Report on the first Biannual Summer School on Control of Surgical Robots

Organisers:
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Website http://metropolis.scienze.univr.it/altair/events/cosur-2016/

Motivation and novelty

Robotic Surgery has been broadly studied in recent years due to its potential to dramatically impact quality and efficiency of medical and surgical procedures. The many challenges and its multi-disciplinary nature further explain its appeal in the research community. For these reasons, a number of doctoral schools have been established both in Europe and in the United States, with the purpose of giving students and researchers alike a broader perspective on this emerging field. A specific aspect of the application of robots to surgical tasks is the analysis of the interaction between the anatomic district and the robotic instruments, with relies on the perception, cognition and control of the human/robot surgical team.
There is a long history of doctoral schools in surgical robotics in Europe. One of the earliest school was started by Philippe Poignet and Etienne Dombré of the University of Montpellier in 2003 and is held in odd years. This year will be the 7th edition of the school, which trains about 50 PhD students, post-docs and researchers. In 2007, Russell Taylor and Blake Hannaford proposed a North American version of the Surgical Robotics School and the First North American Surgical Robotics School was held in Winter 2009 at Johns Hopkins University. The school is biannual and the 4th school was held in Pittsburgh on August 2014.
A more focused approach to a doctoral school in surgical robotics was started in 2014 at the Hamlyn Center, with a school focusing on the use of high performance computing for medical imaging and robotics.

COSUR follows this trend of a more focussed school. The main differences with respect to the existing school are:

- COSUR will be held in even years in Europe
- COSUR focus is more on **control**, **teleoperation** and **cognitive** aspects of robotic surgery
- Its aim is to pave the way for training students for the next generation of **semi-autonomous** surgical interventions

Program of the school

	05/09/2016	06/09/2016	07/09/2016	08/09/2016	09/09/2016
9.00-9.45	Welcome to the school and structure of the school (Dr. Marta Capiluppi) Room: Sala Verde	Advanced teleoperation I (Dr. Riccardo Muradore) Room: Sala Verde	Ultrasound for intervention guidance (Prof. Chris de Korte) Room: Sala Verde	Students projects: introduction Room: Laboratorio Ciberfisico	Students presentations and evaluation Room: Sala Verde
9.45-10.30	Introduction to robotic surgery (Prof. Arianna Menciassi) Room: Sala Verde	Motor strategies investigation in human robot interaction during teleoperation (Dr. Elena De Momi) Room: Sala Verde	Motion planning and neural interfaces for surgical robots (Prof. Joel Burdick) Room: Sala Verde	Students projects Room: Laboratorio Ciberfisico, Laboratorio Alfa	Students presentations and evaluation Room: Sala Verde
10.30-11.00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11.00-11.45	Presentation of participants Room: Sala Verde	Advanced teleoperation II (Dr. Riccardo Muradore) Room: Sala Verde	Surgical robot control - human interfaces (Prof. Tamas Haidegger) Room: Sala Verde	Students projects Room: Laboratorio Ciberfisico, Laboratorio Alfa	Students presentations and evaluation Room: Sala Verde
11.45-12.30	Presentation of participants Room: Sala Verde	Robotic StereoElectroEncephaloGraphy (Prof. Francesco Cardinale, Ospedale Niguarda "Ca' Granda") Room: Sala Verde	Robotic Cardiothoracic Surgery (Prof. Marco Zenati, Harvard Medical School) Room: Sala Verde	Robotics in Urology (Prof. Salvatore Siracusano, University of Verona) Room: Laboratorio Ciberfisico	Medical perspective: From Robotic Instruments to Robotic Operating Room (Prof. Marco Zenati, HMS) Room: Sala Verde
12.30-14.00	Lunch	Lunch	Lunch	Lunch	Lunch
14.00-14.45	Focused Ultrasound Therapy Using Robotic Approaches - FUTURA (Dr. Selene Tognarelli) Room: Sala Verde	Enhanced Delivery Ecosystem for Neurosurgery in 2020 - EDEN2020 (Dr. Elena De Momi) Room: Laboratorio Ciberfisico	Image guided robot for precise prostate biopsy - ROBIOPSY (Prof. Paolo Fiorini) Room: Sala Verde	Robot-Assisted Laser Microsurgery (Dr. Leonardo Mattos) Room: Laboratorio Ciberfisico	Passivity and Telemanipulation: a wish or a must? (Prof. Stefano Stramigioli) Room: Sala Verde
14.45-15.30	Basic teleoperation (Dr. Riccardo Muradore) Room: Sala Verde	Laboratory exercises: introduction Room: Laboratorio Ciberfisico (Groups As), Laboratorio Alfa (Groups Bs)	Laboratory exercises: introduction Room: Laboratorio Ciberfisico (Groups Bs), Laboratorio Alfa (Groups As)	Early stage Start-up Strategies in Robotic Surgery (Dr. Giuseppe Prisco) Room: Laboratorio Ciberfisico	Future perspectives (Prof. Paolo Fiorini) Room: Sala Verde
15.30-16.00	Break	Break	Break	Break	End
16.00-16.45	Some recent advances for robotic assistance in training, interventional radiology and endoluminal surgery (Prof. Philippe Poignet) Room: Sala Verde	Laboratory exercises Room: Laboratorio Ciberfisico (Groups As), Laboratorio Alfa (Groups Bs)	Laboratory exercises Room: Laboratorio Ciberfisico (Groups Bs), Laboratorio Alfa (Groups As)	Students projects Room: Laboratorio Ciberfisico, Laboratorio Alfa	
16.45-17.30	Perceptual Docking for Robotic Control (Prof. Guang-Zhong Yang) Room: Sala Verde	Laboratory exercises Room: Laboratorio Ciberfisico (Groups As), Laboratorio Alfa (Groups Bs)	Laboratory exercises Room: Laboratorio Ciberfisico (Groups Bs), Laboratorio Alfa (Groups As)	Students projects Room: Laboratorio Ciberfisico, Laboratorio Alfa	
17.30-18.30	Visit of Altair Lab			Students projects Room: Laboratorio Ciberfisico, Laboratorio Alfa	
18.00-20.30			Guided tour of Verona		
19:30-23:00				Social Dinner	

Structure of the school

The school mixed up lectures and practical experiences. Lectures focus was mainly on:

- Teleoperation and teleoperated interventions
- Human-robot interaction
- Cognitive Control

The medical requirements were presented by senior surgeons in different fields: Neurology, Cardiology, Urology. Recent advancements were shown with presentations on ongoing projects in robotic surgery and industrial applications.

For practical experiences, the students were divided into 10 groups of 3-4 people each. The groups were decided by the organisers, based on the expertise and the year of PhD/post-doc of the students. Afternoons of day 2 and day 3 were dedicated to the practical application of basic teleoperation and image registration processes. We wanted to show how basic exercises can be transformed in more complex projects. To this end, day 4 was almost entirely dedicated to the implementation of group projects. Day 4 was devoted to the presentations of such projects, to give the students the opportunity to practice their ability to present and explain their work in front of some of the lecturers of the school. Students' results and presentation were evaluated by the organisers and lecturers, with the aim of producing a certificate of attendance.

At the end of the school all the students received the slides of the lectures. Also, most of them participated to CRAS workshop (https://www.cras-eu.org/cras-2016), which took place immediately after the school, with posters and lectures on their results. This was recognised as a good opportunity for them to be introduced into the surgical robotic community.

Projects proposed

Teleoperation

1. Modify the Lee-Spong algorithm using time-varying dissipative elements (K_{diss} as a function of the network conditions)
2. Introduce within the TDPA algorithm filters at the master side
3. Modify the original Position-Force TDPA algorithm into a Position-Position architecture
4. Modify the Two-layer approach from Position-Force to Position-Position
5. Comparison of different energy transportation protocols within the Two-layer approach

Images

1. Compute in Matlab the distance from the needle tip to the center of a sphere and the relative orientation of the needle with respect to the ultrasound image.
2. Compute in Matlab the volume of an ellipsoid manually segmented from 2 sections of a tumor.
3. Compute in Matlab the area of an irregular region segmented by placing points on the contour.
4. Use the Ultrasonix research interface and scanner to acquire 3D volumes through PLUS software, optical tracking and 3D calibration (which are given). Compute the volume of anatomical areas through segmentation (you can use Slicer 3D, Mevislab, Matlab or an other medical image processing software).
5. Use the Ultrasonix research interface and scanner to acquire a set of 2D images as video files containing tumors of different dimensions. Use Matlab scripting to automatically extract or highlight areas of given dimension. If the calibration is not given, apply the techniques learnt during the laboratory sessions.
6. Use the Ultrasonix research interface and scanner to acquire a set of 2D images as video files containing the view of a needle. Implement in Matlab an algorithm to automatically detect the needle and compute the orientation with respect to the ultrasound image.

Students' choices and results

- 5 groups chose teleoperation projects.
- 2 groups chose imaging projects.

- The others decided to mix teleoperation with imaging.
- During their presentations, the students showed their understanding of the basic principles of teleoperation and imaging.
- Not all the groups were able to complete the project, due to the short time and practical problems with software and instrumentation, but they always presented correct conclusions.

Key numbers

- 55 applications
- 40 accepted
    - Coming from: Italy, Germany, UK, China, Belgium, USA, Spain, Japan, France, Kazakhstan, Russia
- 38 attending
- 7 female students
- 24 IEEE RAS students (present, 25 registered)
- Mostly PhD, 3 post-docs, 2 MS
- Basically all students had background in control and robotics, most of them in robotic surgery, few of them on image guided robotic surgery

Evaluation of the school

We distributed a questionnaire with scores from 1 to 10. We received 29 feedbacks. We present mean scores and variance.

1. How high was your interest in the subjects introduced by the school before coming? **8.6 (1.3)**
2. How successful were the courses in increasing your interest in surgical robotics? **8.8 (0.8)**
3. How do you rate the supporting material for the courses? **8.3 (1.1)**
4. Was the school content sufficiently balanced between theory and practice? **7.6 (2.9)**
5. How do you rate the presence of the hands-on/exercises during the school? **8.4 (1.5)**
6. How do you rate the presence of final projects during the school? **7.3 (3.5)**
7. Were the rooms/laboratories adequate? **8.5 (2.9)**
8. Were the theoretical lectures enough detailed to perform the practical experience? **8.2 (1.9)**
9. Do you expect that the school content will turn out to be useful for your present or future reasearch activity? **8.9 (1.1)**

Students' suggestions from the questionnaire

Do you think that the presentations should be more/less technical?

In general the students appreciated the balance of technical/non-technical lectures offered by the school. Some would have preferred to receive more technical details and applications overview. Some students would have enjoyed more medical presentations with more details on challenges to be solved by engineers.

Which of the topics introduced by the school was more interesting for you? Do you think this topic needed to be more deeply described?

In general all, mostly teleoperation and human-robot interfaces and interaction. The level of description is sufficient, some details would have been appreciated in HRI, some applications (for exercises) have been required.

Do you have any suggestions about how to improve the organization or the effectiveness of the courses offered by the School?

The students would have preferred to have more time to do practical projects and exercises. They suggest to reduce the number of lectures and focus more on some topics. Some of them also suggest to finish the school on Saturday morning. Some of them suggest to give exercises/project some time before the school.

Do you think that exercises/projects should be more/less complex? Do you have any suggestions about them?

In general they think they are appropriate. They complain basically about the lack of time. Some of them suggest to remove projects, some to remove exercises. Some students suggest to prepare exercises finalized to do projects.

What was your background and how much did you knew about the school topics before coming?

Most of the students were quite new about the topics introduced by the school. In particular, they were new on the software tools for exercises. Probably, the background to achieve them should be better specified before the school.

What aspect(s) of this school did you like most?

Everything! Mostly: the variety of lectures, the practical experiences, the energy of people, the exchange with other students and professors, the medical and entrepreneurial perspectives, the tour of the city! Oh and the organisers!

Pictures of the school are downloadable at
https://www.dropbox.com/sh/8oj3zkyelj82maj/AADbHQZrVQfgWxr4dZVE38n0a?dl=0