BING SONG

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EDUCATION

Columbia University, New York, NY

Doctor of Philosophy, Mechanical Engineering, GPA 3.94/4.0, 2011-2018

Master of Science, Mechanical Engineering, GPA 4.0/4.0, 2010-2011

Tianjin University, Tianjin, China

Bachelor of Science, Measuring and Control Technology and Instruments, rank 1/125, 2005-2009

RESEARCH EXPERIENCE

Columbia University, Robotic Manipulation and Mobility Lab, New York, NY

Principal Investigator: Prof. Matei Ciocarlie

Postdoctoral Researcher, 2019/01-Present

Proposed and developing a hierarchical framework for rigid-body robot-hand manipulation. Implemented iterative linear-quadratic regulator (iLQR) for automatic gait generation in simulation and evaluated computation time for real world implementation. Implemented iLQR for grasps and in-hand manipulation in simulation and iterative learning control (ILC) for snake robots in simulation.

University of Massachusetts Amherst, Autonomous Learning Laboratory, Amherst, MA

Director: Prof. Andrew Barto, Co-Director: Prof. Philip Thomas

Visiting Scholar, 2018/05-2018/08

Developed a model-free RL policy design feedforward signals for trajectory tracking problems. Compared its performance with ILC based on linearized models for nonlinear systems. Model-based ILC uses fewer iterations and achieves better tracking accuracy.

Columbia University, Control Systems Research Group, New York, NY

Principal Investigator: Prof. Richard Longman

Graduate Research Assistant, 2014-2018

Thesis Title: From Model-Based to Data-Driven Discrete Iterative Learning Control. Developed (1) model-based ILC for nonlinear systems based on feedback linearization that has a faster learning rate compared to linearization/bilinearization-based method at the cost of real-time measurements of states, (2) model-based ILC for nonlinear systems based on Carleman bilinearization with a homotopy of a desired trajectory that has a faster and closer-to-monotonic convergence compared to linearization-based methods, (3) model-free ILC algorithms using reinforcement learning that can be seen as the first step to bridge these two fields, (4) adaptive linear ILC algorithms by embedding a deadbeat observer for Markov parameter estimation to increase the tracking speed during learning, and (5) a circulant zero-phase filter for ILC that

represents the desired steady state response cutoff for finite trajectories to avoid destabilizing a stable ILC law.

Philips Research North America, Briarcliff Manor, NY
Principal Scientist: Prof. Nicolas Chbat
Summer Intern, 2015/07-2015/09
Applied system identification algorithms to estimate the models of lung mechanics in ventilated patients based on non-invasive and maneuver-free measurements.

Columbia University, BioMEMS Group, New York, NY
Principal Investigator: Prof. Qiao Lin
Graduate Research Assistant, 2011-2014
Participated in writing the implanted glucose-binding MEMs sensor proposal (NIH Grant No. 1DP3DK101085-01): (1) designed, fabricated, and tested heuristic calcium-binding hydrogel MEMs sensors by impedance analyzer for preliminary results; (2) designed the wireless telemetry module for the implanted glucose sensors; (3) helped in designing in vivo tests.

State Key Laboratory of Precision Measuring Technology and Instruments, Tianjin, China
Principal Investigator: Prof. Kexin Xu
Research Assistant, 2009-2010
Processed and analyzed data from surface plasmon resonance sensor for glucose monitoring.

PUBLICATIONS

E. Hannigan, B. Song, G. Khandate, M. H. Heger, J. Yin, & M. Ciocarlie. "Automatic Snake Gait Generation Using Model Predictive Control", *IEEE Intl. Conference on Robotics and Automation, 2020* (in press).

B. Song, M. Phan, and R. W. Longman. "Feedback Linearization-based Discrete-Time Iterative Learning Control for Nonlinear Systems", *Advances in the Astronautical Sciences*, 168, 1603–1616, 2019.

E. Hannigan, B. Song, G. Khandate, J. Yin, M. Haas Heger, and M. Ciocarlie. "SBP-Guided MPC to Overcome Local Minima in Trajectory Planning", *Workshop on Toward Online Optimal Control of Dynamic Robots, IEEE Intl. Conference on Robotics and Automation*, Montreal, May 2019.

G. Khandate, E. Hannigan, M. Hass Heger, B. Song, J. Yin, and M. Ciocarlie. "Algorithmic Gait Synthesis for a Snake Robot", *Workshop on Toward Online Optimal Control of Dynamic Robots, IEEE Intl. Conference on Robotics and Automation*, Montreal, May 2019.

B. Song, M. Phan, and R. W. Longman. "Data-Driven Model-Free Iterative Learning Control using Reinforcement Learning", *Advances in the Astronautical Sciences*, 167, 2579–2597, 2018.

B. Song, M. Phan, and R. W. Longman. "Bilinearized Model-Based Discrete-Time Iterative Learning Control for Nonlinear Systems", *Advances in the Astronautical Sciences*, 167, 2563–2578, 2018.

B. Song and R. W. Longman. "Modifying Iterative Learning Control to Increase Tracking Speed by Markov Parameter Updates", *Advances in the Astronautical Sciences*, 158, 2307–2326, 2016.

J. Shang, J. Yan, Z. Zhang, X. Huang, P. Maturavongsadit, B. Song, Y. Jia et al. "A hydrogel-based glucose affinity microsensor", *Sensors and Actuators B: Chemical*, 237, 992–998, 2016.

B. Song and R. W. Longman. "Circulant Zero-Phase Low-Pass Filter Design for Improved Robustification of Iterative Learning Control", *Advances in the Astronautical Sciences*, 156, 2161–2180, 2015.

X. Huang, C. Leduc, Y. Ravussin, S. Li, E. Davis, B. Song, D. Li et al. "A differential dielectric affinity glucose sensor", *Lab on a Chip* 14, 2, 294–301, 2014.

D. Li, H. Yu, X. Huang, B. Song, Y. Jia, Y. Ji, N. Li, J. Chen, K. Xu, and Q. Lin. "A microfluidic system with volume sensor and dielectric glucose sensor for continuous glucose monitoring", *The 17th International Conference on Solid-State Sensors, Actuators and Microsystems (TRANSDUCERS & EUROSENSORS XXVII)*, Barcelona, 365–368, 2013.

S. Li, E. Davis, X. Huang, B. Song, R. Peltzman, D. Sims, Q. Lin and Q. Wang. "Synthesis and Development of Poly(N-hydroxyethyl acrylamide)-ran-PAAPBA (PHEAA-ran-PAAPBA) Polymer Fluid for Potential Application in Affinity Sensing of Glucose", *Journal of Diabetes Science and Technology* 5: 1060-1067, 2011.

INVITED SEMINAR AND WORKSHOP

GRASP Seminar, University of Pennsylvania, Philadelphia, PA, February 14, 2020.

Rising Stars in Mechanical Engineering, Stanford University, October 17-18, 2019.

TEACHING EXPERIENCE

Columbia University, New York, NY

Teaching Assistant/Grader

Space Vehicle Dynamics (Spring 2016), Classical Control (Fall 2015, Fall 2014): Prof. Richard Longman. Hosted hardware demonstration classes.

Tianjin University, Tianjin, China

Participated in writing a textbook on instrument measurements with Prof. Dachao Li. (2010)

LEADERSHIP AND SERVICE

Mechanical Engineering Graduate Association at Columbia University, 2015-2018
Lab Representative.

Stuyvesant High School, 2017
Volunteered to interpret for Chinese parents at the parent/teacher conferences.