research will investigate the structure and the actual evolution of robot-assisted surgery through the examination of data collected during different types of real and simulated robotic interventions. The research will focus on the development of data-driven models that use/embed prior knowledge in the data analysis, identify possible variants to prior knowledge and propose the reward functions optimized by the operating surgeons.
b. **Modeling, analysis** and **control of a cognitive robot as a hierarchy of hybrid systems.**
This research will analyze the interaction between the reasoning and the control parts of a cognitive robot, by modeling the complete system as a hierarchy of discrete and continuous controllers whose properties, including safety, should be theoretically analyzed and experimentally verified.
Applicants should have a MSc/MEng (or equivalent) in Engineering, Computer Science, Mathematics or related disciplines. Applicants must have strong programing skills and background in Machine Learning or Control Engineering preferably with some experience in the integration of control and machine learning. The successful candidate to the first position is expected to have a strong background in machine learning and mathematical modeling. The successful candidate to the second position is expected to have a strong background in system theory, hybrid system control, and formal property analysis. Both candidates must be able to work in a heterogeneous multi-disciplinary team, and be able to test their results on the laboratory robots. The positions will start in October 2019.

2. Two full-time Post-Doc positions (1-year renewable contract).

The specific research topics are:
a. Real time **reasoning and situation awareness in robotic surgery**.
This research will investigate the structure and the actual implementation of a real-time reasoning system that analyzes the data collected during simulated and real robotic interventions. The system should be able to compute the conditions determining the evolution of the surgical intervention, as well as identifying possible risk situations related to the patient conditions.
b. **Modeling and** real time **simulation of deformable anatomical environments.**
This research will analyze the best bio-mechanical model to represent a deformable organ, identify the most appropriate software formulation to implement the model and integrate the model into real-time anatomical simulator under development within the ARS project.
Applicants should submit the following documents:
• A short CV. Only CVs with considerable scientific achievements will be considered.

Candidates should have an excellent track record of research; they should demonstrate the ability to grow into scientific/technological leadership roles.
• A statement on how the research topics will be addressed.

• A letter of presentation.
• Contacts of two supervisors/mentors who could act as references.

The positions will start as soon as possible.

- **Positions within the project ATLAS**

Two full time PhD students (3-year fully-funded positions)

ATLAS (AuTonomous intraLuminAl Surgery, https://atlas-itn.eu), funded by the Marie Skłodowska-Curie Actions Innovative Training Networks (MSCA-ITN) that will develop smart flexible robots that autonomously propel and navigate through complex deformable tubular structures such as fragile lumens or vessels. The specific research topics are:

a. ESR9: Surgical episode segmentation from multi-modal data.
An autonomous robot must reliably recognize the current surgical phase to decide what action to perform, especially in the case of shared autonomy, i.e. when the human surgeon carries out part of the procedure and the robot intelligently/semi-automatically assists the manual gestures. Deep learning methods (e.g. combined CNN for video and RNN for lower dimensionality data) could be used to extract the intervention phases and trajectories. This research aims at breaking new ground by using multi-modal data: it will build on phase detection in endoscopic video data, and it will include data from intra-operative sensors such as EM trackers, ultrasound images, preoperative data. Feature detectors and descriptors will be developed to perform optimal discrimination of different areas of interest and to reduce the data dimensionality for improved computational performance. Since methods developed in this research use multi-modal data, they may be also applied to intraluminal procedure based on video feedback (i.e. colonoscopy and ureteroscopy) and also to cardiovascular catheterization
Main institution and supervisor: University of Verona, Diego Dall'Alba
Secondary institution and supervisor: University of Strasbourg, Nicolas Padoya
ESR15: Optimal learning method for autonomous control and navigation.
Learning optimal control strategies for autonomous anatomical navigation and on-line decision making is a challenging problem. Currently 2 main strategies could be adopted: learning from data acquired during the execution of surgical procedure by expert surgeon or learning by experimentation. This research should compare motion control strategies for intraluminal navigation learned from intervention data with those learned in simulated environment. Then, it will be possible to identify the optimal control strategies for different clinical scenarios given specific robotic configurations. The trajectories identified in the research ESR9 will be used to define the initial trajectory of the autonomous endoscope. The performance of the different approaches will be evaluated in a realistic setting (physical phantoms) and in a simulated environment using a set of objective evaluation metrics. An integrated testing environment, including advanced visualization, will be developed to improve the evaluation of the different methods (extending/integrating the results of ESR10). The proposed navigation strategies will be tested in the colonoscopy and ureteroscopy clinical scenarios, but possible extensions to cardiovascular catheterization will be considered.
Main institution and supervisor: University of Verona, Paolo Fiorini
Secondary institution and supervisor: Universidad Politécnica de Catalunya, Alicia Casals

Interested candidates should contact Paolo Fiorini (paolo.fiorini@univr.it) as early as possible.
and apply to the positions using the web form at https://atlas-itn.eu/we-are-hiring/

- **Two Expressions of Interest for the Marie Skłodowska-Curie Actions Individual Fellowships (MSCAIF).**

Researchers for these positions will be working, if funded, on the ARS project and on a smart exoskeleton for the upper body, to support people affected by muscular weakness.

a. To establish the fundaments of intelligent surgical instruments
These instruments will be endowed with sensing device and strategies that will be capable to autonomously perform the measurements required to achieve situation awareness and acquire unprecedented level of detail about its surroundings. Aim of this research is the investigation of the proper design of soft and hard instruments with embedded sensors and intelligence. New paradigms for sensor integration will be taken into consideration during the design for guaranteeing a proper fabrication compatible with the working conditions. The design should incorporate adequate intra-operative sensing technologies (FBG, OCT, EM, US) and proper actuation schemes. The optimal sensor/actuation combination will be implemented in dedicated surgical robotic systems by specific integration procedure with the final aim to enhance the selfawareness of the whole robotic system and optimizing application safety. This new generation of self-aware instruments will be tested during in ex-vivo and in-vitro experiments. Through their proprioceptive capabilities these instruments can exceedingly put anatomical information into context, improve the operator's awareness of the surgical site, and increasing the intuitiveness and the efficiency of the intervention.
b. Upper Limb Exoskeleton Control for ADL Assistance
This research aims at developing advanced sEMG decoding and exoskeleton control algorithms considering one or more of the following specific topics:
i. Advanced sEMG decoding algorithms with a specific focus on robustness to sensor misplacements and self-calibration.
ii. Advanced assistive algorithms working at the interface between sEMG decoding and exoskeleton control.
iii. Advanced force and impedance control of series elastic systems based on low cost implementations and with specific focus on identification and estimation techniques to compensate for system uncertainties.
iv. Mechatronic design of mobility support systems (e.g. exoskeletons) to help patients with reduced physical mobility exploiting low-cost materials (e.g. plastic materials) and components (low-end sensors and actuators). See the concept of Series Elastic Link which has been recently introduced by our group.
The selected candidate will be invited to submit a MSCA IF proposal together with Prof. Fiorini, supervisor of the proposal. The involvement of the selected candidate in the proposal writing process will provide ample opportunity to tailor the proposal to his / her research interests. A successful application will result in a one-year, or a two-year appointment.
Research Field: Robotics, Automation and Computer Science Engineering
Career Stage: Experienced researcher or 4-10 yrs (Post-Doc)
Research Profiles: Recognized Researcher (R2)

Full information is available here:

http://metropolis.scienze.univr.it/altair/open-positions/

INDUSTRY 4.0

Five full time PhD students

http://www.di.univr.it/?ent=progetto&id=4935