

International Conference on  
Intelligent Robots and Systems (IROS)

October 25-29, 2020 Las Vegas, NV, USA



# Application-Oriented Modelling and Control of Soft Robots

## Format

Specify the duration (half day/full day): Full day

Preferred date (check one of the following):

\_\_\_\_\_ October 25, 202 \_\_\_\_\_ October 29, 2020 \_\_\_\_\_X\_\_\_\_\_ Either October 25 or October 29

## Main Organizer

**Thomas George Thuruthel**, PostDoc

Bio-Inspired Robotics Lab, Department of Engineering  
University of Cambridge, Trumpington Street CB2 1PZ, UK

Phone: +44 7721592290

Email: [tg444@cam.ac.uk](mailto:tg444@cam.ac.uk)

## Co-organizers

**Cosimo Della Santina**, PostDoc

Computer Science and Artificial Intelligence Laboratory,  
Massachusetts Institute of Technology (MIT-CSAIL),  
22 Vassar Street, Cambridge, MA, USA.

Phone: 0039-3403432563.

Email: [cosimodellasantina@gmail.com](mailto:cosimodellasantina@gmail.com)

**S.M.Hadi Sadati**, PostDoc

Robotics and Vision in Medicine (RVIM) Lab, Department of Surgical  
and Interventional Engineering, King's College London,  
Becket House, 1 Lambeth Palace Road, London SE17EU, UK.

Phone: +44 7587374254

Email: [smh\\_sadati@kcl.ac.uk](mailto:smh_sadati@kcl.ac.uk)

**Federico Renda**, Assistant Professor,

Khalifa University Center for Autonomous Robotic Systems,  
Khalifa University of Science and Technology, Abu Dhabi, UAE.

Phone: +971 2401 8082

2020 IEEE/RSJ

International Conference on  
Intelligent Robots and Systems (IROS)

October 25-29, 2020 Las Vegas, NV, USA



Sponsors



Theme: Consumer Robotics and Our Future

Email: federico.renda@ku.ac.ae

**Cecilia Laschi**, Full Professor

The BioRobotics Institute, Sant'Anna School of Advanced Studies

Piazza Martiri della Libertà, Pisa, Italy

Phone: +39 050 883396

Email : [cecilia.laschi@santannapisa.it](mailto:cecilia.laschi@santannapisa.it)

### Sponsorship (if applicable, max. 400 words)

The workshop has confirmed sponsorship from two sources, one representing the industrial side and the other the academic side. Disney Research is sponsoring up to three workshop poster presentation prizes, \$200 each, for a total of \$600. Our Academic sponsor, Frontiers in Robotics and AI, has expressed strong interests in a potential article collection around themes that fall within the scope of our Journal. Additionally, they have expressed support in cross-promotional advertisement via their channels for the workshop.



### Objectives (max. 600 words)

Soft robotics and its subfields are increasingly becoming relevant in the academic discipline but lagging in its transferability to the industry. This is partly because of the nascency of the field and the lack of knowledge transfer amongst the two. By approaching the modelling-and-control of soft robots from an application-oriented viewpoint, novel problems and technologies can be discovered. This workshop attempts to bring together experts from various research and application domains working towards real-world control problems to identify the industrial requirements in soft-bodied modelling, state estimation, model identification, path planning, control and design optimization; striving towards immediate applications in medicine, entertainment, industrial inspection, space robotics, etc. This workshop is an attempt to help steer the broad field of modelling-and-control of soft robots towards immediate commercial applications.

To conclude, the main aim of the workshop is to inspire new approaches in modeling and control of soft robots with the application in mind. We will bring together recognized experts in both modeling and control of soft robots, trying to answer questions such as:

- What are the needs from the Industry?
- How to effectively bridge traditional control theory with current soft robotics research?

2020 IEEE/RSJ

International Conference on  
Intelligent Robots and Systems(IROS)

October 25-29, 2020 Las Vegas, NV, USA



- What are the new challenges and roadblocks for real-world deployment?
- How do we fairly evaluate diverse control architectures in a field with immense design solutions?
- What are the scopes for future research in the field of soft robot control?

## Topics of interest

Provide a list of topics (keywords) addressed in the workshop.

- Soft Robotics
- Application-oriented modelling and control
- State estimation and model identification
- Design Optimization

## Intended audience (max. 400 words)

The workshop is intended for early-career researchers entering the field of soft robotics control and experienced academicians who are interested in collaborations and feedback from the industry.

## Expected attendance

The expected attendance of the workshop is about **80 people**. This estimate is based on similar past events, such as:

- 80 people at IROS '18: "Workshop on Soft Robotic Modeling and Control: Bringing Together Articulated Soft Robots and Soft-Bodied Robots", co-organized by Cosimo Della Santina
- 80 people at IROS '17: "Workshop on Soft Morphological Design for Haptic Sensation, Interaction and Display", number provided by co-organizer Hongbin Liu
- 50 people at IROS '17: "Workshop On the Energetic Economy of Robotics and Biological Systems", number provided by co-organizer Navvab Kashiri
- between 50 and 150 people at ICRA '17: "Advanced Fabrication and Morphological Computation for Soft Robotics", numbers provided by co-organizer Pablo Valdivia y Alvarado
- 70 people at ICRA '16: "Exploiting contact and dynamics in manipulation", number provided by co-organizer Gionata Salvietti

To make the call more attractive we plan to organize a Special issue within a high impact journal (Frontiers in Robotics and AI), to which speakers and selected poster presenters will be invited to apply.

## Invited Speakers (Both confirmed and/or tentative)

2020 IEEE/RSJ

International Conference on  
Intelligent Robots and Systems (IROS)

October 25-29, 2020 Las Vegas, NV, USA



Sponsors



Theme: Consumer Robotics and Our Future

- 1- *Caleb Rucker*, University of Tennessee, USA - **Confirmed** (Modeling and state observation of Continuum manipulators)
- 2- *Nabil Simaan*, Vanderbilt University, USA – **Confirmed** (Design, modeling and path planning of flexible surgical robots)
- 3- *Isuru Godage*, DePaul University, USA -**Confirmed** (Modeling and control of continuum robots)
- 4- *Christian Duriez*, INRIA, France -**Confirmed** (FEA based modeling and control of soft robots)
- 5- *Mark Killpack*, Brigham Young University, USA – **Confirmed** (Learning-based control of continuum manipulators)
- 6- *Kohei Nakajima*, University of Tokyo, Japan - **Confirmed** (Morphological computation for control of soft robots)
- 7- *Hiroshi Mochiyama*, University of Tsukuba, Japan – **Confirmed** (Theory and application of continuum manipulators)
- 8- *Ian Walker*, Clemson University, USA – **Confirmed** (Control of continuum manipulators for industrial and in-Space inspection)
- 9- *Pierre E. Dupont*, Harvard Medical School, USA -**Confirmed** (Theory and control of flexible robots in medical applications)
- 10- *Tania Morimoto*, UCSD, USA – **Confirmed** (Control of flexible robots in minimally invasive surgery)
- 11- *Zheng Wang*, University of Hong Kong, China- **Confirmed** (Application of soft robotics in endoscopic surgery)
- 12- *Stelian Coros*, ETH Zurich, Switzerland – **Confirmed** (Application of soft robots in future robotics ecosystems)
- 13- *Moritz Bächer*, Disney Research, Switzerland – **Confirmed** (Application of flexible robots for safe human-robot interaction)

## Relationship to the conference proper (max. 300 words)

Application oriented theoretical investigations and performance analysis of soft robots is the key to transfer soft robotics research results to real world scenarios and industrial applications. Despite the presence of control and modeling oriented sessions within the conference, this crucial aspect is rarely stressed. Being an academic conference, we do not anticipate it becoming the main theme of the submitted articles in the field nor the subject of a regular session. Hence, we are organizing this full-day workshop to understand the needs of the vast field, its challenges and future directions.

## Other workshops

- Thomas George Thuruthel is also an invited speaker in the workshop “New Advances in Soft Robots Control”
- Zheng Wang is also organizing a workshop on superlimb devices

## Structure of the event (max. 300 words)

2020 IEEE/RSJ

International Conference on  
Intelligent Robots and Systems (IROS)

October 25-29, 2020 Las Vegas, NV, USA



We will organize two poster sessions for late-breaking results, to encourage young researchers to join the workshop. The two poster sessions will foster interaction between the speakers and the audience. We left a few extra minutes in between each talk, to allow for extended and more relaxed discussions. Finally, we plan to include a panel discussion at the end of the workshop, within which the participants can discuss and draw conclusions about the topics presented during the day, and overall on open challenges in the field.

## Endorsement

The workshop is endorsed by the IEEE Technical Committee on Soft Robotics and Wearable Robotics

## Program

Time	Talk	Comments
9:00 – 9:20	Welcome	Brief introduction by the organizers
9:20 – 9:45	First Invited talk	including Q&A
9:45 – 10:10	Second Invited talk	including Q&A
10:10 - 10:20	Poster teasers	
10:30 – 11:00	Coffee break	Posters
11:00 – 11:25	Third Invited talk	including Q&A
11:30 – 11:55	Fourth Invited talk	including Q&A
12:00 – 12:25	Fifth Invited talk	including Q&A
12:30 – 13:30	Lunch	
13:30 – 13:55	Sixth Invited talk	including Q&A
13:55 – 14:10	Seventh Invited talk	including Q&A
14:10 – 14:35	Eight Invited talk	including Q&A
14:35 – 15:00	Coffee break	Posters (possibly the same as in the first session)
15:00 – 15:25	Ninth Invited talk	including Q&A
15:25 – 15:50	Tenth Invited talk	including Q&A
15:50 – 16:10	Short break	Relax and posters
16:10 – 16:35	Eleventh Invited talk	including Q&A
16:35 – 17:00	Twelfth Invited talk	including Q&A
17:00 - 17:25	Thirteenth Invited talk	including Q&A
17:25 - 18:00	Panel discussion	Brief remarks by the organizers

## Equipment (max. 300 words)

10 poster stands standard A0 size, one whiteboard, and some markers.

CONFIDENTIAL. Limited circulation. For review only.

2020 IEEE/RSJ

International Conference on  
Intelligent Robots and Systems(IROS)

October 25-29, 2020 Las Vegas, NV, USA



Sponsors



Theme: Consumer Robotics and Our Future

***Note that a projector and a screen will be provided by default. Upon acceptance, the organizers will be required to provide an abstract and a dedicated website for their workshop.***

\*\*\*

*Please submit the filled template as your proposal via PaperPlaza for IROS 2020 by March 15, 2020.*

*Feel free to add any other information at the end that will help us to evaluate your proposal, with a limit of one page on this information.*



CONFIDENTIAL - Limited circulation. For review only

Conference Receiving the Support: IROS 2020 Workshop- Control of soft robots: Theory and Applications

Sponsorship Amount: \$600

I look forward to working with you on this sponsorship.

Best regards,  
Susan

**Susan M. Harden**

Resource Manager

Walt Disney Imagineering- Research & Development

521 Circle Seven Drive

Glendale, CA 91201

office: 818-553-6887 (teline: 8494-6887)

fax: 818-553-5111

email: [susan.m.harden@disney.com](mailto:susan.m.harden@disney.com)




---

**From:** Sadati, Seyedmohammadhadi [mailto:[smh\\_sadati@kcl.ac.uk](mailto:smh_sadati@kcl.ac.uk)]

**Sent:** Friday, March 06, 2020 3:54 AM

**To:** Moritz Baecher <[moritz.baecher@disneyresearch.com](mailto:moritz.baecher@disneyresearch.com)>; Harden, Susan M. <[Susan.M.Harden@disney.com](mailto:Susan.M.Harden@disney.com)>

**Subject:** RE: IROS 2020 Workshop- Control of soft robots: Theory and Applications

Dear Moritz, Susan,

Many thanks for your help and consideration.

Kind regards,  
Hadi

--

**S.M.Hadi Sadati**, Ph.D.

Postdoc Research Associate in Robotic Systems Engineering,

[RViM Lab](#), Dep. Surgical and Interventional Engineering,  
King's College London, UK

---

**From:** Moritz Baecher <[moritz.baecher@disneyresearch.com](mailto:moritz.baecher@disneyresearch.com)>

**Sent:** Thursday, March 5, 2020 12:34:25 PM

**To:** Sadati, Seyedmohammadhadi <[smh\\_sadati@kcl.ac.uk](mailto:smh_sadati@kcl.ac.uk)>; Harden, Susan M. <[Susan.M.Harden@disney.com](mailto:Susan.M.Harden@disney.com)>

**Cc:** Cosimo Della Santina <[cosimodellasantina@gmail.com](mailto:cosimodellasantina@gmail.com)>; [federico.renda@ku.ac.ae](mailto:federico.renda@ku.ac.ae)

<[federico.renda@ku.ac.ae](mailto:federico.renda@ku.ac.ae)>; Cecilia Laschi <[cecilia.laschi@antannapisa.it](mailto:cecilia.laschi@antannapisa.it)>; [tg444@cam.ac.uk](mailto:tg444@cam.ac.uk)

Manuscript 2398 submitted to 2020 IEEE/RSJ International Conference

on Intelligent Robots and Systems, Received March 15, 2020





Lausanne, 9 March 2020

To whom it may concern,

With this letter I would like to highlight our strong interest in the workshop on “Application-Oriented Modelling and Control of Soft Robots”, proposed by Dr Thomas George Thuruthel, University of Cambridge; Dr Cosimo Della Santina, MIT-CSAIL; Dr S.M. Hadi Sadati, King’s College London; Professors Federico Renda, Khalifa University of Science and Technology and Cecilia Laschi, Sant’Anna School of Advanced Studies – for IROS 2020.

I believe this workshop could be of great interest to the academic community and the readership of our Journal, *Frontiers in Robotics and AI*. Elements of the workshop could result in a potential article collection around themes that fall within the scope of our Journal and the workshop could benefit from cross-promotional advertisement via our channels.

Should you require any additional information, please feel free to contact me.

Kind regards,

A handwritten signature in black ink, appearing to be "Paola Morelli", written over a light blue horizontal line.

Paola Morelli, PhD  
Journal Development Manager

**Frontiers** | Editorial Office  
[www.frontiersin.org](http://www.frontiersin.org)  
Avenue du Tribunal-Fédéral 34  
1005 Lausanne, Switzerland  
T + 41 21 510 1700



Trumpington Street

Cambridge

CB2 1PZ

Tel: +44 (0) 1223 332719

Fax: +44 (0) 1223 332662

Email: fumiya.iida@eng.cam.ac.uk

www.eng.cam.ac.uk

Letter of Support:

The IROS2020 Workshop on “**Application-oriented modelling and control of soft robots**”

March 12, 2020

To whom it may concern,

On behalf of the co-chairs of Soft Robotics Technical Committee, It is our great pleasure to provide this letter of support for the proposal of the IROS2020 Workshop on “**Application-oriented modelling and control of soft robots**”, proposed by Dr Thomas George Thuruthel, et al.

The Technical Committee of Soft Robotics has reviewed the proposal thoroughly, and confirmed that the topic areas and intended speakers/participants are inline with the scope of our technical committee. The theoretical framework of soft robot control is one of the high-priority areas in our community. Once approved, we will provide the best support possible to make this workshop successful.

Sincerely,

Fumiya Iida, Dr. sc. nat.

On behalf of the IEEE RAS Technical Committee on Soft Robotics

(Co-chairs: Fumiya Iida, Cecilia Laschi, Ryuuma Niiyama and Yigit Menguc)

Paris, March 12<sup>th</sup>, 2020

## Letter of support

The **IEEE/RAS Technical Committee (TC) on Wearable Robotics** fully supports the workshop proposal entitled "***Application-Oriented Modelling and Control of Soft Robots***" submitted to the IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS 2020**).

This workshop proposal attempts to bring together experts from various research and application fields working towards real-world control problems to identify the industrial requirements in soft-bodied modelling, state estimation, model identification, path planning, control and design optimization. Applications concern mainly medicine, entertainment, industrial inspection, space robotics, etc.

The TC on Wearable Robotics finds that the objectives of the workshop proposal are well aligned with the interests and scope of the TC.

We wish you a successful workshop.

Faithfully,  
On behalf of the IEEE/RAS TC on Wearable Robotics



Samer Mohammed, PhD  
Professor, University of Paris Est Créteil, UPEC  
61 avenue du Général de Gaulle 94010 Créteil, France  
Tel. : +33141807318, Fax : +33141807376, Email : [samer.mohammed@u-pec.fr](mailto:samer.mohammed@u-pec.fr)  
Web: <http://www.ieee-ras.org/wearable-robotics>



Thomas George <[thomasgeorge2571766@gmail.com](mailto:thomasgeorge2571766@gmail.com)>

---

## **RE: RoboSoft 2020 Workshop:: Control of soft robots: Theory and Applications**

---

**Federico Renda** <[federico.renda@ku.ac.ae](mailto:federico.renda@ku.ac.ae)>  
To: Thomas George <[tg444@cam.ac.uk](mailto:tg444@cam.ac.uk)>

Sat, Mar 14, 2020 at 12:06 PM

Federico Renda  
Assistant Professor  
Mechanical Engineering

Khalifa University of Science and Technology  
PO Box 127788, Abu Dhabi, UAE  
T +971 2 401 8082  
F +971 2 447 2442  
[federico.renda@ku.ac.ae](mailto:federico.renda@ku.ac.ae)

ku.ac.ae-----Original Message-----

From: Godage, Isuru <[IGODAGE@depaul.edu](mailto:IGODAGE@depaul.edu)>

Sent: Tuesday, February 4, 2020 8:41 PM

To: Federico Renda <[federico.renda@ku.ac.ae](mailto:federico.renda@ku.ac.ae)>

Subject: RE: [EXT] RE: RoboSoft 2020 Workshop:: Control of soft robots: Theory and Applications

[EXTERNAL EMAIL]

Hi Federico,

Thank you for the follow-up.  
I'm happy to be included in this workshop.

Best of luck,  
Isuru  
[Quoted text hidden]





Thomas George &lt;thomasgeorge2571766@gmail.com&gt;

---

**IROS 2020 Workshop:: Control of soft robots: Theory and Applications**

---

**Rucker, Daniel Caleb (Caleb)** <druker6@ibme.utk.edu>

Wed, Feb 26, 2020 at 8:48 PM

To: Federico Renda &lt;federico.renda@ku.ac.ae&gt;, "caleb.rucker@utk.edu" &lt;'caleb.rucker@utk.edu'&gt;

Cc: Thomas George &lt;tg444@cam.ac.uk&gt;, Cosimo Della Santina &lt;cosimodellasantina@gmail.com&gt;, "smh\_sadati@kcl.ac.uk" &lt;smh\_sadati@kcl.ac.uk&gt;, Cecilia Laschi &lt;cecilia.laschi@santannapisa.it&gt;

Hi Federico,

Looks like a great proposal. I would be glad to participate.

Best,

Caleb

-----Original Message-----

From: Federico Renda &lt;federico.renda@ku.ac.ae&gt;

Sent: Wednesday, February 26, 2020 1:20 AM

To: 'caleb.rucker@utk.edu'

Cc: Thomas George &lt;tg444@cam.ac.uk&gt;; Cosimo Della Santina &lt;cosimodellasantina@gmail.com&gt;; smh\_sadati@kcl.ac.uk; Cecilia Laschi &lt;cecilia.laschi@santannapisa.it&gt;

Subject: IROS 2020 Workshop:: Control of soft robots: Theory and Applications

[External Email]

[Quoted text hidden]



Thomas George &lt;thomasgeorge2571766@gmail.com&gt;

---

**IROS 2020 Workshop:: Control of soft robots: Theory and Applications**

---

**Marc Killpack** <marc\_killpack@byu.edu>

Fri, Feb 28, 2020 at 12:01 AM

To: Federico Renda &lt;federico.renda@ku.ac.ae&gt;

Cc: Thomas George &lt;tg444@cam.ac.uk&gt;, Cosimo Della Santina &lt;cosimodellasantina@gmail.com&gt;, "smh\_sadati@kcl.ac.uk" &lt;smh\_sadati@kcl.ac.uk&gt;, Cecilia Laschi &lt;cecilia.laschi@santannapisa.it&gt;

Dear Prof. Federico Renda,

I would be delighted to participate. Thank you very much for the invitation. I hope your proposal for this workshop is accepted! Please let me know if I can help in any way.

best wishes,  
Marc Killpack

[Quoted text hidden]



Thomas George &lt;thomasgeorge2571766@gmail.com&gt;

---

**IROS 2020 Workshop:: Control of soft robots: Theory and Applications**

---

中嶋浩平 <k\_nakajima@mech.t.u-tokyo.ac.jp> Fri, Feb 28, 2020 at 5:26 AM  
To: Federico Renda <federico.renda@ku.ac.ae>  
Cc: Thomas George <tg444@cam.ac.uk>, Cosimo Della Santina <cosimodellasantina@gmail.com>, "smh\_sadati@kcl.ac.uk" <smh\_sadati@kcl.ac.uk>, Cecilia Laschi <cecilia.laschi@santannapisa.it>

Dear Federico,

Nice to hear from you and thank you for your invitation!

Yes, I am happy to join the workshop.

Please let me know if I need something further to process.

Thank you!

Best regards,

Kohei Nakajima

[Quoted text hidden]

--

Kohei Nakajima, Ph.D.  
Chair for Frontier AI Education,  
Graduate School of Information Science and Technology,  
The University of Tokyo







Thomas George <thomasgeorge2571766@gmail.com>

---

## IROS 2020 Workshop:: Control of soft robots: Theory and Applications

---

**Moritz Baecher** <moritz.baecher@disneyresearch.com>

Thu, Feb 27, 2020 at 9:40 PM

To: Federico Renda <federico.renda@ku.ac.ae>

Cc: Thomas George <tg444@cam.ac.uk>, Cosimo Della Santina <cosimodellasantina@gmail.com>, "smh\_sadati@kcl.ac.uk" <smh\_sadati@kcl.ac.uk>, Cecilia Laschi <cecilia.laschi@santannapisa.it>

Dear Federico, all:

Thank you for the invitation. It would be my pleasure to give a talk at your proposed workshop.

With best regards,  
- Moritz

[Quoted text hidden]







3/14/2020

Gmail - Re: RoboSoft 2020 Workshop:: Control of soft robots: Theory and Applications [EXTERNAL]

**CONFIDENTIAL. Limited circulation. For review only.**

Thanks and best regards,  
Federico Renda on behalf of all the organizers.







3/14/2020

Gmail - RE: RoboSoft 2020 Workshop:: Control of soft robots: Theory and Applications  
**CONFIDENTIAL. Limited circulation. For review only.**

[Quoted text hidden]

Manuscript 2398 submitted to 2020 IEEE/RSJ International Conference  
on Intelligent Robots and Systems - Received March 15, 2020



Thomas George <thomasgeorge2571766@gmail.com>

---

**RE: RoboSoft 2020 Workshop:: Control of soft robots: Theory and Applications**

---

**Federico Renda** <federico.renda@ku.ac.ae>  
To: Thomas George <tg444@cam.ac.uk>

Sat, Mar 14, 2020 at 12:07 PM

**Federico Renda**  
Assistant Professor  
Mechanical Engineering



P O Box 127788, Abu Dhabi, UAE  
**T** +971 2 401 8082  
**F** +971 2 447 2442  
federico.renda@ku.ac.ae

ku.ac.ae



**From:** Tania Morimoto <tkmorimoto@eng.ucsd.edu>  
**Sent:** Tuesday, February 4, 2020 8:53 PM  
**To:** Federico Renda <federico.renda@ku.ac.ae>  
**Subject:** Re: RoboSoft 2020 Workshop:: Control of soft robots: Theory and Applications

**[EXTERNAL EMAIL]**

Hi Federico,

I would be happy to participate in the workshop at IROS. Thank you for the kind invitation.

Best,

Manuscript 2398 submitted to 2020 IEEE/RSJ International Conference  
on Intelligent Robots and Systems - Received March 15, 2020



