ETH2: Dynamic Walking and Running with Robots

Hosted by the ETH Zurich
Course dates: 11- 15 July 2011

Course Description

40 years after the first autonomous walking robot and 20 years after Mark Raibert's seminal work on robotic running, research on legged locomotion is renewing itself vibrantly and innovative as never before. With the problem of statically stable locomotion nearly solved, the commercialization of ZMP-controlled bipeds at hand, and the ongoing large-scale application of Raibert's principles, the robotics community now strives to close the performance gap that still separates robotic devices from their counterparts in nature. Energy efficiency, higher locomotion speeds, versatility, and robustness, are the key ingredients that will allow a wide-spread application of legged locomotion in autonomous systems. In this school, we want to prepare a new generation of engineers for these challenges, expose them to the current state of the art, and highlight fascinating areas of future research.

To this end, the school will give a compact introduction into the engineering fundamentals of legged locomotion. It will provide the participants with the necessary concepts, tools, and methods that allow them to extend their knowledge of design, simulation, and control to the thrilling field of legged robotics. Within this general scope, we will specifically focus on all forms of dynamic locomotion and thus include lectures and exercises on exciting issues such as under-actuation, hybrid dynamic modeling, limit cycle analysis, and optimal control. Stressing the importance of learning from nature, the engineering perspective will be complemented by an introduction to the basic concepts of walking and running in biological systems. Physiology, morphology, and the characteristics of different gaits will be discussed and set into perspective with respect to robotics and prosthetics. Finally, in a number of selected case studies presented by internationally recognized experts in the field, we will point to areas of stimulating research and allow you to see beyond the current state of the art.

The school is designed for graduate students of all levels. A solid background in engineering will enable you to profit most from the lectures and exercises, while the course might still serve as a good introduction to people of different background who want to learn more about this inspiring field. This summer school is part of the Swiss National Competence Center for Research in Robotics.

Target Audience

The course is primarily aimed for graduate students (Master or PhD) and students who have just completed their undergraduate degree, with a solid background in engineering. However, students with a different background who want to learn more about this inspiring field are also welcome.

Delivery Method, Exams & Learning Outcomes

Course schedule
Monday, 11 July:
Engineering Fundamentals: Basic Concepts of Dynamic Locomotion
8.15-10.00 -> What is walking/running
10.15-12.00 -> Modelling
13.15-15.00 -> Limit cycles & passive dynamics
15.15-17.00 -> Exercise: A passive dynamic walker
Evening reception

Tuesday, 12 July:
Engineering Fundamentals: Efficient Locomotion on Flat Ground
8.15-10.00 -> Exercise: Running in simulation
10.15-12.00 -> Hardware
13.15-15.00 -> Optmization
15.15-17.00 -> Exercise: Optimization

Wednesday, 13 July:
Engineering Fundamentals/Biology: Locomotion in Rough Terrain
8.15-10.00 -> Stability on extended support
10.15-12.00 -> Force control
13.15-15.00 -> Exercise: Force control
15.15-17.00 -> Conceptual models in biology
Social/barbecue

Thursday, 14 July:
Biology: Physiology
8.15-10.00 -> Morphology and gaits
10.15-12.00 -> Energetics and efficiency
13.15-15.00 -> Exercise: Gait analysis
15.15-17.00 -> Multiple legs

Friday, 18 July:
Case studies & farewell dinner

Speakers include:

- Roland Siegwart (http://www.mavt.ethz.ch/people/professoren/rolandsi/index)
- C. David Remy (http://www.asl.ethz.ch/people/cremy)
- Marco Hutter (http://www.asl.ethz.ch/people/mahutter)
- Katja Mombaur (http://www1.iwr.uni-heidelberg.de/groups/orb/people/prof-katja-mombaur/#c1009)
- Jonas Buchli (http://www.buchli.org/jonas/acad/Jonas_Buchli/Welcome.html)
- Fumiya Iida (http://www.mavt.ethz.ch/people/professoren/iidaf/index)
- Hartmut Geyer (http://www.cs.cmu.edu/~hgeyer/)
- Shuuji Kajita (http://staff.aist.go.jp/s.kajita/index-e.html)
- Stefano Stramigioli (http://www.ce.utwente.nl/smi/UT-Stefano-Personal-Site/Welcome.html)
- Russ Tedrake (http://groups.csail.mit.edu/locomotion/russt.html)
- Art Kuo (http://www-personal.umich.edu/~artkuo/)
- Auke Ijspeert (http://people.epfl.ch/Auke.Ijspeert)

Where you will stay

We will provide basic accommodation for all participants in a remodeled former air-raid shelter in the basement of the Computer Science building (no windows). This is right next door to the main building, and will feature dormitory style rooms with shared bathrooms. This accommodation will be free of charge for all participants. It will be open from Sunday evening to Saturday morning, to accommodate travel that requires an additional night in Zurich.

If more privacy and comfort is desired, students must organize alternative accommodation on their own responsibility and expense (double rooms start at around CHF 65 per night and person).

Costs

Tuition fee: Waived for IARU partner students
Accommodation: Basic accommodation (air-raid shelter) is free of charge
Miscellaneous: CHF200 for all course materials, as well as breakfast, coffee-breaks, and two dinners during the school.
Living Expenses: CHF200 (estimated). Lunch and dinner is available at the ETH Zurich Cafeterias and in nearby venues from ~15 CHF (including a drink)