Optimal prostheses, orthoses and exoskeletons for physical activity

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Abstract

In this talk, we discuss the role of prostheses, orthoses and exoskeletons for supporting different motions in sports. Model-based optimization and simulation play an important role in this context to analyze the effect of each device on the particular motions and to develop the best possible devices for given tasks. In the case of the special prostheses for the use in sports, we will discuss the frequently asked question, if the prostheses may provide an advantage to the disabled athlete with respect to able bodied athlete and if competitions between the two would be fair. Model-based optimization provides a mean to study internal torques and forces in the human model with and without prostheses and compare them. In the case of orthoses and exoskeletons, we analyze the necessary characteristics of the devices for the support of different desired motions, i.e. which torques they would have to produce and which loads to carry. On the one hand we are interested in cases of paraplegic athletes where the exoskeleton would have to produce the full torques to carry the athlete as well as the exoskeleton itself. On the other hand, we also see a big need and challenge in developing suitable exoskeletons or orthoses that allow quite healthy people to continue their physical activity such as long hikes even in the presence of a small injury, or up to a high age. Such devices could produce such as drastic change for walking or running based types of movements as e-bikes did for biking. Model-based optimization can help to develop orthoses and exoskeletons that provide the right level of support for every demand. All computations presented are based on efficient multi-body system models of the human body which can be personalized to a particular athlete as well as multibody system model of the respective device. We then solve multi-phase optimal control problems to either perform model-based movement predictions or to fit the model to given data.

Professor Katja Mombaur's bio

Prof. Dr. Katja Mombaur is professor at the University of Heidelberg and head of the Optimization in Robotics & Biomechanics (ORB) group of the Interdisciplinary Center

for Scientific Computing (IWR) as well as the IWR Robotics Lab. Her research interests include model-based optimization for studying movements of humans in medical applications (exoskeletons, orthoses and prostheses as well as functional electrical stimulation), sports, cognitive sciences as well as of humanoid robots and other types of dynamic robots. On the mathematical side, she is interested in optimal control, inverse optimal control, non-smooth optimization and multibody system modelling algorithms. She holds a diploma degree in Aerospace Engineering from the University of Stuttgart and a Ph.D. degree in Mathematics from Heidelberg University. She was a postdoctoral researcher in the Robotics Lab at Seoul National University, South Korea. She also spent two years as a visiting researcher in the Robotics department of LAAS-CNRS in Toulouse. Katja Mombaur is founding chair of the IEEE RAS technical committee Model-based optimization for robotics. She is currently coordinator of the EU project KoroiBot and PI in the EU project MOBOT. She was leading the EU Project ECHORD – GOP and was PI in the Heika-Exo project. In addition, she is PI in the Graduate School HGS MathComp at IWR.

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