Seunghoon Hwang, Ph.D.

Rehabilitation Robotics, Human-Robot Interaction, Safety-Critical Control, Exoskeleton Robot

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Education

Arizona State University *USA*

Postdoctoral Researcher *2021 - Current*

- Advisor: Dr. Hyunglae Lee (Arizona State University) and Dr.Sze Zheng Yong (Northeastern University)

HANYANG UNIVERSITY *South Korea*

PhD MECHATRONICS ENGINEERING *2017 - 2020*

- Advisor: Dr. Changsoo Han

HANYANG UNIVERSITY *South Korea*

MS Interdisciplinary Engineering Systems *2015 - 2017*

- Advisor: Dr. Changsoo Han

HANYANG UNIVERSITY *South Korea*

BS MECHANICAL ENGINEERING *2009 - 2015*

Publications

Journal Papers - Published

[J1] **S Hwang**[†], C Dongjune [†], A Saxena, E Oleen, SL Paing, J Atkins, and H Lee. "Characterization of Human Shoulder Joint Stiffness across 3D Arm Postures and its Sex Differences." IEEE Transactions on Biomedical Engineering (2024).

[J2] **S Hwang**, L Seungchan, S Dongbin, B Inhyuk, H Seoyeon, K Wansoo. 2022. Development of a Prototype Overground Pelvic Obliquity Support Robot for Rehabilitation of Hemiplegia Gait. Sensors 22.7 (2022): 2462.

[J3] Baek, I., Shin, K., Kim, H., **Hwang, S.**, Demeester, E.,Kang, M. S. (2021). Pre-grasp manipulation planning to secure space for power grasping. Ieee Access, 9, 157715-157726.

[J4] D Sun, **Hwang, S. H.**, J Han. 2021. Lever Control for Position Control of a Typical Excavator in Joint Space Using a Time Delay Control Method. Journal of Intelligent and Robotic Systems 102 (3), 1-16 (First author: equally contributed

[J5] **Hwang, SH**, Sun, DI, Han JK, Kim WS. 2021. Gait pattern generation algorithm for lower-extremity rehabilitation–exoskeleton robot considering wearer's condition. Intelligent Service Robotics (2021): 1-11.

[J6] D Shin, S Lee,**Hwang, S. H.**[*]. 2021. Locomotion Mode Recognition Algorithm Based on Gaussian Mixture Model Using IMU Sensors. Sensors 21 (8), 2785 (Corresponding author)

[J7] D Sun, I Baek, **S Hwang.**, S Lee, SK Lee, S Jang, C Han. 2020. Sensor-based straight-line control of the end-point of a typical retrofitted hydraulic excavator. Automation in Construction 120, 103385.

[J8] Sun, D., **Hwang, S.**, Kim, B., Ahn, Y., Lee, J., Han, J. (2020). Creation of one excavator as an obstacle in c-space for collision avoidance during remote control of the two excavators using pose sensors. Remote Sensing, 12(7), 1122.

[J9] **Hwang, S. H.**, et al. 2019. Intuitive gait pattern generation for an exoskeleton robot. International Journal of Precision Engineering and Manufacturing 20.11 (2019): 1905-1913.

[J10] Sung, J., Choi, S., Kim, H., Lee, G., Han, **Hwang, S. H.**, et al. 2017. Feasibility of rehabilitation training with a newly developed, portable, gait assistive robot for balance function in hemiplegic patients. Annals of rehabilitation medicine, 41(2), 178.

[J11] Moon, S. B., Ji, Y. H., Jang, H. Y., **Hwang, S. H.**, et al. 2017. Gait analysis of hemiplegic patients in ambulatory rehabilitation training using a wearable lower-limb robot: A pilot study. International Journal of Precision Engineering and Manufacturing, 18(12), 1773-1781.

In Review

[J12] **Hwang, Seunghoon**, Tarun Pati, Aditya Saxena, Hyunglae Lee, Sze Zheng Yong "Safe Variable Stiffness Control for Shoulder Exoskeleton Robots." IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY (2024).

Conference Papers

[C1] **Hwang, S.** et al. "CHARACTERIZATION OF HUMAN SHOULDER JOINT STIFFNESS ACROSS VARIOUS ARM POSTURES AND ITS SEX DIFFERENCES", American Society of Biomechanics, ASB, 2024.

[C2] **Hwang, S.**, Edward Chan, Hyunglae Lee. "Quantification of Shoulder Joint Impedance during Dynamic Motion: A Pilot Study Using a Parallel-Actuated Shoulder Exoskeleton Robot", 21st International Conference on Ubiquitous Robots (UR), IEEE, 2024.

[C3] Pati, T.$^{+}$, **Hwang, S.**$^{+}$ and Yong, S.Z. Control Barrier Functions for Linear Continuous-Time Input-Delay Systems with Limited-Horizon Previewable Disturbances. 2024 American Control Conference (ACC). IEEE, 2024. (First author equally contributed)

[C4] Tarun Pati^{+}, **Hwang, S.H.**$^{+}$, Sze Zheng Yong. 2023. Preview Control Barrier Functions for Linear Continuous-Time Systems with Previewable Disturbances. 2023 European Control Conference (ECC). IEEE, 2023. (First author equally contributed)

[C5] **S. Hwang**, D. Chang, A. Saxena, H. Lee, "Feasibility study for the quantification of intact human shoulder joint stiffness in various 3D arm postures with relaxed muscles," NSF DARE Conference, Los Angeles, CA, April 2023

[C6] Seoyeon Ham, Brian Byunghyun Kang, Jihoo Kim, **Seunghoon Hwang**, Wansoo Kim. Development of soft variable stiffness actuator with tendon-driven layer jamming mechanism. 2022 9th IEEE RAS/EMBS International Conference for Biomedical Robotics and Biomechatronics (BioRob)

In Review

[C7] **Hwang, S.**, Pati, T., Lee H., Yong, S.Z. "Preventing Ankle Sprain: Integrating Preview Control Barrier Functions with Human Movement Primitive Prediction" IFAC Workshop on Cyber-Physical Human Systems (CPHS). IFAC, 2024.

[C8] Pati, T.$^{+}$, **Hwang, S.**$^{+}$ and Yong, S.Z. "Robust Control Barrier Functions with Limited-Horizon Preview for Linear Continuous-Time Input-Delay Systems" 2024 Conference on Decision and Control (CDC). IEEE, 2024. (First author equally contributed)

[C9] Pati, T., **Hwang, S.** and Yong, S.Z. "Limited Preview Control Barrier Functions for Linear Continuous-Time Nonlinear Systems with Input Delays" 2024 Conference on Decision and Control (CDC). IEEE, 2024.

Workshop Papers

[W1] **Hwang, S.**, Tarun Pati, Aditya Saxena, Hyunglae Lee, Sze Zheng Yong. "Safe Variable Stiffness Control for Shoulder Exoskeleton Robot", 6th Ergonomic Physical Human-Robot Collaboration: Harnessing Advancements in Robot Learning at IROS 2023.

[W2] **Hwang, S.**$^{+}$, Donggyu Lee^{+}, Aditya Saxena, Wansoo Kim. Generation of Human Motion Trajectories Maintaining Overloading Joint Torque Within Safe Limits", 6th Ergonomic Physical Human-Robot Collaboration: Harnessing Advancements in Robot Learning at IROS 2023.

Patents

[P5] Crain Type of Mobile Robot System for Gait Assist of Lower Paralytic(P20170781OP)

[P4] Development of Assist Mechanism of Passive Upper Limb Exoskeleton for Lifting a Particular Weight(P20170262OP)

[P3] Exoskeleton Passive Mechanism for Support of Ankle Strength(P20170865OP)

[P2] Linkage Type of Mobile Robot System for Gait Assist of Lower Paralytic(P20170783OP)

[P1] SEA Module Type of Mobile Robot System for Gait Assist of Lower Paralytic(P20170782OP)

Awards, Fellowships, & Grants

2021	**Biomedical Engineering Global Talent Training Grant**, Korea Health Industry Development Institute	*$ 81,000*
2016	**Graduate School of Convergence Systems Department Creative Convergence Talent Scholarship**, Hanyang University	
2015	**Graduate School of Convergence Systems Department Creative Convergence Talent Scholarship**, Hanyang University	

Research Project Experiences

[R8] Smart User-Effective Data-Enabled (SUEDE) Shoe for Ankle Injury Prevention. *United States, Sponsor: NIH*

Objective: Design and evaluate a smart shoe system called "Smart User- Effective Data-Enabled (SUEDE) Shoe" for ankle injury prevention. *2023-*

Supervisor: Dr. Hyunglae Lee and Dr. Sze Zheng Yong

[R7] User-Adaptive and Safe Control of a Wearable Upper-Extremity Exoskeleton Robot. *United States, Sponsor: NSF*

Objective: Develop an exoskeleton robot for the upper extremity for alleviating the potential for fatigue-related injuries during highly repetitive motions. *2022-2023*

Supervisor: Dr. Hyunglae Lee and Dr. Sze Zheng Yong

[R6] A study on the framework for improving the mutual stability of humans and wearable robots. *KOREA SOUTH*

Objective: Develop the robotic controller considered ergonomics metric to prevent work-related musculoskeletal disorders *2021*

Supervisor: Dr. Wansoo Kim

[R5] Development of artificial intelligence-based stability and active walking judgment technology. *Gyeonggi Provincial Government, KOREA SOUTH*

Objective: Develop a methodology to improve gait stability by identifying conditions prior to a fall while walking. *2019 - 2020*

Supervisor: Dr. Jeakweon Han

[R4] Collaborative research to develop integrated precision rehabilitation solutions for healthy living. *KISTEP, KOREA SOUTH*

Objective: Research assignment to design a government research grant to improve the lives of people through rehabilitation. *2017-2018*

Supervisor: Dr. Changsoo Han

[R3] Development of exoskeleton robots capable of gait rehabilitation/assistance for paralyzed patients. *COMPA, KOREA SOUTH*

Objective: Design the lower-extremity exoskeleton robot and implement a control algorithm to assist gait for stroke patients. *2016-2017*

Supervisor: Dr. Changsoo Han

[R2] Development of a Lightweight Knee Rehabilitation Device. *National Research Foundation of Korea, KOREA SOUTH*

Objective: Developing a lightweight knee rehabilitation device for knee rehabilitation in a variety of situations. *2015-2016*

Supervisors: Dr. Changsoo Han

[R1] Development of rehabilitation ankle module robots to prevent hemipleic patients foot drop. *Korea Association of University, Research Institute and Industry, KOREA SOUTH*

Objective: Develop a tendon-driven ankle module robot to prevent foot drop in stroke patients during walking. *2015-2016*

Supervisors: Dr. Mijeong Kim, Dr. Changsoo Han

Teaching Experience

Fall 2018	**Research Assistant**, ABEEK (Accreditation Board for Engineering Education of Korea) Assistant	*Hanynag University*
Spring 2018	**Research Assistant**, ABEEK Assistant	*Hanynag University*
Fall 2017	**Teaching Assistant**, Robotics Capstone Design	*Hanynag University*
Spring 2017	**Teaching Assistant**, Introduction to Robotics	*Hanynag University*
Fall 2016	**Teaching Assistant**, Basic Robotics Experiments	*Hanynag University*
Spring 2016	**Teaching Assistant**, Introduction to Basic Robotics	*Hanynag University*

Mentoring

2024	**Edward Chan**, Project title: Quantification of Shoulder Joint Impedance During Dynamic Motion: A Pilot Study Using a Parallel-Actuated Shoulder Exoskeleton Robot. (Mentor)	*Arizona State University*
2024	**Ellory Oleen**, Thesis title: Patient-Adaptive Robotic Balance Training for Lower-Extremity Stroke Rehabilitation. (2nd Committee)	*Arizona State University*
2022-2023	**Aditya Saxena (now at Carl Zeiss Group)**, Thesis title: Quantification of Shoulder Stiffness at Various Arm Postures using a 4-Bar Parallel Exoskeleton Robot. (Mentor)	*Arizona State University*
2021	**Seoyeon Ham (now at UIUC)**, Paper title: Development of soft variable stiffness actuator with tendon-driven layer jamming mechanism. (Mentor)	*Hanyang University*

Invited Talks

Sep, 2023	**Safety Impedance Controller for Exoskeleton Robot User**, Hanyang University	*South Korea*
June, 2021	**Introduction to Rehabilitation Exoskeleton Robot Control**, Yonsei Severance Hospital	*South Korea*

PROFESSIONAL ACTIVITIES

Reviewer

IEEE International Conference on Robotics and Automation (ICRA)

IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)

IEEE Conference on Decision and Control (CDC)

International Conference on Biomedical Robotics and Biomechatronics (BioRob)

IEEE International Conference on Robotics and Biomimetics (ROBIO)

IEEE International Conference on Advanced Robotics and Its Social Impacts (ARSO)

IEEE Transactions on Human-Machine Systems

Skills

Skills **ROS, Labview, Matlab, SPSS, Python, Vicon Nexus, Experiment with Human Subjects**