Title: Personalized robotic rehabilitation and assistance - a controls perspective

Abstract: Personalized robotic rehabilitation and assistance shows great promise to address societally important challenges such as demographic change and well-being of the society. It is expected that personalization leads to higher user acceptance and therefore improved rehabilitation outcomes and prolonged high-quality independent living. Control design plays a key role in this context. Focusing on sensorimotor rehabilitation and assistance, personalized control should be able to adapt to the high inter-personal variability in human motor behavior but also to intra-personal changes over time. Control adaptation is further challenged by the sparsity of person-specific data because calibration routines need to be brief for user acceptance. Above all, guaranteed safety is one of the key requirements.

In this talk we will present recent results on learning-based control with performance and safety guarantees for highly uncertain systems with particular focus on challenges arising from personalized rehabilitation and assistance. In order to achieve high sample efficiency as well as transparency of the system, available knowledge of neuromuscular dynamic models will be exploited and augmented by Bayesian non-parametric model components. Epistemic uncertainty due to limited training data will be explicitly taken into account in the control design in order to achieve uncertainty-aware behavior of the closed loop system. Online learning as well as realtime capabilities are further important aspects. The results will be demonstrated in user intention-driven shared control designs for upper limb rehabilitation and assistance with exoskeletons and functional electrical stimulation. Furthermore, the limits of learning control and personalization will be discussed.

Biography: Sandra Hirche holds the TUM Liesel Beckmann Distinguished Professorship and heads the Chair of Information-oriented Control in the Faculty of Electrical and Computer Engineering at Technical University of Munich (TUM), Germany (since 2013). She received the diploma engineer degree in Aeronautical and Aerospace Engineering in 2002 from the Technical University Berlin, Germany, and the Doctor of Engineering degree in Electrical and Computer Engineering in 2005 from the Technische Universität München, Munich, Germany. From 2005-2007 she has been a PostDoc Fellow of the Japanese Society for the Promotion of Science at the Fujita Laboratory at Tokyo Institute of Technology, Japan. Prior to her present appointment she has been an Associate Professor at TUM.

Her main research interests include learning, cooperative, and networked control with applications in human-robot interaction, multi-robot systems, and general robotics. She has published more than 200 papers in international journals, books and refereed conferences. She has received multiple awards such as the Rohde & Schwarz Award for her PhD thesis, the IFAC World Congress Best Poster Award in 2005 and - together with students - Best Paper Awards of IEEE Worldhaptics and IFAC Conference of Manoeuvring and Control of Marine Craft in 2009 and the Outstanding Student Paper Award of the IEEE Conference on Decision and Control 2018. In 2013 she has been awarded with an

ERC Starting Grant on the "Control based on Human Models" and in 2019 with the ERC Consolidator Grant on "Safe data-driven control for human-centric systems".

Sandra Hirche is Fellow of the IEEE. She has served as IEEE Control System Society (CSS) Vice-President for Member Activities (2014/15), as Chair for Student Activities in the IEEE CSS (2009-2014), as Chair of the CSS Awards Subcommittee on "CDC Best Student-Paper Award" (2010-2014), and has been elected member of the Board of Governors of IEEE CSS (2010-2013). She has been Co-Chair of the IFAC TC 1.5 "Networked Control Systems" (2010-2017).