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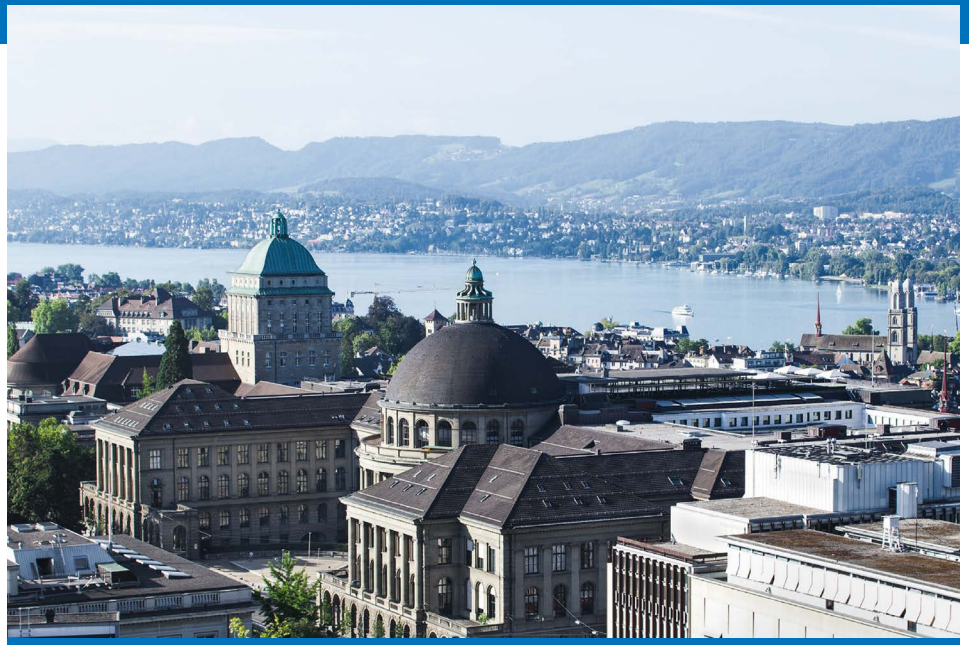

Workshop on Dynamic Locomotion and Manipulation with Complex Robotic Systems in the Real World (DLMC 2016)

13.–15.07.2016 ETH Zürich, Switzerland

http://www.dlmc2016.ethz.ch

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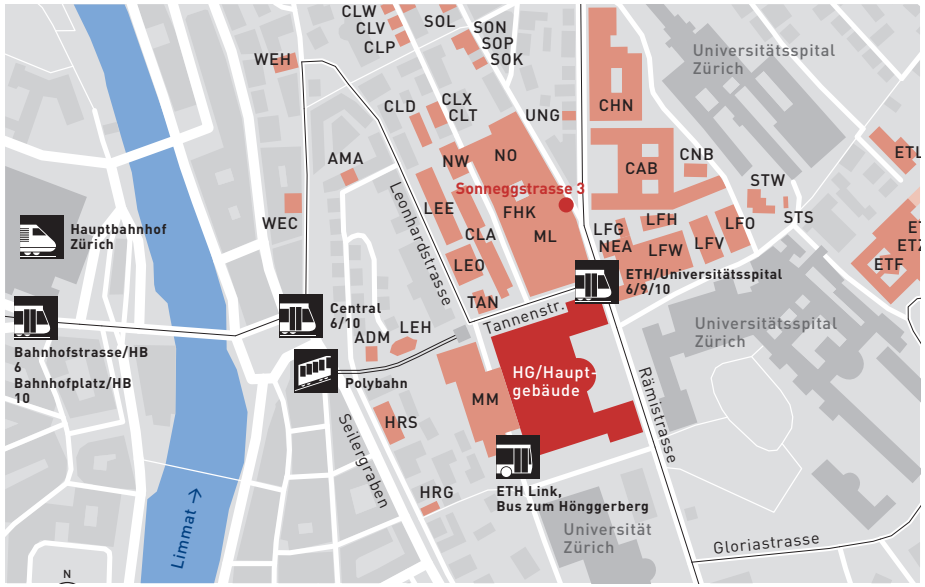
ADRL

DLMC 2016 workshop on Dynamic Locomotion and Manipulation

Building and Room

The conference will be held at ETH Zürich Zentrum
Building: ML / Level: E / Room: 12
Address: Sonneggstrasse 3, 8092 Zürich



From Zürich Central Station

From the "Bahnhofstrasse/HB" stop: Tram no. 6 (towards the Zoo) as far as the "ETH/ Universitätsspital" stop. Journey time: approx. 6 minutes.

From the "Bahnhofplatz/HB" stop: Tram no. 10 (towards the Airport or Oerlikon station) as far as the "ETH/Universitätsspital" stop or Tram Nr. 3 (towards Klusplatz) as far as the "Central" stop (1 stop), from "Central" by Polybahn (departs every three minutes) to the Polyterrasse. Journey time: approx. 8 minutes

You will require a ticket that is valid for zone 110 (city of Zurich).

Invited Speakers

Stelian Coros
Assistant Professor
Carnegie Mellon University.
Design and Fabrication of Personalized Robotic Devices

In the not-so-distant future, a rich ecosystem of robotic devices for service, assistive care, therapy, education and entertainment will improve many aspects of our lives. Digital fabrication will play a major role in how these robotic systems will be made. As key advantages over traditional manufacturing, 3D Printing, for example, is unmatched in its ability to create complex geometric structures, it employs an ever-expanding range of materials (rigid, compliant, conductive, etc), is able to create one-off parts at no extra cost, and is increasingly accessible to the general public. These exciting new capabilities are paving the way to a shift from mass production to fabrication of robots that are customized according to individual needs and preferences. This talk will discuss our first efforts in developing computational approaches that enable on-demand design of such personalized robotic devices.

Ugo Cupcic
Shadow Robot Company.
Our roadmap towards useful Robotics

To deliver the best hands in the world, we've collaborated with the best researchers. But what does it take to reach out of a research-oriented market? Solve real world problems using robots? We're convinced that tailoring a custom solution for each problem is not the way forward. We want the people facing those problems to be able to use our solutions themselves. And we have a roadmap to get there.

Moritz Diehl
Head of the Systems Control and Optimization Laboratory.
Department of Microsystems Engineering (IMTEK)
University of Freiburg.

Embedded Optimization for Model Predictive Control of Mechatronic Systems

Model Predictive Control (MPC) for mechatronic systems is based on the online solution of medium scaled constrained optimization problems with sampling times in the milli and microsecond range. This poses specific challenges for the numerical solution methods. This talk presents and discusses algorithms and open source software implementations that are designed to address these challenges. In particular, it reports on recent algorithmic progress within one subcomponent, sparse quadratic programming. We also present experimental tests with mechatronic, aerospace and automotive applications and discuss what numerical choices seem most promising for a possible application of online MPC for legged robots.

Roy Featherstone
Visiting professor in the Department of Advanced Robotics
Italian Institute of Technology.

Skippy: Reaching for the Performance Envelope

Skippy is an extremely simple hopping and balancing machine that is currently still at the design stage. The objective of the Skippy project is to create a robot with an exceptionally high physical performance, which can safely push itself all the way to its performance limits. The machine will weigh about 2kg, stand approximately 1m high when fully stretched, and hop to a height of 4m. It will also be able to hop in all directions, somersault, tumble, balance on a point, pirouette, land on a target spot, bow, lie down and get back up again, crash land from 4m without sustaining damage, bounce off walls, hop up and down stairs, and many more activities, all in full 3D, unaided, and with no umbilical or safety harness. This talk will explain how it is possible to design such an athletic prodigy, and some of the lessons learned from the design process so far.

Bert Kappen
Professor at Donders Institute
Radboud University, Netherlands
Gatsby Unit, UCL London.

Integrating control, inference and learning. Is it what robots should be doing?

Intelligent systems, whether natural or artificial, must act in a world that is highly unpredictable. To plan actions with uncertainty is a stochastic optimal control problem. However, there are two fundamental problems: the optimal control solution is intractable to compute and intractable to represent due the non-trivial state dependence of the optimal control. This has prevented application of stochastic optimal control theory to robotics or as a model for the brain so far.

The path integral control theory describes a class of control problems whose solution can be computed as an inference computation through Monte Carlo sampling. The sampling can be made more efficient by adaptive importance sampling. This defines a recursive learning problem, where a better importance sampler is learned from self-generated data. I formalize the intuitive notion that the efficiency of the importance sampling is related to the proximity of the sampling control to the optimal control. Secondly, I show how parameterized feed-back control functions can be estimated using the cross entropy method. The resulting methods (sampling and gradient computation) are trivially parallelizable, and I will hopefully show some first results on larger problems.

Scott Kuindersma
Assistant Professor.
Harvard School of Engineering and Applied Sciences.
Head of the Harvard Agile Robotics Laboratory.
Optimizing Robot Motions Through Contact

The ability to control dynamic motions through intermittent frictional contact is a fundamental requirement of any walking, running, and manipulating system. This simple fact has significant computational ramifications that force control system designers to solve hard optimization problems typically involving complementarity constraints or integer variables. We will describe some of our recent work designing algorithms to plan and stabilize dynamic motions involving contact, including convex optimization-based feedback design for Atlas, extensions to direct collocation methods to handle arbitrary contact constraints and improve tracking performance over transcription methods.

Igor Mordatch
Post-doctoral at the Artificial Intelligent Research Lab
University of California, Berkeley.
Automated Discovery and Learning of Complex Movement Behaviours

In order to create truly autonomous physical robots, understand the underlying principles behind human movement, or tell narratives in animated films and interactive games, it is necessary to synthesize movement behaviours with the same variety, richness and complexity observed in humans and other animals. Moreover, these behaviours should be discovered automatically from only a few core principles, and not be a result of extensive manual engineering or a mimicking of demonstrations. In this talk at the intersection of robotics, computer graphics and biomechanics, I will show work on novel trajectory and policy optimization methods that give rise to a range of behaviours such getting up, climbing, moving objects, hand manipulation, acrobatics, and various cooperative actions involving multiple characters all in a single system. The resulting movements can be used to control a physical bipedal robot and coupled with detailed models of human physiology, motions that match real human motion can be produced de novo, giving the predictive power to conduct virtual biomechanics experiments. The approach is fully automatic, based on general neural network policy representations and does not require domain knowledge specific to each behaviour, pre-existing examples or motion capture data. Although discovery and learning are computationally-expensive and rely on cloud and GPU computing, the animation can run in real-time on any hardware once the controllers are learned.

Jerry Pratt
Leader of the Robotics, Exoskeletons, & Human Robotic Interdependence lab at the Florida Institute for Human & Machine Cognition (IHMC).
Humanoid walking with partial footholds on pointy rocks

Walking on top of pointy rocks is tricky. Only partial footholds are available, which limits the location of the center of pressure on each support foot. We present an algorithm for walking on top of pointy rocks and demonstrate preliminary results with the humanoid robot Atlas. An operator inputs the approximate location to step. Upon contact with the ground, the robot explores the new foothold by attempting to shift the center of pressure around on the foot. The available foothold is inferred by the way in which the foot rotates about contact edges and by the actual achieved center of pressure locations on the foot during exploration. This available contact information is then used by our whole body momentum based controller to balance the robot. When taking a step with a support foot that has limited contact area, the robot uses upper body angular momentum to assist in balance.

Claudio Semini
Head of the Dynamic Legged Systems Lab at Istituto
Italiano di Tecnologia (IIT).
The Mechatronics behind Torque-Controlled, Hydraulic Legged Robots

HyQ and HyQ2Max are hydraulically actuated quadruped robots developed at IIT. HyQ has shown a wide repertoire of motions ranging from crawling over rough terrain to dynamic running and jumping. Its successor HyQ2Max has higher joint torques and range of motion, and is able to get up after a fall. HyQ-Centaur is a quadruped robot with a hydraulic manipulator. In this talk I will present the hardware evolution of these machines, including the most recent developments of titanium additive-manufactured actuators in collaboration with MOOG. The talk will also briefly touch hydraulic torque control, higher level locomotion control and illustrate the current performance levels of the robots.

Marc Toussaint
Professor at University of Stuttgart.
Head of the Machine Learning and Robotics Lab.
From trajectory optimization to inverse KKT and sequential manipulation

Constrained optimization is a standard approach to control and motion generation problems, ranging from fast online MPC to complex non-convex trajectory optimization. I will briefly report on the specific methods I like using for trajectory optimization (Augmented Lagrangian on a k-order Markov constrained path optimization formulation) and its relations to Gaussian Process path priors and graph SLAM methods. However, my actual motivation is to push this optimization view to higher level behaviours, such as sequential manipulation, which include categorical decisions (task planning) and kinematic switches. I will first report on work for learning sequential manipulation from demonstration. This implies inverting the optimization problem (as in inverse optimal control), which we call inverse KKT. I will then report on optimization-based approaches to combined task and motion planning (TAMP), including multi-agent cooperative assembly.

Conference Program

	July 13	July 14	July 15
8:00	Registration Opening		
8:45	Welcome Talk		
9:00	Jerry Pratt	Claudio Selmini	Ugo Cupcic
10:00	Papers A,B	Paper G + Spotlight I	Papers H,I
10:30	Coffee Break	Coffee Break	Coffee Break
11:00	Scott Kuindersma	Moritz Diehl	Igor Mordatch
12:00	Paper D	Spotlight II + III	Discussion Panel +Closure
12:30	Lunch	Lunch	
14:00	Marc Toussaint	Bert Kappen	Lab Tour
15:00	Stelian Coros	Roy Featherstone	
16:00	Coffee Break	Coffee Break	
16:30	Papers C,F	Spotlight IV	
17:30		Poster Session	
19:00	Social Event-Dinner	BBQ-Dinner	

Papers Presentations

ID	Title	Author
A	A Stable Momentum-Based Controller for Balancing Tasks with Contact Switching	Daniele Pucci
B	Interlocking Perception-Action Loops at Multiple Time Scales - A System for Manipulation in Uncertain and Dynamic Environments	Jeannette Bohg
C	Trajectory Optimization Through Contacts and Automatic Gait Discovery for Quadrupeds	Michael Neunert
D	Memory-Based Robotic Motion Primitive Learning for Kicking and Striking Tasks	Glen Henshaw
F	Motion Planning and Tracking for Quadrupedal Robots	Christian Gehring
G	Exploring Mobile-Manipulation Domains	David P. Miller
H	Pose Control for Legged Robots: A Quadruped Case Study	Farbod Farshidian
I	Risk-sensitive Model Predictive Control for Reproducing Uncertain Dynamical Systems	Jose Ramon Medina

Conference DLMC 2016

Poster Presentations

ID		Author	Session
1	Fast Kinematic Planning for non-holonomic Mobile Manipulators using a Constrained Sequential Linear Quadratic Approach	Markus Giftthaler	I
2	Learning Inverse Dynamics At Different Time Scales	Franziska Meier	I
3	An Adaptive Model for 3D Locomotion	Paramtap Mewada	I
4	Preview Optimization for Learning Locomotion Policies on Rough Terrain	Carlos Mastalli	I
5	Preliminary Results on the Effect of an Active Hip Assistance on Heartrate	Romain Baud	I
6	Towards advanced control of hyper degrees of freedom robots	Janne Koivumäki	I
7	Optimizing contact locations and CoM-trajectory simultaneously.	Alexander Winkler	I
8	Interactive Locomotion of mechanically coupled bipedal agents	Jessica Lanini	II
9	Efficient Learning Control in Dynamic Motion Task	Dessislava Despotova	II
10	A Low-Cost, Highly-Maneuverable, Miniature Robot intended for Collective Behaviors	Florian Berlinger	II
11	Smooth Real-Time Gait Phase Estimation for Lower-Limb Exoskeletons	Tingfang Yan	II
12	Multi-Level Predictive Control for Dynamic Motion	John R. Rebula	II
13	Task-based design of robots	Nitish Kumar	II
14	Leveraging Uncertainty Information for Robust Contact Interaction	Brahayam Ponton	II
14b	Learning to Organise Objects in Cluttered Environments	Yue Zhou	II

ID		Author	Session
15	Free Gait: Versatile Control of Legged Robots	Peter Fankhauser	III
16	Learning Compact Goal Representations from Rewards and Values	Matthias Rolf	III
17	Compliant Leg with Mono- and Biarticular Actuation to Support Dynamic Walking	Steffen Schütz	III
18	Generation of a Quadrupedal Bounding Gait on Rough Terrain	Romeo Orsolino	III
19	(Partial) Differential Flatness on Dynamical Systems	Carlo Sferrazza	III
20	Dynamic Coupling Map: Trajectory Analysis Technique for Dynamic Motions of Underactuated Systems	Ziad Zamzami	III
21	Acceleration-based transparency control framework for wearable robots	Thiago Boaventura	III
22	High-Velocity Motion Control of CoM by Contact Wrench Generation for Torque Control based Biped Robot	Yisoo Lee	IV
23	Minimalistic and Blind Locomotion of Quadruped Robots on Rough Terrain	Michele Focchi	IV
24	Enabling Dynamic Manipulation by Integrating Simultaneous Object and Arm Tracking with Continuous Motion Optimization	Jan Issac	IV
25	Online step location and timing adjustment for robust walking	Majid Khadiv	IV
26	Learning tool use to infer prehistoric human behaviour	Johannes Pfleging	IV
27	Stabilizing the End-Effector of a Mobile Manipulator in Task Space	Timothy Sandy	IV
28	Mechanically springy legs and high impedance control actuation common ground or design and control segregation for dynamic legged locomotion?	Alexander Spröwitz	IV
29	Emerging Terrain Adaptation from Hierarchical Whole Body Control	Dario Bellicoso	IV

Events

July 13

- ➔ Lunch (@ETH ML)
- ➔ Welcome Dinner (@Üetliberg)

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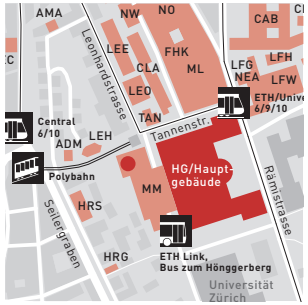
The Üetliberg is a mountain in the Swissplateau,part of the Albis chain, rising to 869 m. The Üetliberg offers a panoramic view of the entire city of Zurich and the Lake of Zurich.

July 14

- ➔ Lunch (@ETH ML)
- ➔ Poster Session & Social Event for Dinner (@ETH GEP Pavilion)
- ● Building GEP
  Leonhardstrasse 34, 8092 Zürich



July 15

ETH - Robotics Labs Tour

Robotics Systems Lab (LEE)
Vision 4 Robotics Lab (LEE)
IDSC (ML)
Robotics Perception Group (UZH)
ADRL (HPT)

Internet

Login: DLMC-2016
Password: DLMc.2016@ETH

Notes

Notes