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Lecture by

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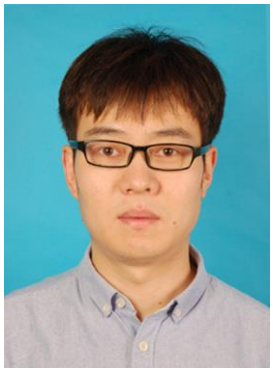
Speech Title: Dynamics and Advanced Control of Pneumatic Artificial Muscle Robot Systems

Abstract:

With the rapid development of rehabilitation robots and the growing demands for human-robot interaction, modeling and intelligent control of pneumatic artificial muscle (PAM) robots have increasingly attracted the attention of many researchers. It is a challenging research topic to overcome the effects of PAMs' inherent defects (e.g., high nonlinearities, hysteresis, time-varying characteristics, etc.), despite the merits of lightness, safety, and high power-to-weight/volume ratios of PAMs. To this end, we aim to achieve accurate modeling and advanced control for PAM robots, which may contribute to their further theoretical research and practical applications. Specifically, for single-PAM robots, there exist some difficulties as follows: 1) PAM systems are susceptible to unknown external disturbances due to their high nonlinearities, creep, hysteresis, etc. 2) PAM robots usually suffer from parameter uncertainties and unmodeled dynamics. 3) The ultimate control inputs (corresponding to the pressurized air) of PAM robots should be constrained to be nonnegative. To solve these problems, we propose a disturbance estimation-based nonlinear control method, a neuroadaptive control method with system uncertainties, and an adaptive control method with unidirectional input constraints, respectively. Further, for multi-PAM robots, the following issues should be considered: 1) Since torques/forces are generated by air pressure and are not the ultimate control inputs, the torque models of PAM robots are not direct and effective. 2) To ensure safety, the system state variables (e.g., contracted lengths of muscles, ranges of robots' movements, etc.) are usually limited. To this end, we propose an accurate dynamic modeling method and a nonlinear control method with overshoot constraints, respectively. Some future research directions will also be discussed.

About the author

Profile Photo:



CV:

Ning Sun received the B.S. degree in measurement & control technology and instruments from Wuhan University, Wuhan, China, in 2009, and the Ph.D. degree in control theory and control engineering from Nankai University, Tianjin, China, in 2014. He is currently an IEEE Senior Member.

He is currently a Full Professor with the Institute of Robotics and Automatic Information Systems, Nankai University, Tianjin, China. He was awarded the prestigious Japan Society for the Promotion of Science (JSPS) Postdoctoral Fellowship for Research in Japan (Standard). His research interests include intelligent control for mechatronic/robotic systems with emphasis on (industrial) applications.

Dr. Sun received the Wu Wenjun Artificial Intelligence Excellent Youth Award in 2019, the China 10 Scientific and Technological Developments in Intelligent Manufacturing (2nd achiever) in 2019, the First Class Prize of Wu Wenjun Artificial Intelligence Natural Science Award in 2017, the First Class Prize of Tianjin Natural Science Award in 2018, the Golden Patent Award of Tianjin in 2017, the IJCAS (International Journal of Control, Automation, and Systems) Academic Activity Award in 2018 and 2019, the Outstanding Ph.D. Dissertation Award from the Chinese Association of Automation (CAA) in 2016, etc.

He serves as an Associate Editor (editorial board member) for several journals, including IEEE Access, Frontiers in Neurorobotics, International Journal of Control, Automation, and Systems, IET Cyber-Systems & Robotics, Transactions of the Institute of Measurement and Control, International Journal of Precision Engineering and Manufacturing, etc. Prof. Sun has been an Associate Editor of the IEEE Control Systems Society (CSS) Conference Editorial Board (including ACC, IEEE CDC) since July 2019, and he is/was an Associate Editor for IEEE ICRA and IEEE/RSJ IROS.