Improving Humanoid Walking Motions by Model-based Optimization

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Abstract: Humanoid robots are supposed to support or replace humans in dangerous, boring and tiring tasks e.g. in households, disaster sites, manufacturing environments or in space missions in the future. But at the moment, they still lack the very fundamental ability to do so, namely to walk in a truly human-like fashion. Compared to all the intelligence that humanoids have to acquire to perform these tasks, the demand for an improved walking performance seems simple, but it is in fact very challenging, and the motion abilities of contemporary humanoids are still far behind their human role models. Humanoid robots are extremely complicated dynamical systems for which the generation of whole-body motions, in particular walking is no easy task since the number of parameters to tune for a behavior is very high. Human and humanoids are redundant, underactuated systems that require dynamic stabilization. But while human gaits are at the same time efficient, robust and versatile, the gaits of humanoids or bipedal robots are at best good in one of these areas. This problem is not only linked to the present hardware, but also to a large extent to the control principles and the software used.

The European FP7 project KoroiBot Improving humanoid walking capabilities by human-inspired mathematical models, optimization and learning aims to address these issues relying to a big part on model-based optimization. With optimization or more precisely optimal control the redundancy can be turned into a benefit rather than a burden, and the best possible solution (according to specified criteria) can be found. Humanoid robot models are highly nonlinear systems of differential algebraic equations with multiple phases. Optimial motions can be generated by efficient direct multiple shooting methods.

In the first part of this talk, we give an an overview of the KoroiBot project and the different subtopics addressed related to human motion studies, modeling, optimization, learning and implementation on robots. In the second part, we show different examples of optimized motions on humanoid robots and focus on the discussion of transfer rules which are needed to transfer optimality principles from humans to humanoids taking into account different kinematic and dynamic properties including the different kinematic and dynamic constraints.

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