Learning-based Trajectory Tracking and Transition-Positioning for High-speed High-Precision Micro/Nano-Manipulation

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Abstract Applications such as robotic operation, nano-manipulation, and additive manufacturing raise challenges in trajectory tracking and transition-positioning related to continuously increasing performance demands and/or non-traditional operation scenarios. For example, how to avoid the performance and robustness trade-off of feedback control, and attain both precision tracking and robustness against system variation and uncertainties—in the presence of adverse nonlinear and dynamics effects such as nonminumum-phase zeros? Such a goal becomes more challenging when the desired trajectory to be tracked is arbitrary, at high-speed, and unknown a priori, or the operation involves non-periodic switching between tracking and transition-positioning. In this talk, we will present a learning-based approach to tackle these challenges, based on an extension of the superposition concept that bridges offline learning via the notion of basis functions and online optimization and adaptation. Experimental results in high-speed nanopositioning control, high-speed probe-based nanofabrication, and high-speed scanning probe microscope imaging will be discussed as illustrative examples.

Bibliography Qingze Zou is a Professor in the Department of Mechanical and Aerospace Engineering of Rutgers, the State University of New Jersey. Previously he had taught in the Mechanical Engineering Department of Iowa State University. He obtained his Ph.D. in mechanical engineering from the University of Washington, Seattle, WA in 2003, his MS. from Tsinghua University, Beijing, China, and his BS. from the University of Electronic Science and Technology of China, Chengdu, China. His research interests include learning-based precision motion control, high-speed scanning probe microscopy, rapid broadband nanomechanical mapping of soft and live samples, control of smart and soft robotics, industrial robotic manipulation, and dynamics modeling of plant stomata. He received the NSF CAREER award in 2009, and the *O Hugo Schuck* Best Paper Award from the American Automatic Control Council in 2010. He is a past Associate Editor of *ASME Journal of Dynamic Systems, Measurement and Control*, and currently a Technical Editor of *IEEE/ASME Transactions on Mechatronics*, *Control Engineering Practices*, and *Mechatronics*. He is a Fellow of ASME.