Nak-seung Patrick Hyun

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Research Goal A cyclic learning between biology, mathematical system theory, and robotics with an emphasis on **Control Theoretic Bio-Inspired Robotics**

Academic Employments

Jun. 2021 ~ present **Research Associate, Harvard Microrobotics Laboratory**
Materials Science and Mechanical Engineering, Harvard University, Cambridge, MA
Mentor: Robert J. Wood

Jun. 2019 ~ May 2021 **Postdoctoral Fellow, Harvard Microrobotics Laboratory**
Materials Science and Mechanical Engineering, Harvard University, Cambridge, MA
Mentor: Robert J. Wood

Jun. 2018 ~ May 2019 **Postdoctoral Fellow, Harvard Agile Robotics Laboratory**
Computer Science, Harvard University, Cambridge, MA
Mentor: Scott Kuindersma

Education

Aug. 2018 **Ph.D. in Electrical and Computer Engineering**
Georgia Institute of Technology, Atlanta, GA
Thesis: "Causal Infinitesimal Modeling of Nonlinear Impulsive Systems and Safe Path Planning in Robotics"
Advisor: Erik I. Verriest and Patricio A. Vela

Dec. 2013 **M.S. in Mathematics**
Georgia Institute of Technology, Atlanta, GA

May 2013 **M.S. in Electrical and Computer Engineering**
Georgia Institute of Technology, Atlanta, GA

Feb. 2009 **B.S. in Electrical Engineering**
Korea University, Seoul, South Korea

Research Interests

• Bio-inspired Robotics: Flapping-Wing Vehicles • Safety-Critical Nonlinear Control • Adaptive Control
• Impulsive Systems • Contraction Theory • Geometric Control • Optimal Motion Planning • Swarm Robotics

Publications

Journal Papers

Automatica **[J8]** **N. P. Hyun**, R. McGill, R. J. Wood, and S. Kuindersma, "A New Control Framework for Flapping-Wing Vehicles based on 3D Pendulum Dynamics", *Automatica*, 123, 109293, 2021

PNAS **[J7]** ∗ **co-first author** E. Steinhardt*, **N. P. Hyun***, J. Koh, M. H. Rosen, F. Z. Temel, and R. J. Wood, "A Physical Model of Mantis Shrimp for Exploring the Dynamics of Ultra-Fast Systems", *Proceedings of the National Academy of Sciences*, 118(33), Aug, 2021

RA-L [**J6**] R. McGill, **N. P. Hyun**, and R. J. Wood, "Modeling and Control of Flapping-Wing Micro-Aerial Vehicles with Harmonic Sinusoids", *IEEE Robotics and Automation Letters*, (Accepted), 2021

PNAS [**J5**] ∗ **co-first author** J. Oberding*, **N. P. Hyun***, A. De* , S. Divi*, X. Liang*, E. Thomas*, R. S. Pierre, E. Steinhardt, J. Jorge, S. J Longo, S. Cox, E. Mendoza, G. Sutton, E. Azizi, A. J. Crosby, S. Bergbreiter, R. J. Wood, and S. N. Patek, "Tunable elastic materials and latch dynamics achieve control objectives in ultrafast systems", *Proceedings of the National Academy of Sciences* (Under review), 2021

PNAS [**J4**] S. Xu, Y. Chen, **N. P. Hyun**, K. P. Becker, and R. J. Wood, "A dynamic electrically-driven soft valve for control of fluidic soft actuators", *Proceedings of the National Academy of Sciences*, 18(34), Aug, 2021

Nature [**J3**] Y. Chen, H. Zhao, J. Mao, P. Chirarattananon, E. F. Helbling, **N. P. Hyun**, D. R. Clarke, and R. J. Wood, "Controlled flight of a microrobot powered by soft artificial muscles", *Nature*, 575(7782), pp. 324-329. , 2019

NAHS [**J2**] **N. P. Hyun**, E. I. Verriest, "Causal Modeling in Impulsive Systems: A New Rigorous Non-Standard Analysis Approach", *IFAC journal of Nonlinear Analysis and Hybrid System*, 25 , pp. 138 - 154, 2017

RAL/ICRA [**J1**] **N. P. Hyun**, P. A. Vela, E. I. Verriest, "A New Framework for Optimal Path Planning of Rectangular Robots Using a Weighted Lp Norm", *IEEE Robotics and Automation Letters*, 2 , pp. 1460 - 1465, 2017

Preprints and In preparation

[**A2**] **N. P. Hyun**, R. McGill, and R. J. Wood, "High Accuracy Control of Flapping-Wing Micro Aerial Vehicle with Soft Landing", *In Preparation*, 2021

arXiv [**A1**] **N. P. Hyun**, M. Petersen, A. Chang, P. A. Vela, E. I. Verriest, "Bendable Cuboid Robot Path Planning with Collision Avoidance Using Generalized Lp norm", *arXiv preprint*, Online : https://arxiv.org/abs/1712.06021

Refereed Conferences Proceedings

CDC [**C15**] **N. P. Hyun**, M. Petersen, and R. J. Wood, "Direct Model Reference Adaptive Control for Tracking Contracting Nonlinear Systems", *in Proceedings of Conference on Decision and Control*, pp. 2026-2031, IEEE, 2020

ACC [**C14**] M. Vishal, **N. P. Hyun**, and E. I. Verriest, "Graceful Transitions between Periodic Walking Gaits of Fully Actuated Robots", *in Proceedings of American Control Conference*, pp. 1043-1048, IEEE, 2020

CDC [**C13**] M. Srinivasan, **N. P. Hyun**, and S. Coogan, "Weighted Polar Finite Time Control Barrier Functions With Applications To Multi-Robot System", *in Proceedings of Conference on Decision and Control*, pp. 7031-7036, IEEE, 2019

ICRA [**C12**] R. Steinmeyer, **N. P. Hyun**, E. F. Helbling, and R. J. Wood, "Yaw Torque Authority for a Flapping-Wing Micro-Aerial Vehicle", *in Proceedings of International Conference on Robotics and Automation*, pp.2481-2487, IEEE, 2019

MTNS [**C11**] E. I. Verriest, **N. P. Hyun**, "Roots of Polynomials with Positive Coefficients", Conference on Decision and Control, *in Proceedings of International Symposium on Mathematical Theory of Networks and Systems*, pp. 259-265, 2018

CDC [**C10**] **N. P. Hyun**, Y. Peres, "Electrostatic Methods for Perfect Matching and Safe Path Planning", *in Proceedings of Conference on Decision and Control*, pp. 912-917, IEEE, 2018

ACC **[C9]** V. Murali, **N. P. Hyun**, E. I. Verriest, "Graceful Gait Transitions for Hopping Robots on Deformable Terrain", *in Proceedings of American Control Conference*, pp. 1299-1304, IEEE, 2018

ACC **[C8]** A. Chang, **N. P. Hyun**, E. I. Verriest, Patricio A. Vela, "Optimal Trajectory Planning and Feedback Control of Lateral Undulation in Snake-Like Robots", *in Proceedings of American Control Conference*, pp., IEEE, 2018

CDC **[C7]** **N. P. Hyun**, V. Murali, E. I. Verriest, "Minimum Sensitivity Analysis of Accurate Open-loop Controllers in Linear Systems using Weighted Gramians", *in Proceedings of Conference on Decision and Control*, pp. 114-119, IEEE, 2017

CDC **[C6]** **N. P. Hyun**, E. I. Verriest, "Causal Impact Modeling of State Dependent Impulsive Affine Systems using Non-Standard analysis", *in Proceedings of Conference on Decision and Control*, pp. 3024-3029, IEEE, 2016

ACC **[C5]** **N. P. Hyun**, P. A. Vela, E. I. Verriest, "Collision Free and Permutation Invariant Formation Control Using the Root Locus Principle", *in Proceedings of American Control Conference*, pp. 2572-2577, IEEE, 2016

ADHS **[C4]** **N. P. Hyun**, E. I. Verriest, "Cause versus Effect in Hybrid Systems: A Rigorous Non-standard Analysis Approach", *in Proceedings of Conference on Analysis and Design of Hybrid Systems*, 48, pp. 129-134, IFAC, 2015

CDC **[C3]** **N. P. Hyun**, P. A. Vela, E. I. Verriest, "Optimal Obstacle Avoidance Trajectory Generation Using the Root Locus Principle", *in Proceedings of Conference on Decision and Control*, pp. 626-631, IEEE, 2015

MTNS **[C2]** **N. P. Hyun**, E. I. Verriest, "Optimal Periodic Locomotion for a Two Piece Worm with an Asymmetric Dry Friction Model", *in Proceedings of International Symposium on Mathematical Theory of Networks and Systems*, 2014

CDC **[C1]** A. B. Memon, E. I. Verriest, **N. P. Hyun**, "Graceful gait transitions for biomimetic locomotion-the worm", *in Proceedings of Conference on Decision and Control*, pp. 2958-2963, IEEE, 2014

Invited Talks & Selected Presentation

Invited Talks

Nov 2021 **Electrical Engineering, Seoul National University**.
"Autonomous Control of Extreme Behaviors in Bio-Inspired Robotics"

Nov 2017 **Microsoft Research**.
"Optimal Safe Path Planning Using Polynomials: From Algebra to Geometry"

Feb 2017 **12th Coordinated Science Laboratory Student Conference at University of Illinois at Urbana-Champaign**.
"Infinitesimal Modeling of Impulsive System: A Nonstandard Analysis Approach"

Jan 2017 **Georgia Tech Mathematics and Application Portal (GT-MAP) seminar**.
"A New Framework of Modeling Impulsive System: A Nonstandard Analysis Approach"

Jun 2016 **Control and Dynamics System Lab (CDSL), Seoul National University**.
"Safe Path Planning in Polynomial Space using Root Locus Principle"

Paper Presentations

2020 Presented the paper "Direct Model Reference Adaptive Control for Tracking Contracting Nonlinear Systems" at the 59th IEEE Conference on Decision and Control (CDC), Jeju, South Korea, Dec., 2020.

2018 Presented the paper "Electrostatic Methods for Perfect Matching and Safe Path Planning" at the 57th IEEE Conference on Decision and Control (CDC), Miami, Florida, Dec., 2018.

2017 Presented the paper "Minimum Sensitivity Analysis of Accurate Open-loop Controllers in Linear Systems using Weighted Gramian" at the 56th IEEE Conference on Decision and Control (CDC), Melbourne, Australia, Dec., 2017.

2016 Presented the paper "Causal Impact Modeling of State Dependent Impulsive Affine Systems using Non-Standard analysis" at the 56th IEEE Conference on Decision and Control (CDC), Las Vegas, Nevada, Dec., 2016.

2016 Presented the paper "Collision Free and Permutation Invariant Formation Control Using the Root Locus Principle" at the American Control Conference (ACC), Boston, Massachusetts, Jul., 2016.

2015 Presented the paper "Cause versus Effect in Hybrid Systems: A Rigorous Non-standard Analysis Approach" at IFAC Conference on Analysis and Design of Hybrid Systems, Atlanta, Georgia, Oct., 2015. ⋆ **Invited to special issue on NAHS [J2] (Top 20% among 60 presentations)**

2015 Presented the paper "Optimal Obstacle Avoidance Trajectory Generation Using the Root Locus Principle" at the 55th IEEE Conference on Decision and Control (CDC), Osaka, Japan, Dec., 2015.

Abstract Presentations

2017 Presented the abstract on "A Causal Impact Modeling in Impulsive Systems using Non-standard Analysis" at the Joint Mathematics Meetings, Atlanta, Georgia, Jan., 2017.

2015 Presented the abstract on "The Molecular Eigen-Problem and Applications" at the SIAM Conference on Applied Linear Algebra, Atlanta, Georgia, Oct., 2015.

Teaching

Fall 2014 **Lecturer**, ECE3710 Introduction to Electronics
Electrical and Computer Engineering, Georgia Tech

Spring 2016 **Guest Lecturer**, ECE6550 Optimal Control & ECE3550 Feedback Control Systems
Electrical and Computer Engineering, Georgia Tech

Summer 2014 **Graduate Teaching Assistant**, ECE3550 Feedback Control Systems
Electrical and Computer Engineering, Georgia Tech

Summer 2013 **Graduate Teaching Assistant**, MATH4107 Abstract Algebra
Mathematics, Georgia Tech

2009~2012 **Graduate Teaching Assistant**, ECE2025 Introduction to Signal Processing
Electrical and Computer Engineering, Georgia Tech

- ⋆ **Outstanding Graduate Teaching Assistant of the Year 2011**

Awards & Honors

2017 **Outstanding Reviewer Award**
The Editors of Nonlinear Analysis: Hybrid Systems, Elsevier, Amsterdam, Netherlands

2015 **Best Contribution Award**
Georgia Tech Decision and Control Laboratory Graduate Student Symposium

2011 **Outstanding Graduate Teaching Assistant of the Year**
Electrical and Computer Engineering, Georgia Tech

2004 & 2008 **Academic Honors/Scholarships**
Korea University

Service and Professional Activities

Co-Chair IFAC Analysis and Design of Hybrid Systems (2015)

Journals

Reviewer IEEE Transactions on Automatic Control
Reviewer IFAC Journal of Nonlinear Analysis: Hybrid Systems
Reviewer IEEE Robotics and Automation Letter
Reviewer IEEE/ASME Transactions on Mechatronics
Reviewer International Journal of Control, Automation, and Systems

Conferences

Reviewer IEEE Conference on Decision and Control (2016, 2017, 2019, 2020, 2021)
Reviewer IEEE American Control Conference (2018, 2019, 2020)
Reviewer IEEE European Control Conference (2016)
Reviewer IFAC International Workshop on Periodic Control Systems (2016)
Reviewer IEEE International Conference on Robotics and Automation (2020, 2021)
Reviewer IEEE International Conference on Intelligent Robots and Systems (2019)