**2016 IEEE/RSJ International Conference on Intelligent Robots and Systems**

October 9 – 14, 2016, Daejeon, Korea

Towards a unified workflow for multi-contact motion on legged robots: Challenges in planning, optimization and control

# Format

The proposal is for a full-day workshop.

# Title

The title of the workshop is “Towards a unified workflow for multi contact motion on legged robots: Challenges in planning, optimization and control.” A website is available at TODO

# Main Organizer

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# Objectives (max. 600 words)

**Summary:**  
Early contributions on multi contact locomotion for legged robots have underlined the complexity of planning and executing motions in cluttered environments. The last few years have shown that this problem is of interest for both the robotics and computer-graphics communities. More precisely in the robotics, contributions in dextrous manipulation and legged robotics have shown the convergence of the scientific questions addressed. From these three fields results a large variety of approaches proposed to tackle the problem, though often targeting one specific aspect: the planning of a feasible path for the robot, the optimization of its trajectory, or the feedback control of the robot during the execution of a dynamic motion. Integrating these different aspects is not only an engineering issue. It raises scientific questions in terms of robustness of the algorithms and performance requirements. The objective of this workshop is to gather people working in these fields and propose a debate on the combination of these various aspects into a functional workflow for robot motions in cluttered environments.

Renowned speakers from the robotics and computer graphics field will present their work, and recommend the reading of selected papers prior the conference. This will provide the audience with the ability to prepare their venue and ask relevant questions that will be analyzed by student groups and discussed during dedicated debate sessions.

**Situation of the problem:**Achieving multi-contact locomotion is challenging: Theoretically, the motion or manipulation planning problem is known to be particularly difficult due to the complex topology of the configuration space. In practice, the execution of a planned trajectory on a robot requires the resolution of the problem of moving in contact while maintaining the balance of an underactuated unstable system, or respecting other similar dynamic constraints in manipulation.

This problem is recognized by both the robotics and computer-graphics community, and their respective approaches have a lot to share.

It has gained visibility and interest with the advent of humanoid and legged robots, and in particular with the DARPA Robotics Challenge. While impressive advances have been emphasized, the challenge also showed that legged robots are far to be as mature as wheeled robots.

The problem can be roughly divided in three aspects. At the planning level, it is often considered to compute a discrete sequence of statically balanced key contact postures. In a second level, the complete continuous trajectory connecting all the postures is considered. The last level considers the control law that executes the complete movement on the robot despite the uncertainties of the model. These three aspects of the problem are strongly correlated and might be treated separately to reduce the complexity or together to provide a better approximation of a targeted optimality.

**Summary of the objectives:**The workshop aims at gathering the key researchers studying all three aspects of the problem, to provide an exhaustive painting of the state of the art, the current blocking problems and the future promising directions. One originality is that we have brought several key researchers from separate fields, namely computer graphics, robotics, so as to courage sharing of different viewpoints. Another important point is the place accorded to young student researchers, with a strong incentive to encourage them to participate in the debate, by requiring them to prepare in advance and supervise discussion sessions.

# Topics of interest

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

* Multi-contact motion planning
* Legged locomotion
* Dextrous manipulation
* Motion synthesis
* Character animation
* Force control
* Robust Optimization-based control
* Whole-body control

# Intended audience (max 300 words)

The recent popularity of research in Multi contact planning is illustrated by events such as the Darpa Challenge. From the computer graphics side, many contributions have been presented on the topic at the prestigious SIGGRAPH conference.

The topic is thus popular in both communities, and our speakers are among the most renowned in their respective fields: for instance, Russ Tedrake led the MIT team at the DARPA challenge, Antonio Bicchi is a respected leader of manipulation research, and Perttu Hämäläinen and Igor Mordatch are authors of several of the mentioned SIGGRAPH. Our list is composed of highly renowned researchers, as well as promising young researchers.

The workshop format is a unique chance for researchers, especially young students, to collaborate and exchange with the speakers.

We thus aim at a large audience, including researchers from several fields: computer graphics, motion planning, dextrous manipulation, optimization and control.

# Expected attendance

Because it is multidisciplinary and aims at creating synergies between researchers from motion planning, optimization and control, and character animation for computer graphics, we expect an important attendance, higher than 60 participants.

# Invited Speakers

Attached to this document is the list of presentation titles and abstract for the confirmed speakers.

1. Russ Tedrake, MIT, USA
2. Antonio Bicchi, University of Pisa, Italy
3. Shunichi Nozawa, The university of Tokyo, Japan
4. Siddhartha Srinivasa, Carnegie Mellon University
5. Adrien Escande, CNRS/AIST, JRL, Tsukuba, Japan
6. Patrick Wensing, MIT, USA
7. Quang-Cuong Pham, Nanyang Technological University, Singapore
8. Igor Mordatch, University of California, Berkeley USA
9. Steve Tonneau, LAAS CNRS, France

# Support/Endorsement

The workshop is supported by the Whole Body Control Technical Commitee, represented by Dr. Luis Sentis. It is also supported by Prof. Dr. Katja Mombaur, chair of the Technical Comitee on Model-based Optimization. Letters of support are attached to this submission.

# Program

The workshop consists in three topic specific presentation sessions, completed by two inter topic debate/poster sessions. These sessions are organized in an original fashion so as to enhance exchange and communication: the talks of each session will be completed with a topic specific debate session, prepared by students.

A few months before the workshop, each presenter will recommend the reading of one or two papers, available on the workshop website.

The students will read the paper, collect questions asked online by the public, and prepare a critic presentation of the papers that will start the debate session. Additionally, the audience will be given the opportunity to ask questions in real time using social networks during presentations.

An inter topic poster session aims at connecting two topic specific research issues, namely motion planning / trajectory generation and trajectory generation / robot control, and will result from a call for poster contributions.

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| Time | Talk |
| 8:30  8:40 | Welcoming and introduction  Motion planning: 3 talks + topic debate |
| 10:25 - 10:40  10:40 | Coffee Break  Trajectory optimization: 3 talks + topic debate |
| 12:25 - 13:25 | Lunch break |
| 13:25  14:25 | Poster session 1  Robot feedback control: 3 talks + topic debate |
| 16:15  17.15 | Poster session 2  Conclusion and farewell |

# Equipment

In addition to standard equipment we anticipate the need of a number of 20 poster interactive screens or stands.

Please submit the filled template as your proposal via PaperPlaza for IROS2016