RoboSoft

The Newsletter of RoboSoft
Coordination Action for Soft Robotics

RoboSoft Grand Challenge Edition

Issue 4, September 2015

Contents:

Editorial

While the Soft Robotics community is well aware that important research challenges are still open in new materials, actuators, sensors, control algorithms, and other enabling technologies for soft robots, potential real-world applications are making their appearance in the framework of soft robotics research and development.

This fact was evident during the events that have been organized in the past months by the RoboSoft Coordination Action and was discussed at the Annual RoboSoft event. This year, it was organised as the "Soft Robotics Week": the first week totally dedicated to soft robotics with a series of scientific, cultural and educational events. It was successfully held last April 13-17, 2015, in Livorno (Italy).

During workshops, meetings and other joint events, novel technologies and approaches were shown during presentations, while the discussion sessions were focused on what the real needs are and which the possible applications for soft technologies will be in the future, involving robotics leaders and people from industry and promoting the dialogue and the collaboration in support of research trends.

At this stage of soft robotics, an important tool that is already well-known and used in robotics is going to be applied for the first time for soft robots: the challenges. During outdoor challenges, or competitions, researchers are provided with real-world scenarios where they can test innovative technologies and see their behaviour in case of real applications. For robotics, they are a great instrument for education, for pushing and advancing technology development, for experimental evaluation and for benchmarking.

We need now to measure the status of current soft robots, to compare their performance, to evaluate the use of a specific technology in a well-defined application, to get a benchmark and to define general standards. Challenges are a way to respond to all these needs. What is more, challenges are opportunities to have fun, enforce the activities of a community, compare and compete with each other, stimulate imagination, understand real needs and, last but not least, they are a nice chance to bring (soft) robots closer to the general public and stakeholders.

So, while our Coordination Action is periodically organizing activities for the growth of the community, for having joint brainstorming events and for networking with stakeholders, last June 2015 RoboSoft have also launched the first outdoor challenge for soft robots: the RoboSoft Grand Challenge.

The competition is intended for soft robots and the tasks have been designed to tackle specific features of soft robots, like resilience, body compliance, delicate contact and deformability. It aims to be an important guide for research trends, for evaluating the performance of technologies and systems for soft robots, and for seeing where soft robots can really make the difference in real-world applications that could be useful for human beings.

The RoboSoft Grand Challenge will be held in Livorno, next April 29-30 2016, in the framework of the 2016 Soft Robotics Week (April 25-30, 2016). The total prize will be 5000 €, plus additional in-kind prizes and financial support for participants. You can read more inside this Newsletter issue or go to the RoboSoft website:
http://www.robosoftca.eu/events/robosoft-grand-challenge .

Stay tuned not to miss the coming deadline of October 31, 2105 for expressions of interest and for last-minute news!

During the same week of April, we are also organizing the annual Plenary Meeting for the RoboSoft community (April 27-28, 2016) and the School for PhD students (April 25-29, 2016), so you can take the opportunity to come for all the events in those same days. We look forward to seeing many of you participating in the RoboSoft Grand Challenge and attending the other events of the second Soft Robotics Week.

In this Newsletter, you will read more about the major events organized by RoboSoft in the past months, you will meet people from the RoboSoft Community and read about current technologies for variable stiffness soft robots, you will have a picture of two great institutions, members of RoboSoft, and more. Enjoy the reading and stay tuned with RoboSoft!

Laura Margheri, Helmut Hauser and Cecilia Laschi

RoboSoft Pills

There is a growing number of attendees at workshops and meetings that are related to soft robotics and several new members have joined RoboSoft during the last months, including several European universities and Disney Research Zurich.
The Community counts now 31 members worldwide:
http://www.robosoftca.eu/robosoft-community/community-members.

The Coordination Action has organized several events at major robotics conferences and forums in order to keep the Community active and updated and to involve new members and stakeholders interested in the application and use of soft robotics technologies. During the European Robotics Forum (ERF2015, Vienna, Austria), the Coordinator of RoboSoft, Cecilia Laschi, has been invited to give a talk at the special session "Robotics projects…beyond the Robotics Unit", to present RoboSoft to the Officers of the European Commission and to the European robotics research and industry community, as an example of Coordination Action under the FET Open programme.

April 2015 is a month to remember for the launch of the first "**Soft Robotics Week**". The event was organized as the yearly Plenary Meeting for the community of soft robotics based around a unique concentration of scientific, cultural and educational events to help the growth of this emerging field and provide an opportunity to build on the visibility of soft robotics for increased marketing and outreach. The event was held on April 13-17, 2015, in the sunny city of Livorno, in Italy. About 100 international leaders and talented students from 15 countries and 46 institutions worldwide participated in the events during the week, contributing with plenary talks, posters, and during the brainstorming sessions of working groups.
The RoboSoft and SMART-E Joint School on "Applications and Frontiers of Soft Robotics" and the RoboSoft Plenary Meeting were the major scientific events. The School took place from Monday to Friday, with a programme that combined lectures and hands-on sessions with an exhibition of posters and robots by the 38 students participating in the School, and a robot competition on the last day.

Group picture of the RoboSoft Community

The two-day Plenary Meeting included a scientific workshop with plenary talks and a series of brainstorming activities of the RoboSoft working groups. Plenary speakers presented and discussed the current state of the art and growth of the soft robotics field, from the foundations based on the theory of embodied intelligence and its correlation and use in soft robotics and biology, towards the more recent use and applications, like in the field of architecture and entertainment, discussing future technological challenges and research roadmaps.
The brainstorming sessions were organised around 2 main activities aimed at analysing the status of the community, setting a vision and discussing the perspectives of Soft Robotics:
- a questionnaire, intended to stimulate the discussion by giving a view of the community by the community itself,

- a creative session focused on the robots of the future.
The results of the brainstorming sessions are reported in the second RoboSoft Working Paper, released on September 30, 2015, and available at: http://www.robosoftca.eu/results.

If you want to read more about the first Soft Robotics Week, look at pictures or at the movie, you can link to the RoboSoft website or Facebook, or read the report on the June issue of the Soft Robotics Journal: http://online.liebertpub.com/doi/full/10.1089/soro.2015.29001.lma.

The next **Soft Robotics Week in 2016** has been already scheduled and it will took place in Livorno (Italy) from **April 25 to 30, 2016**. The Week will include a **School for PhD students (April 25-29), the RoboSoft Plenary Meeting (April 27-28)** and the **RoboSoft Grand Challenge (April 29-30)**.
More information about the full program of the 2016 Soft Robotics Week will come in the next months: http://www.robosoftca.eu/information/events/soft-robotics-week.

RoboSoft has also co-organized the workshop on "**Soft Robotics: Actuation, Integration, and Applications - Blending Research Perspectives for a Leap Forward in Soft Robotics Technology**" and a Special Session on Soft Robotics at the 2015 IEEE International Conference on Robotics and Automation (**ICRA 2015**), the IEEE Robotics and Automation Society (RAS) flagship conference and a premier international forum for robotics researchers. Both the events had a large number of attendees and good feedback for new collaborations.

Another workshop has been organized at the 17th ICAR – International Conference on Advanced Robotics (Istanbul, Turkey) and several talks and posters were presented at other international events (InnoRobo, AMAM and Living Machines).

In these days there is the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2015) in Hamburg, Germany and we are organizers of the workshop on "New Frontiers and Applications for Soft Robotics". The event will be on October 2: if you are in Hamburg, don't miss it.

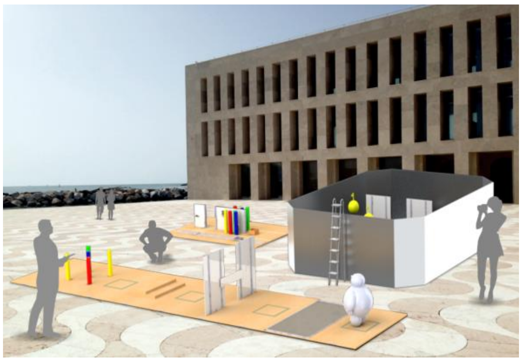
October will be an important month for events for stakeholders. The first one will be on October 8 in Bristol (UK), a day dedicated to Industrial Networking and Engagement on Soft Technologies: http://www.robosoftca.eu/information/events/industry-event.

The second event will be held during the ICT2015 conference in Lisbon (Portugal). On October 22 RoboSoft will coordinate a Networking Session on "Soft Machines – The Next Technological Revolution!" https://ec.europa.eu/digital-agenda/events/cf/ict2015/item-display.cfm?id=15841.

During the next months, the RoboSoft team will take care of the organization of the Soft Robotics Week, including the program of the School for PhD students and the Plenary meeting, and the selection of candidates for the RoboSoft Gran Challenge. Proposals for talks, candidature for the Challenge and other ideas are welcome from all. For any question or proposal, you can contact Laura Margheri (laura.margheri@sssup.it) or Cecilia Laschi (cecilia.laschi@sssup.it).

RoboSoft Grand Challenge

RoboSoft has launched the first outdoor Challenge for Soft Robots in terrestrial locomotion, underwater exploration and dextrous manipulation. “Soft” is used more and more as a required characteristics for robotics systems, especially for those that have to negotiate natural environment or interact with humans. The RoboSoft Grand Challenge aims at inspiring and pushing innovations in robotics technology and includes tasks in three different challenge scenarios: “Terrestrial race”, “Manipulation”, “Underwater race”.



The RoboSoft Grand Challenge scenarios

Challenge yourself and your robot on one or more of the three amazing scenarios, or tackle the whole Grand Challenge!

The RoboSoft Grand Challenge is open to international teams of experts in soft robotics, young researchers and students, but also to the wide public and curiosity driven people able to compete in this field.

Stay tuned not to miss the coming deadline of October 31, 2105 for expressions of interest and for last-minute news!

Date and Location: April 29 - 30, 2016, Livorno (Italy)

Total prize: 5000 € + additional in-kind prizes and financial support for participants

Registration procedure and documents: http://www.robosoftca.eu/information/events/robosoft-grand-challenge

RoboSoft’s Outreach Events for Industry

One of the core goals of the RoboSoft project is to inform and engage the private sector. The vision is to translate fundamental soft robotics research in the academic context to real-world application and novel products. We have two exciting upcoming events, which are specifically geared toward industry, SMEs and the private sector in general:

1. The RoboSoft Industrial Networking and, Engagement Day on Soft Technologies

This event will take place on **October 8th** in Bristol at the Bristol Robotics Laboratory under the theme:

Explore the possibilities of soft technologies and soft robotics in your field!

Invitation flyer for the Industrial Networking and Engagement Day on Soft Technologies

We have invited industrialists and entrepreneurs to come and have a look at the state-of-the-art in soft robotics, to interact physically with demonstrators, and to engage in exciting discussions about the possibilities of soft technologies with the goal to improve manufacturing workflows and to build better and novel products.

Industrial Networking and Engagement Day on Soft Technologies

Date: October 8, 2015

Place: Bristol Robotics Lab (Bristol, UK)

Webpage: http://www.robosoftca.eu/information/events/industry-event

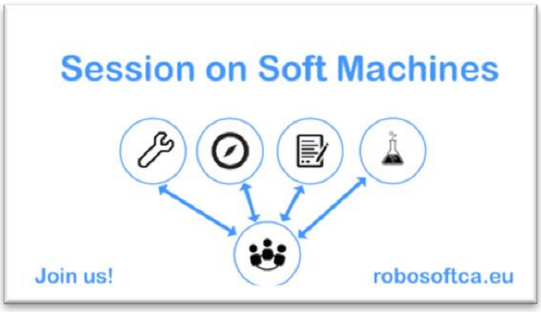
To sign up for free, contact Helmut Hauser
Email: helmut.hauser@bristol.ac.uk

Still some places available!

2. RoboSoft Engagement Workshop at the ICT (Innovate, Connect, Transform) conference in Lisbon

Our workshop has been selected to be part of the networking session. The date is October 22 and it is entitled: **Soft Machines – The Next Technological Revolution!**

We have an exciting program including short power presentations and hands-on demonstrations. Please download the programme here: http://goo.gl/4lce6U. We have edited a one-minute video pitch for the session. You can watch it here: https://goo.gl/5eBn4E. On the right you can see some screen shots of the video. If you are at the ICT conference please come and join us!"



ICT Networking Session: "Soft Machines – The Next Technological Revolution!"

Date: October 22, 2015

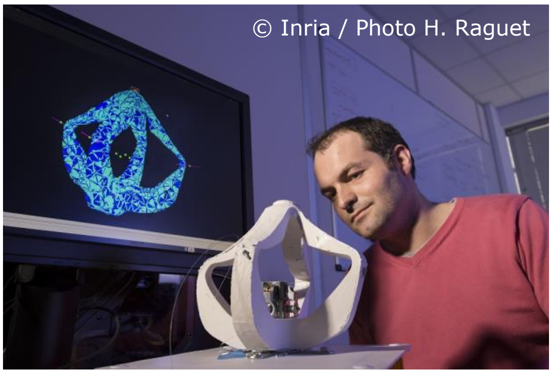
Place: ICT Conference, Lisbon, Room 12, 09:00-09:45

Webpage: https://ec.europa.eu/digital-agenda/events/cf/ict2015/item-display.cfm?id=15841

To sign up for the conference: https://ec.europa.eu/digital-agenda/events/cf/ict2015/register.cfm

Soft Bites

People: Christian Duriez



Christian Duriez received the engineering degree and PhD degree in robotics in France. His thesis work on haptic rendering of contact with deformable objects was realized at CEA/Robotics lab and followed by a postdoctoral position at the CIMIT SimGroup in Boston on surgical simulation for training. He arrived at INRIA in 2006 and was one of the founders of SOFA, a software framework dedicated to real time physics-based simulation of soft-tissues for surgical simulation. His research topics are fast Finite Element Methods (FEM), simulation of contact response and other complex mechanical interactions, new algorithms for haptics. Recently, he created a new team, called DEFROST, dedicated to modeling and control of soft-robots.

Christian on soft robotics:
Q. What does soft robotics mean to you?

To me, soft robotics is a natural evolution of robotic technology. When humanity invented the wheel, at the first time, it was rigid. Now, wheels are covered with a tire to enable better performance and robustness! Deformable bodies have very interesting properties for robots that could considerably improve their design.

Q. What can soft robotics deliver now and in the future?

Very exciting results have been presented by this growing community in the domain of new robot design concepts based on soft materials: soft actuators, soft electronics, soft-power source, soft mechanisms and corresponding fabrication methods. These concepts illustrate the main potentialities of soft-robot design in term of flexibility, robustness, safety, possibility to access complex and tortuous environments… In the future, I think that we will integrate physics-based modeling and simulation tools in the design process as well as for the control of such robots. This is one of the key point of the new methodologies that will emerge with soft-robotics. »

Q. *What needs to be done to advance soft robotics?*

Soft robotics is a perfect example of multidisciplinary research. Everyone can contribute with his own background. With our new team, we want to bring our experience on real-time soft-tissue modeling. We have co-developed SOFA with 3 other teams at INRIA. SOFA implements fast models and algorithms for the simulation of soft-body behavior in real-time. Based on SOFA, we want to provide accurate models, designed for the control and the design of soft robots that rely on continuum mechanics formalism. The solutions, based on Finite Element Methods, shall include actuators and sensors and be computed in real-time. In soft-robotics, sensing, actuation, contacts and motion are coupled by the deformations. Deformable models will be the core of the control methods. Finally, we want to reproduce the interactions between the robot and its environment and include generic methods of planning.

Christian Duriez

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DEFROST: https://team.inria.fr/defrost/

Email: christian.duriez@inria.fr

People: Yiğit Mengüç

Dr. Yiğit Mengüç works at the interface of mechanical science and robotics, creating soft devices inspired by nature and applied to robotics. He received his B.S., 2006, at Rice University and his M.S., 2008, and Ph.D., 2011, in Mechanical Engineering at Carnegie Mellon University. More recently, he completed his postdoctoral work at Harvard University's Wyss Institute for Biologically Inspired Engineering in 2014. He is now an assistant professor of Robotics, Material Science, and Mechanical Engineering at Oregon State University, where he heads the mLab, which researches soft active materials, biologically inspired mechanisms, and rapid digital manufacturing.

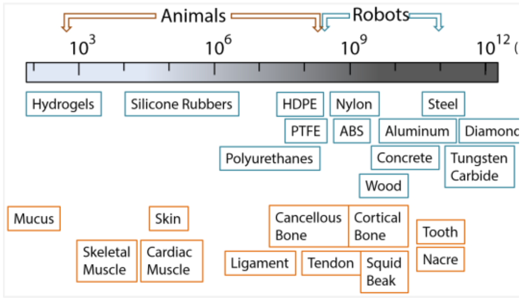
> HELENA: *What mixers?*
>
> DOMIN: *(drily) For mixing the dough. Each one of them can mix the material for a thousand robots at a time. Then there are the vats of liver and brain and so on. The bone factory. Then I'll show you the spinning-mill.*
>
> Karel Čapek, *Rossum's Universal Robots*, 1920

The first robots were soft:

The original vision of a "robot" was that of a autonomous machine molded — literally molded — in the image of humans. The field of robotics owes its name to this original vision of humanoid servants. This vision which has since pervaded science fiction and given a target for roboticists to strive for. Interestingly, Čapek's play begins the introduction of mimetic robotics with a discussion of the means of fabrication with soft materials that are molded and spun and extruded [1]. Apparently, it was intuitive to imagine robots not just in our image but also from the same kind of squishy materials. The field of soft robotics will make this vision a reality, but it requires a new way of considering soft robotics, as closely influenced by and contributing to the study of materials. As such, in this essay I consider the importance of materials in soft robotics as seen in unique bioinspired capabilities and in the demand for new fabrication approaches.

Soft materials' unique properties are a new challenge for roboticists:

Making robots soft means exploiting the unique behaviors of soft materials. Compliance in robotic systems has been introduced and emphasized as a critical component for stability, for robustness, for close human interaction [2]. A qualitative evaluation reveals a dichotomy between the compliance seen in robot materials and in biological materials (Figure). Soft materials provides attractive properties beyond compliance, however, such as self-healing [3].



Elastic moduli of materials in animals and robots

The materials themselves can also be imbued with a degree of intelligence, but soft roboticists must generate the basic materials-knowledge to exploit these new capabilities. Little in the way of off the shelf components exist, and as such any fully autonomous soft robots must make major concessions in the choices of subcomponents.

Consider former DARPA Robotics Challenge initiator Gill Pratt's recent review of the field of robotics [4]. Pratt makes an exciting prediction of the coming evolutionary explosion in robotics thanks to the proliferation of cheap, capable, and accessible subcomponents from computation to actuation. Soft roboticists often have to build every aspect of their robot from scratch — nearly nothing exists off the shelf. Since we are already building things from scratch, why not take our efforts to a further fundamental level and synthesize our own materials as well?

Understanding and exploiting material properties gives robots new capabilities:

Ecoflex and PDMS are the most common selection as a "robot dough," but by partnering with materials scientists and chemists we have the potential to introduce entirely unexpected capabilities from self-healing to electrical conductivity to complex nonlinear dynamics to programmed destruction. By way of example consider the capabilities provided by adhesion in climbing robots – famously demonstrated in gecko-like robots , but which allows careful gentle manipulation of small objects [5] – and can be expanded to irregular objects when coupled with pneumatic actuation [6]. These adhesive effects come directly from compliance. The resulting adhesion is a result of the balance between the material stiffness and the quantum mechanical van der Waals interactions between surfaces. Increasing the compliance of a flat surface permits it to deform as it presses against a rough contact surface. Making the flat surface even more compliant — past the Dahlquist criterion of 100 kPa elastic modulus [7] — allows the van der Waals forces to overcome the restoring forces of the deformed elastic solid thus making the squishy material adhesive in nature. This same effect can be achieved through patterning the surface at the microscale into a forest of fibers – thus creating an effectively softer surface and achieving a level of controllable adhesion matching geckos [8], [9]. Considering the material properties of the as they originate from quantum mechanical effects increases the impact of soft robots.

Controlling material properties can help meet demands for new fabrication methods:

Controlling the materials at the molecular level gives us another capability — that of the fabrication processes itself. The excitement surrounding 3D printing focuses squarely on incredible new processes of fabrication and novel applications of the technology. However, there is less invested into improving the final product's material properties. The incredible speed of the CLIP printer is exceptional but the printer is constrained by dependence on photosensitive chemistry [10]. Multimaterial printing also often has limited mechanical properties that must be solved through gradients [11], [12]. The elastomers most common in research for soft robotics, wearable robotics, and stretchable electronics are as such due to their ease of use, excellent stretchability, and final material toughness. To control the fabrication of such materials at a mechanistic level, we need to control the viscoelasticity in order to achieve high morphological fidelity. The alternative to 3D printing is to use molds, as is currently done [11], [13]. Casting elastomer into molds still requires considerable design and effort, but the possibility of direct digital manufacturing of soft robots may hold the key to circumventing such artisanal techniques. Active and open research areas included printing functional materials such as actuators and electronics, printing food, and the design tools needed for 3D printing [14]. Absent in the discussions so far is the need for mechanically tough and stretchy 3D objects which is defined by the applications of soft robots. However, the goal of a standardized manufacturing of elastomers will require a fundamental understanding of the transient behavior of the materials, not just their final elastic moduli, loss moduli, and ultimate yield strengths.

The future of soft robotics is the future of materials:

In conclusion, robots can be made more capable by exploiting soft materials, but the use of soft materials brings the need for better materials knowledge. Future efforts will expand on current success in leveraging material compliance and achieve new dimensions of material parameters. Though there remains considerable effort in combining materials research with robotics, there are already clear benefits seen in the literature in terms of adhesion, stiffness gradients, stretchable electronics, and self-healing actuators. As a community, we have received a great deal of attention in demonstrating the exciting potentials, and now we must build a strong fundamental foundation to make our work generally applicable and generally accessible to robotics as a whole. To build such a foundation, roboticists can take inspiration from standardized material charts such as Ashby diagrams [15]. Ultimately, if we want to realize the original vision of mixing vats of dough to mold into a thousand robots at a time – then the study of soft robotics is inextricably the study of soft materials.

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Technologies: Granular Jamming: An Enabling Technology for Variable Stiffness Soft Robots

The Soft Robotics community, gathered under the umbrella of the RoboSoft CA, agreed on the first formal definition of “soft robots” during its first Plenary meeting: soft robots are devices which can actively interact with the environment and which can undergo “large” deformations relying on inherent or structural compliance. This definition contains strong statements on the passive characteristics of the robot and in particular on the use of soft materials with inherent compliance. But once the passive characteristics meet the deformability requirement, how can the robot be equipped with active systems to “interact with the environment” without compromising its passive behaviour? Soft actuators are the answers [1]. They generally undergo the same classification used for traditional actuators and can be grouped into Active and Semi-Active. While on the Active side it is worth mentioning Electro-Active Polymers (EAP), Shape Memory Alloys (SMA), flexible fluidic Actuators (FFA) and the very recent fishing line actuators [2], on the Semi-Active side a few technologies have been developed so far. Electro- and Magneto-Rheological Fluids (ERF and MRF) are already well-known technologies, exploited in variable stiffness shock absorber and dampers, but recently Granular Jamming (GJ) is earning attention for being a low cost solution with easy implementation. The jamming transition, as a general phenomenon, is described as a slowing down of the dynamics of a system due to “overcrowding” of particles, which are compressed. When the particles show no residual motion, the system dynamics is arrested. Jamming refers directly to this arrest [3,4]. This is not a recent observation, and until recently it had been taken into consideration in the study of granular matter motion especially applied to agriculture (cereals flowing out from silos or containers).

Recently researchers found a way to exploit this principle to develop variable stiffness structures. The main driver to the exploitation of this principle is the ability to control the jamming: if the granular material is enclosed in a compliant membrane, the application of vacuum makes the membrane collapse on the granules and thereby causing a dense packing, or jamming. The particles in this condition cannot move and tend to resist any external force. Thus, the general behavior of the jamming structure is associated with a stiffness change.

The areas with the most immediate potential to benefit from the use of the GJ mechanism are mainly related to the development of soft grippers, manipulators and crawlers.

The “universal gripper” represents one of the most successful examples of exploitation of the GJ mechanism. A single saccule of granular material, pressed onto a target object, flows around it and conforms to its shape. Upon application of a vacuum the granular material contracts and hardens (jams) to pinch and safely hold the object without the need for sensory feedback [5,6].

JamBot was one of the first robots to utilize the GJ technology to implement locomotion. It is a soft robot able to modulate the direction and magnitude of the work performed by a single central actuator. By jamming and unjamming the granular medium housed in the external skin, the central actuator deforms the robot and makes it roll on a substrate [7]. A different approach has been used in [8] where an amoeboid locomotion has been replicated. The system is based on the periodic deformation of an elastomeric structure including segments with a GJ system, which varies the local mechanical compliance and thus the locomotion direction.

The GJ has been used quite successfully also to change the stiffness of manipulators. For example, the Jamming Modulated Unimorph (JMU) uses a single linear actuator and a discrete number of jamming cells to turn the 1 degree of freedom (DOF) linear actuator into a multi DOF bending actuator [9].

The MIT manipulator, in common with the JamBot and in the JMU, exploits the GJ phenomenon to introduce asymmetries or discontinuities in the deformation of the robot. It changes the local stiffness properties while a coupled active actuator is used for the primary motion. Local tunable stiffness is thus coupled with off-board spooler motors and tension cables to achieve complex manipulator configurations [10].

A different approach has been used in the STIFF-FLOP manipulator. In this case the GJ system and the primary actuation do not act antagonistically, but are used for different purposes. The manipulator is based on a series of identical modules, each one consisting of a silicone tube with pneumatic chambers for 3D motion and one central channel housing a GJ system for tuning the stiffness of the modules when necessary [11].

Despite these successful examples of effective use of the GJ principle, its massive exploitation is still hindered by some shortcomings. The main limitation on the use of such a technology is the almost total absence of usable modeling tools to precisely design a system able to achieve a desired mechanical behavior. Currently, the approach is mainly empirical and most of the results are at the research level and published in specialized journals. They are commonly based on the direct comparison among very different material, tested under the same conditions [12]. No parametrization has been attempted, because the number of implied variables would be very high, including size, material, shape and surface characteristics. Modelling is made even more challenging by properties of the external membrane. This membrane does not only contain the granular material, but it has a fundamental role in the system performance. Recent research has underlined its importance and the influence it gives to the overall result, but, again, a general law of device behavior are lacking [13].

Another important limit is the difficulty to use the GJ phenomenon to realise intermediate levels of stiffness. The activation mechanism (driven by air removal) is commonly very fast and difficult to tune. More than 3 levels of stiffness are rarely obtained.

These limitations are far from being solved, but the increasing number of works which use GJ as a stiffening system demonstrate the increasing efforts of engineers, roboticists and physicists to face these issues. In the near future we expect to have a range of ready-to-used GJ-based stiffening mechanism on the market shelves, enabling many new technological solutions in different application areas related to soft robotics.

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Matteo Cianchetti

Matteo Cianchetti is Assistant Professor at the BioRobotics Institute of Scuola Superiore Sant'Anna. He received his MSc in Biomedical Engineering (with Honors) from the University of Pisa (2007) and the Ph.D. in Biorobotics (with Honors) from Scuola Superiore Sant'Anna. He has been, and is currently, involved in EU-funded projects with the main focus on the development of Soft Robotics technologies (OCTOPUS IP, STIFF-FLOP IP, I-SUPPORT, RoboSoft CA and SMART-E Marie Curie ITN). His research aims at studying and developing new mechatronic systems based on soft materials including soft actuators, smart compliant sensors and flexible mechanisms.

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Audio-Animatronics, referring to choreographed robotics animation, was pioneered by Walt Disney starting in the early 1960s. Examples extend from the Enchanted Tiki Room (1963) to a recent Audio-Animatronic of Barack Obama in the Hall of Presidents at Walt Disney World.

This extended history in robotics provides the background context for current research at Disney Research Zurich (DRZ) in Computational Materials, Mobile Robots, Robot-Human Interaction, plus a new research initiative in Soft Robotics as part of the SOMA project. Within SOMA, we will explore the potential that soft robotics offers for compelling interactions between robots and humans while still guaranteeing safety and comfort.

A recent example of our work in Mobile Robots is the Beachbot [1], a robot that draws artwork or text in beach sand. A key aspect of the research is the automatic conversion of real images to line drawings and then to feasible robot paths that realize the drawings.

Beachbot mobile robot

More closely related to SOMA, DRZ is exploring the computational design of several soft structures. The goals of computational design techniques are to automate tedious design tasks by hiding the complexity of the underlying material models and physics from the user, allowing artists and novice users to focus on the design rather than the engineering aspects. Two examples that illustrate this methodology are the computational design of rubber balloons [2] and foil balloons [3]. For rubber balloons, it is impossible to manually identify the uninflated shapes for a given target 3D model. Foil balloons consist of a collection of flat panels whose shapes are manually tailored by artists in a tedious trial-and-error manner. We have built tools that allow to automatically infer the uninflated shapes and flat panels, given user-provided input. Concurrent soft robotic designs (see, e.g., [4]) consist of stretchable and bendable chambers that are constrained by non-stretchable but bendable areas. Hence, our two techniques are of high relevance when paired with one another and applied to soft robotic design tasks.

Also relevant to SOMA is our recent work on 3D printing elasticity using microstructures [5]: given a target elasticity, the method automatically identifies the closest proxy within the gamut of a single material printer by tiling the volume of the model with microstructures. We highlight a soft robotics gripper as application where we direct the bending using microstructures. Another option to manufacture 3D models with a user-specified elasticity, are multi-material printers such as Stradasys's Object family. We have explored the replication of a measured deformation behavior by again mapping an input behavior to its closest behavior within the multi-material printer gamut [6]. We believe that both methods enable rapid design of soft robotics when paired with actuation design.

As a final example from the area of Computational Materials, DRZ has also explored the replication of a human face on an existing animatronics head [7]. To closely match captured expressions and transitions between them, we explored the thickness of the silicone skin and the actuation patterns as degrees of freedom.

Within SOMA, DRZ will investigate human interaction with soft hands including social interaction, passing tasks, and play interaction, producing quantitative evaluation by means of user studies. This then provides the basis for design recommendations to inform a new generation of soft hands and manipulators.

DRZ is currently seeking a talented and motivated Postdoc candidate for the SOMA project. Disney Research undertakes basic research with open publication, while also offering an excellent environment for researchers who want to connect their research to real-world use. For further information about the Postdoc position, please contact Paul Beardsley, mailto:pab@disneyresearch.com.

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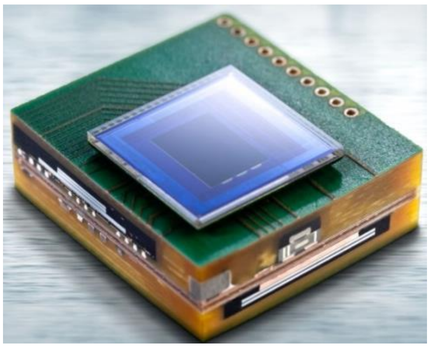
At Fraunhofer IZM diverse technologies for the fabrication of electronics systems are developed. Two of these are particularly well suited for potential application in soft robotics: the "embedding and modularization technology" on one hand and "soft and stretchable electronics" on the other.

In a nutshell Embedding Technology is the highly compact integration of electronic components into the three-dimensional wiring architecture of a printed circuit board. It allows the build-up of electronic systems or modules with extremely high functional density and robustness, see first figure below. Printed circuit board industries meanwhile offer first products realized with this technology.

Stretchable Electronics has attracted much attention in electronic systems fabrication during the last ten years. The research in this field has to a large part been driven by potential application in medical electronics, where dynamic 3D shape compliancy is mandatory for user (patient) comfort. Typically such systems consist of sensors or actuators (stretchable or rigid) distributed over a stretchable substrate containing conductors which electrically connect them to central control, driver or read-out electronics. At Fraunhofer IZM a relatively simple approach to build such substrates has been developed, which makes use of established printed circuit board fabrication and electronics assembly technologies. The base material for the stretchable substrate is rubber-like thermoplastic polyurethane film, with a thickness between 25 and 200 µm. The electrical interconnect structures are copper tracks as in conventional printed circuit boards, but with a meandering layout, see second figure. Assembled components are typically encapsulated by a soft glob-top, resulting in an overall soft and stretchable character of the whole electronic system.

The use of advanced printed circuit board technologies for the build-up of modular and/or distributed systems allows for a high versatility in design and material combinations. Lead time and iteration cycles for systems fabrication are short compared with alternative electronics miniaturization technologies.



An embedded module. The sections at two sides expose a number of components integrated into the build-up of the printed circuit board.

Stretchable electronic system with distributed LEDs, a soft sensor and a central control unit mounted on a stretchable textile carrier.

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Call for Fertilization Events

Soft robotics can be a source of inspiration, a useful tool, or a challenging application field for diverse disciplines: it can enable the realization of physical prototypes for the validation of theories and hypotheses in science; it can propose interesting case-studies for theoretical studies, mathematical analyses and techniques.

There are many potential interested scientists in other scientific communities who could fruitfully explore the field of soft robotics, which they may be not fully aware of, such as those working in the fields of neuroscience, biology, mathematics, material science, theory of modelling in fluido-dynamics or elasto-dynamics, medicine, and many others.

In consideration that scientists in these disciplines may not be easily attracted by soft robotics events, the strategy put in place in RoboSoft is to organize "fertilization" events at their main scientific meetings. These fertilization events can be special sessions or workshop or talks on soft robotics at, e.g. a biology or material science conference, mathematical modelling or medical symposia, or even exhibitions.

RoboSoft Community Members are invited to propose events for fertilization to promote soft robotics.

These events can be financially supported by RoboSoft. All RoboSoft community members are invited to contribute. If you are interested in this initiative, if you are planning a participation in a scientific event where soft robotics could be presented, and if you are available to give a presentation of RoboSoft, please write to Laura Margheri (laura.margheri@sssup.it).

Call for Pictures and Movies

One of the mission of RoboSoft is to increase the visibility of the soft robotics research and technologies. We organize events and prepare material for dissemination, such as flyers, potters, movies. If you want to publicize your research you can use the RoboSoft dissemination actions for free. Just send pictures and/or movies to us, with a description and the credits and we can include them in our website and printed material for dissemination (email to Laura Margheri: laura.margheri@sssup.it) .

Follow RoboSoft

RoboSoft is planning a series of events and meeting opportunities for the next months:

- Workshop at IROS 2015, October 2, Hamburg, Germany
  http://www.robosoftca.eu/events/iros-2015-workshop
- Industrial Networking and Engagement Day on Soft Technologies, October 8, 2015, Bristol, UK
  http://www.robosoftca.eu/events/industry-event
- ICT Networking Session, October 22, 2015, Lisbon, Portugal
- Soft Robotics Week 2016, April 25-30, 2016, Livorno, Italy, with:
  - RoboSoft Plenary Meeting, April 27-28
  - RoboSoft School, April 25-29

  http://www.robosoftca.eu/information/events/soft-robotics-week
- RoboSoft Grand Challenge April 29-30, 2016, Livorno, Italy
  http://www.robosoftca.eu/events/robosoft-grand-challenge

More at RoboSoft Website and socials:

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