A Coordination Action for Soft Robotics

Plenary Meeting

March 31 – April 1, 2014

Scuola Superiore Sant'Anna, Pisa, Italy

Introduction to RoboSoft Coordination Action

RoboSoft Coordination Action started on October 1, 2013 as **EU-funded Coordination Action (CA) for Soft Robotics under the Future and Emerging Technologies Open Scheme** (FP7-ICT-2013-C project #619319). RoboSoft is coordinated by Prof. Cecilia Laschi (The BioRobotics Institute, Scuola Superiore Sant'Anna, Pisa, Italy) in partnership with the ETH Zurich (Switzerland) and the University of Bristol (UK),

RoboSoft rationale

Soft robotics, intended as the use of soft materials in robotics, is a young research field, going to overcome the basic assumptions of conventional rigid robotics and its solid theories and techniques, developed over the last 50 years. Using soft materials to apply forces on the environment, as expected in a soft robot able to locomote, grasp, and perform other tasks, poses new problems at the level of the different components as well as at the whole system level. The technologies for actuating the soft materials have not yet been demonstrated to exist in a general form, although specific effective examples exists. The same is true for sensors embedded in the soft materials and for soft robotic energy suppliers.

A Coordination Action for Soft Robotics is extremely necessary and timely in the current and future landscape of robotics and biorobotics and can capitalize on the competitiveness of European research in this new field. A common forum will help soft robotics researchers to combine their efforts, to maximize the opportunities and to materialize the huge potential impact.

RoboSoft will create this missing framework for the soft robotics scientists, regardless of their background disciplines, and will enable the accumulation and sharing of the crucial knowledge needed for scientific progress in this field. RoboSoft will not only create and consolidate the soft robotics community, but will also create assets that go beyond the end of the three-year CA.

RoboSoft objectives

RoboSoft aims at creating a common forum to help soft robotics researchers to combine their efforts and enable the accumulation and sharing of scientific and technological knowledge to maximize the opportunities and materialize the huge potential impact of soft robotics technologies.

The Coordination Action aims first at creating and consolidating a scientific community in the field of soft robotics. For this objective the RoboSoft Consortium will involve the major excellent research laboratories and institutions at European and international level working in the field of soft robotics to take part to the scientific initiatives of the RoboSoft Community (plenary meetings and workshops, Summer Schools, working groups, and more).

Besides, with the activities organized in the framework of the Coordination Action, RoboSoft aims at: (i) creating the common places for gathering and for exchange of ideas and experiences for researchers in soft robotics and in the many scientific and technological sectors related to it; (ii) promoting the visibility of soft robotics beyond its community and towards stakeholders and special interest research communities; (iii) providing means for better exploiting the potential of soft robots and technologies in future ICT.

RoboSoft Community Members

The RoboSoft Community is intended to comprise the major excellent research laboratories, at European and international level, working in the field of soft robotics, identified by RoboSoft Consortium on the base of the following criteria:
- Vision of soft robotics in line with the RoboSoft philosophy;
- Scientific activities in soft robotics currently being carried on (publications, projects, educational activities, etc.);
- Potential contribution and commitment to Working Groups and to RoboSoft events and publications.

Membership to the RoboSoft community will be open for all the duration of the CA. The RoboSoft Executive Board will approve the membership of candidates. Members joining the RoboSoft community will be organized in a number of thematic Working Groups (WGs) to focus on critical or emerging topics and technologies.

The following list of WGs has been discussed and defined during RoboSoft kick-off meeting (November 13, 2013, Pontedera, Pisa, Italy):
- Smart Materials and Soft Actuators;
- Control Architectures and Paradigms for Soft Robots;
- Soft Sensors;
- Energy harvesting;
- Stretchable Electronics;
- Biological insights.

Each WG is composed by experts of the respective research topics. The number and type of WGs could change along the project duration on the basis of the members' needs and of strategic decisions under the supervision of the Executive Board and Advisory Board.

Coordinated by the RoboSoft consortium, the WGs shall deliver working papers derived from brainstorming sessions, describing the challenges and the expected milestones of soft robotics and providing research roadmaps for the soft robotics community and needed actions for the European Commission. The consultations should address both scientific and technological aspects as well as necessary supporting actions to materialize the potential impact of soft robotics.

RoboSoft Working Groups shall also participate in the organization of events for cross-fertilization with other scientific communities (i.e. biology, medicine, neuroscience, material science and chemistry, mathematics and model theory, etc.), like workshops or special sessions organized at major conferences of such disciplines where fertilization and promotion of soft robotics can take place.

Coordination Action Initiatives

The RoboSoft Consortium and Community will consolidate a network for scientists and roboticists, providing opportunities and common places for gathering and for exchange of ideas and experiences, promoting discussions on open issues, tracking technical developments and encouraging innovation, fostering the exchange of personnel and collaboration activities, and drawing up working papers and a book series collecting the knowledge of soft robotics.

RoboSoft workplan (Figure 1) foresees the following major activities:

- 3 Periodic plenary meetings involving the scientific community and stakeholders;
- 2 Summer Schools for PhD students and young researchers;
- A series of interdisciplinary events for cross-fertilization with other scientific communities (i.e. biology, medicine, neuroscience, material science and chemistry, mathematics and model theory, etc.);
- A series of dedicated workshops and exhibitions for stakeholders
- The setup and maintenance of the RoboSoft website with online tools available to the Community Members;
- The periodic publication of the RoboSoft Newsletter and engagement material for RoboSoft Community, other scientific communities and stakeholders (each 6 months);
- The writing of Working Papers with the RoboSoft Community Members resulting from brainstorming and discussions in the WGs during and right after the first two Plenary meetings, definition of scientific and technical standards for soft robotics;
- A book series for soft robotics resulting from Working Papers and from brainstorming and discussions meetings.
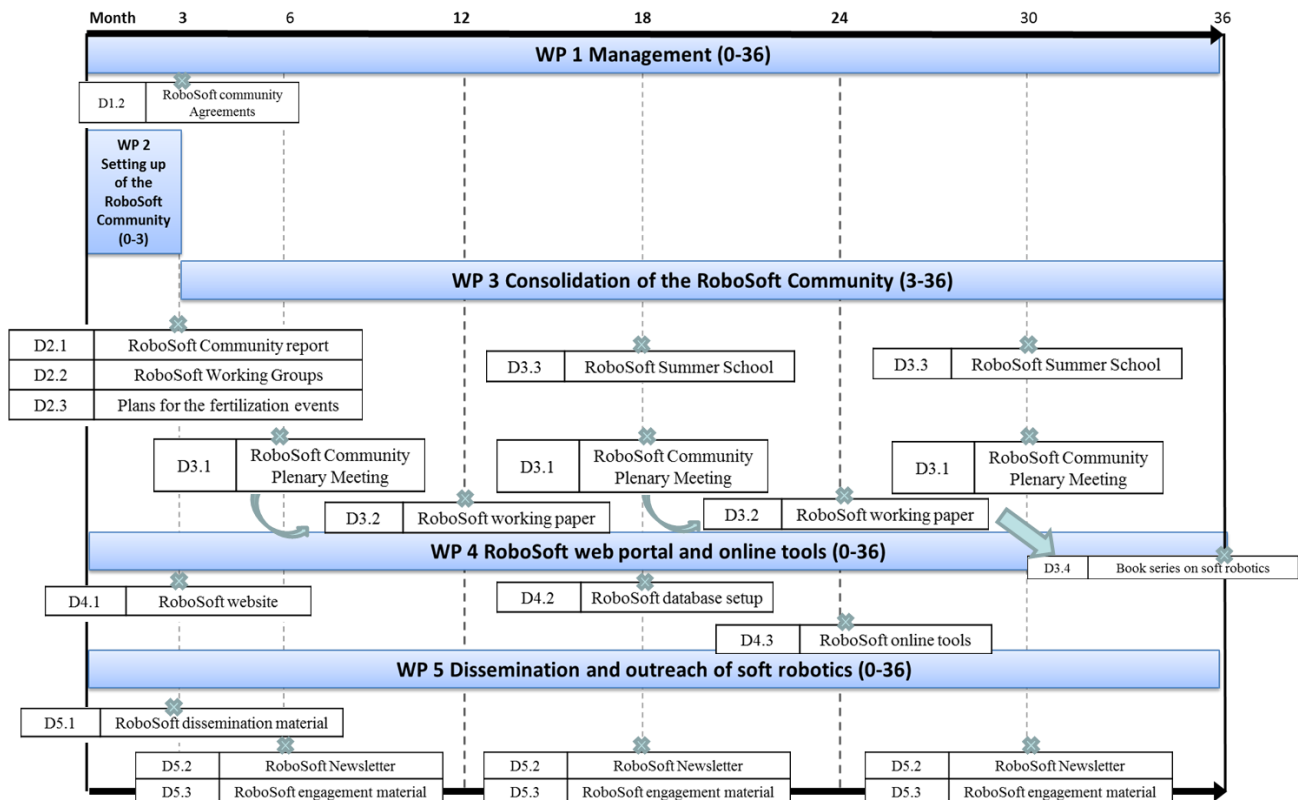

Figure 1 RoboSoft workplan and deliverables (Dx.y)

RoboSoft Consortium

The BioRobotics Institute is Coordinator of the CA and is responsible of the project coordination and management, of the organization of the scientific community and initiatives, and supervises and contributes to the dissemination and outreach activities.

Prof. Cecilia Laschi and her team have been working in the field of soft robotics since 2007 (http://sssa.bioroboticsinstitute.it/research/softrobotics). The past 6 years of research in Soft Robotics concerned the design and development of a soft-bodied robot inspired to the octopus, with locomotion and grasping capabilities (FP7-ICT FET OCTOPUS IP). The OCTOPUS soft robotics technologies are being exploited in biomedical applications, in building a soft endoscope for minimally invasive surgery (EU STIFF-FLOP IP), and in marine robotics, in building a soft robot for underwater explorations (PoseiDRONE Project). Among others, the BioRobotics Institute has participated in FP6-IST CAs, in FP7-ICT CA AALIANCE and was the coordinator of the FP7-ICT-FET Flagship Initiative Preparatory Actions CA-RoboCom.

The Swiss Federal Institute of Technology Zurich (Eidgenössische Technische Hochschule Zürich, Switzerland, http://www.birl.ethz.ch/) is responsible of the project web portal and online tools setup and management and supports and is involved in all the coordination action initiatives. In the recent years, Prof. Fumiya Iida and his team have been actively contributing the soft robotics community, as they organized Swiss-Japan Seminar on Soft Robotics (2010), the Summer School on Soft Robotics (in Zürich, 2012), and the International Workshop on Soft Robotics and Morphological Computation (in Ascona, Switzerland, 2013). Prof. Iida has been guest editor of a special issue on Soft Robotics in Advanced Robotics Journal (2012) and proposed and founded the IEEE Robotics and Automation Technical Committee on Soft Robotics (2012), where also Prof. Cecilia Laschi is a Co-Chair.

The Soft Robotics research group (http://www.brl.ac.uk/researchthemes/softrobotics.aspx) is part of the Bristol Robotics Laboratory, a joint research centre set up by the **University of Bristol** and the University of the West of England and headed by Prof. Chris Melhuish. Dr. Jonathan Rossiter is the team leader and with his group focus on the development and exploitation of compliant technologies for robotic, user interfaces and medical applications. The Bristol team is responsible of the dissemination and engagement activities and contacts with stakeholders for RoboSoft and supports and is involved in all the coordination action initiatives.

During the first months of the project, the RoboSoft Consortium has established the Executive Board and Advisory Board.

RoboSoft Executive Board is chaired by the CA coordinator, Prof. Cecilia Laschi, and composed of one person in charge of each partner: Prof. Fumiya Iida, for ETH Zurich, and Dr. Jonathan Rossiter, for the University of Bristol. The Executive Board will support the Project Coordinator with CA strategic orientation and in fulfilling the tasks and obligations on the basis of the provision of the EC Contract, the consortium Agreement, and the community Agreement.

RoboSoft Advisory Board is chaired by Prof. Rolf Pfeifer, Full Professor at University of Zürich, and Prof. George Jeronimidis, University of Reading (UK). The Advisory Board will supply the consortium and the community with scientific, technological and management evaluations and advising for future activities.

First RoboSoft Plenary Meeting

Programme

	March 31, 2014	
Time	**Session**	**Room**
9.00 – 9.15	Registration	Aula Magna
9.15 – 9.45	**RoboSoft welcome and introduction**: *Cecilia Laschi* RoboSoft CA Coordinator (BioRobotics Institute, Scuola Superiore Sant'Anna)	Aula Magna
9.45 – 10.30	Invited talk: *Paolo Dario* (BioRobotics Institute, Scuola Superiore Sant'Anna) **"Soft robotics: new frontiers for BioRobotics and Robot Companions"**	Aula Magna
10.30 – 11.00	Teasers (I)	Aula Magna
11.00 – 11.30	Poster Session & Coffee Break	Aula Magna Storica
11.30 – 12.15	Invited talk: *Rolf Pfeifer* (AI Lab, University of Zurich) **"Soft robotics - the next generation of intelligent machines"**	Aula Magna
12.15– 13.00	Assignment of Working Groups	Aula Magna
13.00 – 14.30	*Lunch break (free time)*	
14.30 – 16.30	Working Group Session Parallel Sessions	
	Smart Materials, Soft Actuators and Soft Sensors (Coordinator: *Barbara Mazzolai*, IIT)	Aula 3
	Control Architectures and Paradigms for Soft Robots (Coordinator: *Helmut Hauser*, University of Zurich)	Aula 6
	Energy Harvesting and Stretchable Electronics (Coordinator: *Jamie Paik*, EPFL)	Aula 8
16:30 – 17.00	Poster Session & Coffee Break	Aula Magna Storica
	Break (free time)	
20:00…	Social Dinner at "Antica Trattoria il Campano" (via Domenico Cavalca, 19)	

Time	April 1, 2014	
	Session	Room
9.00 – 9.45	Invited talk: *Robert Shepherd* (Cornell University) **"Innovative solutions for design and manufacturing of soft components and systems"**	Aula Magna
9.45 – 10.45	Teasers (II)	Aula Magna
10.45 – 11.15	Poster Session & Coffee Break	Aula Magna Storica
11.15 – 12.00	Invited talk: *George Jeronimidis* (University of Reading) **"Materials strategies and systems for Soft Robotics"**	Aula Magna
12.00 – 13.00	Working Group Parallel Sessions	
	Smart Materials, Soft Actuators and Soft Sensors (Coordinator: *Barbara Mazzolai*, IIT)	Aula 3
	Control Architectures and Paradigms for Soft Robots (Coordinator: *Helmut Hauser*, University of Zurich)	Aula 6
	Energy harvesting and Stretchable electronics (Coordinator: *Jamie Paik*, EPFL)	Aula 8
13.00 – 14.30	*Lunch break (free time)*	
14.30 – 16.00	Wrap-up of Working Groups	Aula Magna
16.00 – 16.30	Conclusions	Aula Magna

Teaser presentations and poster sessions

<u>**Teaser Session 1, March 31, 10:30-11:00**</u>

#	Corresponding Author	Title	Institution
1.1	Aiva Simaite	Functionalization of PVDF membranes for increased interface strenght of trilayer conducting polymer actuators	LAAS-CNRS
1.2	Indrek Must	An autonomous sub-gram scale soft robot based on ionic electroactive polymer actuators	University of Tartu
1.3	Raphael Addinall	Carbon nanotube ionic actuators – System integration, as example micro pipette	Fraunhofer- IPA
1.4	Andreas Ostmann	Stretchable and modular electronics	Fraunhofer- IZM
1.5	Espen Knoop	Towards soft robotics skin and smart textiles: shear tactile displays with soft actuators	University of Bristol
1.6	Massimiliano Gei	Optimal energy-harvesting cycles for load-driven soft dielectric generators	University of Trento

<u>**Teaser Session 2, April 1, 9:45-10:45**</u>

#	Corresponding Author	Title	Institution
2.1	Vito Cacucciolo	Grasping with muscular hydrostats: a biomechanical investigation	The BioRobotics Institute
2.2	Luzius Brodbeck	Physically adaptive robots exploiting thermoplasticity and adhesion	ETH Zurich
2.3	Vito Cacucciolo and Francesco Corucci	Evolving optimal swimming in different fluids: a study inspired by batoid fishes	The BioRobotics Institute
2.4	Francesco Corucci	The locomotion of an underwater soft robot as a case study for further investigating morphological computation and embodied intelligence	The BioRobotics Institute
2.5	Francesco Giorgio-Serchi	Soft Robots for the offshore industry: going where no soft robot has gone	The BioRobotics Institute
2.6	Mariangela Manti	A physical model of the human larynx and a biorobotic prototype of vocal cords	The BioRobotics Institute
2.7	Sheila Russo	Flexible Robotic Approaches to Enhancing Laser Surgery and Microsurgery	The BioRobotics Institute
2.8	Tommaso Ranzani	A soft modular manipulator for minimally invasive surgery	The BioRobotics Institute
2.9	Utku Culha	Sensorization of Soft Structures with Guidance of Strain Vectors	ETH Zurich
2.10	Xiaoxiang Yu	Soft Robotics Education: from Concepts to Implementation	ETH Zurich

Working Group consultation objectives

RoboSoft Working Groups shall deliver working papers derived from brainstorming sessions, describing the challenges and the expected milestones of soft robotics and providing research roadmaps for the soft robotics community and needed actions for the European Commission.

The consultation should address both scientific and technological aspects as well as supporting actions (i.e. what we need from EC, stakeholders, etc) to materialize the potential impact of soft robotics.

RoboSoft Working Groups shall also participate in the organization of events for cross-fertilization with other scientific communities (i.e. biology, medicine, neuroscience, material science and chemistry, mathematics and model theory, etc.), like workshops or special sessions organized at major conferences of such disciplines where fertilization and promotion of soft robotics can take place.

Proposed consultation themes

(1)   Discuss the state of the art (in brief)

(2)   Which are the main scientific and technological challenges for frontier research in soft robotics that need to be tackled in the next 10-20 years, and which is the nature of the challenges (vision-driven and high-risk, embryonic or foundational)?

(3)   Which are the main challenges and which impact will have soft robotics technologies in different applications fields, like in service robotics (at home, at work), rehabilitation/prosthetics (soft-hard wearable robotics), surgical robotics, marine robotics, aerial robots, human-robot interactions?

(4)   Which research topics should be included in the next workprogrammes to foster research addressing the challenges identified in (2) and (3)?

(5)   Which are the technologies that limit soft robotic potential today and which bottlenecks need to be addressed in the medium term?

(6)   Which funding 'instruments' the EC should employ in order to support the research in soft robotics, and to be useful to maximize the opportunities and materialize the huge potential impact of soft robotics technologies (small projects < 3M€ - 3yrs or large projects ~4-6 M€ - 4-5 yrs, coordination actions, support of stakeholders, specific actions, specific course, competitions, new infrastructures…)?

(7)   Which international collaboration and synergies outside the EU are important for the research, organisations and exploitation of results?

(8)   Which roles should have high-tech companies, SMEs, large industries in the participation in frontier research?

(9) Discuss on differences and compare soft robotics technologies with traditional robotics technologies and control architectures, and on the scalability of soft robots.

(10) Identify the major bridges and collaborations among disciplines to merge the large network of scientists around the soft robotics community (material science, biology, mathematics and modeling, medicine, …): inputs to contribute to the RoboSoft plans for the fertilization events.

(11) Which are the main technological challenges and design technics for the development of integrated systems (sensors/actuators)?

(12) Which could be the "killer applications" for soft robotics?

(13) Inputs to share with the other Working Groups to exchange knowledge and to identify possible gaps.

Meeting venue:

The First RoboSoft Plenary Meeting is organized at the Scuola Superiore Sant'Anna, Pisa, Italy (http://www.sssup.it/).
The main buildings of the Scuola Superiore Sant'Anna are located in the heart of Pisa, at 10 minutes walking distance to Piazza dei Miracoli and the Tower, near to several boutiques and bars of Borgo Stretto and the Lungarno.

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Scuola Superiore Sant'Anna
P.zza Martiri della Libertà, 33 - 56127 - Pisa (Italy)
Tel. (0039) 050 88.31.11
Fax (0039) 050 88.32.25

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Find here directions on: Google Maps:

RoboSoft Contacts

Project Coordinator: Prof. Cecilia Laschi
The BioRobotics Institute, Scuola Superiore Sant'Anna
viale Rinaldo Piaggio 34, 56025 Pontedera (Pisa), Italy
Tel. +39 050 883486, Fax: +39 050 883497, Mobile: +39-348-0718832
Email: cecilia.laschi@sssup.it

RoboSoft Scientific Secretariat and Management
Dr. Laura Margheri
The BioRobotics Institute, Scuola Superiore Sant'Anna
viale Rinaldo Piaggio 34, 56025 Pontedera (Pisa), Italy
Tel. +39 050 883395, Fax: +39 050 883399, Mobile: +39-347-1329605
Email: laura.margheri@sssup.it

http://www.robosoftca.eu/

Notes

THE BIOROBOTICS
INSTITUTE

Scuola Superiore
Sant'Anna

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

University of
BRISTOL