

# CURRICULUM VITAE

**Inseung Kang**

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## EDUCATION

### Georgia Institute of Technology

*Ph.D. in Mechanical Engineering*

*Aug 2021(expected)*

*M.S. in Mechanical Engineering*

*May 2018*

*B.S. in Mechanical Engineering*

*May 2016*

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## ACADEMIC POSITIONS

### PhD Candidate

Exoskeleton and Prosthetic Intelligent Control Lab

*Aug 2016 - Current*

School of Mechanical Engineering

Georgia Institute of Technology

Advised by Aaron J. Young PhD

**Dissertation Topic:** Adaptive user state estimation for assisting human locomotion using robotic hip exoskeletons

- Incorporate real-time user state estimation/prediction utilizing sensor fusion-based machine learning algorithms
  - User intent recognition (e.g., climbing stairs and ramps) for continuous locomotion mode classification
  - Sensor fusion-based approach for robust user state estimation (e.g., walking speed) during ambulation
  - Online adaptation approach (transfer learning) to accommodate variations in different user's gait dynamics
- Implement dynamic controllers to accommodate different locomotion tasks and user's gait patterns for a robotic hip exoskeleton
  - Biological torque control
  - State machine-based impedance control
  - Proportional myoelectric (EMG) control
- Design a robust mechatronic platform with capabilities in providing torques in wide ranges of locomotion tasks
  - Series elastic actuator: capability in high fidelity closed loop feedback control, additional compliance for mitigating disturbance
  - Quasi-direct drive actuator: high bandwidth, back-drivable, transparent actuator dynamics
- Understand human robot interaction through a formal biomechanical/biological analysis
  - Standard biomechanics measurement using motion capture system
  - Evaluation of user's biological measurement: metabolic cost, EMG signals

- Translate exoskeleton technology to understand the device efficacy in a clinical population (Elders and Stroke patients)
  - Understand the optimal assistance strategy for improving gait function in stroke populations
  - Explore different machine learning techniques to handle signal variations in stroke subjects

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## EMPLOYMENT AND EXPERIENCE

### Graduate Teaching Assistant

School of Mechanical Engineering  
Georgia Institute of Technology

*Aug 2016 – Aug 2018*

- Directed undergraduate students in ‘Creative Decision and Design’ course learning to build task driven robots for a competition
- Trained different machining techniques/design tools relating to manufacturability
- Instructed mechatronics/embedded programming using NI myRIO and LabVIEW

### CAD/CAM Instructor

School of Biological Sciences  
Georgia Institute of Technology

*Spring 2017, 2018*

- Instructed CAD (Solidworks) software to students in Master of Science in Prosthetics and Orthotics program
- Taught design ideation, feature extraction, manufacturability etc.
- Utilized an industry grade 3D scanner and taught its application with CAD software

### Research Assistant

Neuro-Robotic Rehabilitation Team | The Center for Bionics  
Korea Institute of Science and Technology

*Summer 2017*

- Designed and fabricated a full lower limb exoskeleton rehabilitation robot (COWALK) for SCI patients
- Analyzed and optimized data via Simulink for synchronizing the exoskeleton movement with user’s gait pattern
- Presented a full demo of the device to President of Republic of Korea (June, 2014)

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## PUBLICATIONS

### *Journal Articles*

- J7: **I. Kang**, D. Molinaro, S. Duggal, Y. Chen, P. Kunapuli, A. Young, Real-time gait phase estimation for robotic hip exoskeleton control during multimodal locomotion, *IEEE Robotics and Automation Letters / International Conference on Robotics and Automation (ICRA)*, May 2021 – In Press

- J6: D. Lee, **I. Kang**, D. Molinaro, A. Yu, A. Young, Real-Time User-Independent Slope Prediction using Deep Learning for Modulation of Robotic Knee Exoskeleton Assistance, *IEEE Robotics and Automation Letters / International Conference on Robotics and Automation (ICRA)*, May 2021 – In Press
- J5: SE. Lee, C. Kilpatrick, **I. Kang**, H. Hsu, W. Childers, A. Young, Investigating the Impact of the User Interface for a Powered Hip Orthosis on Metabolic Cost and User Comfort: A Preliminary Study, *Journal of Prosthetics and Orthotics*, June 2020
- J4: G. Sawicki, O. Beck, **I. Kang**, A. Young, The Exoskeleton Expansion: Improving Walking and Running Economy, *Journal of NeuroEngineering and Rehabilitation*, February 2020
- J3: D. Lee, EC. Kwak, B. McLain, **I. Kang**, A. Young, Biomechanical Effects of a Robotic Knee Exoskeleton during Incline and Decline Walking, *IEEE Transactions on Neural Systems & Rehabilitation Engineering*, February 2020
- J2: **I. Kang**, P. Kunapuli, A. Young, Real-Time Neural Network-based Gait Phase Estimation using a Robotic Hip Exoskeleton, *IEEE Transactions on Medical Robotics and Bionics*, December 2019
- J1: **I. Kang**, H. Hsu, A. Young, The Effect of Hip Assistance Levels on Human Energetic Cost Using Robotic Hip Exoskeletons, *IEEE Robotics and Automations Letters*, April 2019

### ***Refereed Conference Proceedings***

- C7: **I. Kang**, D. Molinaro, G. Choi, A. Young, Continuous locomotion mode classification using a powered bilateral hip exoskeleton, *IEEE International Conference on Biomedical Robotics and Mechatronics (BioRob)*, June 2020
- C6: D. Molinaro, **I. Kang**, A. Young, Estimation of biological hip moment using a robotic hip exoskeleton, *IEEE International Conference on Biomedical Robotics and Mechatronics (BioRob)*, June 2020
- C5: **I. Kang**, P. Kunapuli, H. Hsu, A. Young, Electromyography (EMG) Signal Contributions in Speed and Slope Estimation Using Robotic Exoskeletons, *IEEE International Conference on Rehabilitation Robotics (ICORR)*, June 2019
- C4: H. Zheng, T. Shen, R. Afsar, **I. Kang**, A. Young, X. Shen A Semi-Wearable Robotic Device for Sit-to-Stand Assistance, *IEEE International Conference on Rehabilitation Robotics (ICORR)*, June 2019
- C3: **I. Kang**, H. Hsu, A. Young, Design and Validation of a Torque Controllable Hip Exoskeleton for Walking Assistance, *ASME Dynamic Systems and Control Conference*, October 2018
- C2: H. Hsu, **I. Kang**, A. Young, Design and Evaluation of a Proportional Myoelectric Controller for Hip Exoskeleton During Normal Walking, *ASME Dynamic Systems and Control Conference*, October 2018

- C1: S. Kim, X. Chen, G. Dreifus, J. Lindahl, **I. Kang**, A. Kim, M. Selim, D. Nuttal, A. Messing, A. Nycz, R. Minneci, J. Bowers, B. Braswell, A. Hassan, B. Pipes, V. Kunc, An Integrated Design Approach for Infill Patterning of Fused Deposition Modeling and its Application to an Airfoil, *SAMPE Conference*, February 2017

### ***Under Review***

- J1: D. Lee, B. McLain, **I. Kang**, A. Young, Biomechanical Comparison of Assistance Strategies Using a Bilateral Robotic Knee Exoskeleton, *IEEE Transactions on Biomedical Engineering*

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## **PRESENTATION**

### ***Invited Seminar Talk***

- T4: **I. Kang**, Improving Human Locomotion Using a User State Adaptive Control of a Robotic Hip Exoskeleton, *Yonsei University College of Medicine*, January 2021
- T3: **I. Kang**, Robotic Exoskeleton for Improving Human Locomotion, *NAVER LABS*, December 2020
- T2: **I. Kang**, User State Adaptive Control of a Robotic Hip Exoskeleton to Improve Human Locomotion During Community Ambulation, *Samsung Electronics*, December 2020
- T1: **I. Kang**, User State Adaptive Assistance Strategy to Enhance Human Locomotion Using a Robotic Hip Exoskeleton, *Georgia Tech IRIM RoboGrads Student Virtual Seminar Session*, August 2020

### ***Conference Talk***

- T5: **I. Kang**, D. Molinaro, G. Choi, A. Young, A biomechanical analysis of adaptive assistance strategy for uphill walking using a powered hip exoskeleton, *American Society of Biomechanics Annual Conference*, August 2020
- T4: D. Molinaro, **I. Kang**, J. Camargo, A. Young, Estimating biological hip torque during overground ambulation: A machine learning approach, *American Society of Biomechanics Annual Conference*, August 2020
- T3: Y. Pan, **I. Kang**, K. Herrin, A. Young, The Biomechanical Effect of Bilateral Assistance for Hemiparetic Gait Poststroke Using a Powered Hip Exoskeleton, *American Society of Biomechanics Annual Conference*, August 2020
- T2: C. Kilpatrick, SE. Lee, **I. Kang**, H. Hsu, L. Childers, A. Young, The Impact of Hip Exoskeleton User Interface on User Comfort and Metabolic Cost: A Pilot Study, *American Academy of Orthotists & Prosthetists Conference*, March 2019

- T1: **I. Kang**, H. Hsu, A. Young, Effects of Assistance Levels on Energetic Savings Using a Robotic Hip Exoskeleton, *Dynamic Walking Conference*, May 2018

### **Poster Presentation**

- P7: B. McLain, D. Lee, **I. Kang**, A. Young, EMG-informed neuromusculoskeletal model for knee joint load estimation with a powered knee exoskeleton during inclined walking, *American Society of Biomechanics Annual Conference*, August 2020
- P6: A. Groff, S. Thai, **I. Kang**, H. Hsu, A. Young, Control Strategies of a Powered Assist Hip Exoskeleton in Subject with Stroke, *American Academy of Orthotists & Prosthetists Conference*, March 2019
- P5: **I. Kang**, A. Young, Understanding the Optimal Assistance Levels for Human Augmentation Using Robotic Hip Exoskeletons, *The Career, Research, and Innovation Development Conference*, February 2019
- P4: P. Kunapuli, **I. Kang**, A. Young, Neural Network Based Estimation of Gait Phase in a Powered Hip Exoskeleton, *Biomedical Engineering Society Conference*, October 2018
- P3: EC. Kwak, D. Lee, **I. Kang**, A. Young, The Effect of Powered Assistance on Uphill Human Walking Using a Robotic Knee Exoskeleton, *Biomedical Engineering Society Conference*, October 2018
- P2: C. Kilpatrick, SE. Lee, **I. Kang**, H. Hsu, L. Childers, A. Young, Investigating the Impact of Hip Exoskeleton User Interface on User Comfort and Metabolic Cost, *American Academy of Orthotists & Prosthetists Conference*, February 2018
- P1: **I. Kang**, H. Hsu, D. Lee, A. Young. Robotic Human Augmentation using Exoskeleton Devices, *NextFlex Workshop: Powering the Internet of Everything*, November 2017

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### **PATENTS**

- U.S. Patent 63,046,956: "Powered Bilateral Knee Exoskeleton" – Filed July 1, 2020

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### **CONTRIBUTED RESEARCH FUNDING**

- National Science Foundation: National Robotics Initiative Award *Aug 2018*
  - Title: Robotic Human Enhancement Enabled through Wearable Hip Exoskeletons Capable of Community Ambulation
- National Institute of Health: R03 New Investigator Award *Apr 2019*
  - Title: Improving Community Ambulation for Stroke Survivors using Powered Hip Exoskeletons with Adaptive Environmental Controllers

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### **AWARDS AND HONORS**

- Outstanding Capstone Research Award, P&O Research Symposium *2018*

- Best Poster Award, AAOP Conference 2018
- Highest honor upon graduation for bachelor's degree 2016
- Georgia Tech Korean Student Association Scholarship 2015

## OUTREACH PROGRAM

- National Robotics Week, Georgia Tech 2017 – Present

## MENTORING

- Gayeon Choi, PURA Program, Georgia Tech Spring 2021
- James Joh, PURA Program, Georgia Tech Spring 2021
- Reese Peterson, MSME, Georgia Tech 2020 - Present
- Julian Park, MSME, Georgia Tech 2019 – Present
- Henry Luk, MSME, Georgia Tech 2019 – 2020
- Srijan Duggal, PURA Program, Georgia Tech Fall 2020
- Emily Keller, NSF SURE Program, NCSU Summer 2019
- Dawit Lee, MSME, Georgia Tech 2017 – 2018
- Hsiang Hsu, MSME, Georgia Tech 2017 – 2019
- Michael Groff, MSCS, Georgia Tech 2019
- Bailey McLain, Petit Scholar Program, Georgia Tech 2019
- Michelle Myrick, Petit Scholar Program, Georgia Tech 2017
- Harnjoo Kim, PURA Program, Georgia Tech Spring 2019
- Pratik Kunapuli, PURA Program, Georgia Tech Summer 2018
- Joonho Seo, PURA Program, Georgia Tech (Now in NAVER Labs) Spring 2017
- Alice Zou, NSF SURE Program, Johns Hopkins University Summer 2017

## PROFESSIONAL MEMBERSHIPS AND SERVICES

- Student Member, ASME 2013 – Present
- Student Member, IEEE 2018 – Present
- Member, Pi Tau Sigma 2014 – Present
- Reviewer, IEEE Robotics and Automation Letters 2019 – Present
- Reviewer, IEEE Transactions on Mechatronics 2018 – Present
- Reviewer, IEEE Transactions on Robotics 2018 – Present
- Reviewer, IEEE Transactions on Biomedical Engineering 2017 – Present
- Reviewer, IEEE Transactions on Medical Robotics and Bionics 2019 – Present
- Reviewer, IEEE Transactions on Neural Systems and Rehabilitation Engineering 2020 – Present
- Reviewer, Frontiers in Neurorobotics 2018 – Present
- Reviewer, President's Undergraduate Research Award, Georgia Tech 2017 - Present
- Mentor, Petit Undergraduate Research Scholars Program 2017 – 2019
- Member, Korean Scientist and Engineers Association 2014 – Present
- Organizer, KSEA Ygnite Conference 2015, 2016, 2020, 2021