Prof. Wansoo Kim

Personal Data

Name:	Wansoo Kim | Ph.D.
Place and Date of Birth:	Bucheon-si, Gyeonggi-do, South Korea | January 02 1986
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Research Interests

Wansoo Kim received the B.S. degree in mechanical engineering from Hanyang University ERICA campus, Korea in 2008 and PhD degree in mechanical engineering from Hanyang University, Korea in 2015 (Integrated MS/PhD program). He was a post-doctoral researcher at Human-Robot Interfaces and Physical Interaction Lab, Istituto Italiano di Tecnologia (IIT), Italy from 2016 to 2021. He is an assistant professor with Robotics Department, Hanyang University ERICA, Republic of Korea. He has developed several exoskeleton systems and collaborative robot (Cobot), and conducted research on the control of the powered exoskeleton robot and ergonomics collaboration control with Cobot through the physical human-robot interaction (pHRI) knowledge. He was involved in a Horizon-2020 project SOPHIA (No. 871237) and an European Research Council project Ergo-lean (No. 850932). He has contributed to several projects in the field of exoskeleton robot in Korean projects (Development of Wearable Robot for Industrial Labor Support, etc.) He was the winner of the Solution Award 2019, the winner of the KUKA Innovation Award 2018, of the HYU best PhD paper award 2015, and of the ICCAS best presentation award 2014. His research interests are in Physical human-robot interaction (pHRI), human-robot collaboration, Shared Control, Ergonomics, Human modelling, Feedback devices, and powered exoskeleton robot.

Scientific Education

Feb. 2015	Doctor of Philosophy in Mechanical Engineering **Hanyang University**, Seoul, Republic of Korea Thesis:"Human Synchronized Gait Control of the HEXAR-CR50 to Augment Lowe Body Strength Based on the Human-Robot Interaction Force" Advisor: Prof. Changsoo Han
03/2008–02/2015	PhD student at Hanyang University | Integrated M.S./Ph.D. Program
Feb. 2008	Bachelor of Science in Mechanical Engineering **Hanyang University** ERICA Campus, Ansan-si, Gyeonggi-do, Republic of Korea
03/2004–02/2008	Studies of Mechanical Engineering at Hanyang University

Research Experience

since March 2021	Assistant Professor at Robotics Department,**Hanyang University ERICA**, Republic of Korea • Research on the human robot collaboration
05/2016–02/2021	Post-Doc. at Human-Robot Interface and Physical Interaction(HRI^2) Lab, Dr. Arash Ajoudani, **Istituto Italiano di Tecnologia (IIT)**, Italy • Research on the anticipatory robot assistance technique for the prevention of human joint overloading in human-robot collaboration
03/2015–05/2016	Post-Doc. at Research Institute of Engineering & Technology, Prof. Changsoo Han, **Hanyang University** ERICA Campus, Republic of Korea • Research on the performance index of the exoskeleton robot
03/2008–02/2015	Research Assistant at Cim & Robotics Lab, Prof. Changsoo Han, **Hanyang University**, Republic of Korea • Developed a lower-limb exoskeleton robot for soldiers & labor power augmentation (HEXAR-CR & HL series)
08/2006–02/2008	Intern researcher at Cim & Robotics Lab., Prof. Changsoo Han, **Hanyang University**, Republic of Korea

Publications

International Journals

[1] Marta Lorenzini, **Wansoo Kim**, and Arash Ajoudani. "An Online Multi-Index Approach to Human Ergonomics Assessment in the Workplace". In: *IEEE Transactions on Human-Machine Systems* (2022), pp. 1–12. DOI: 10.1109/THMS.2021.3133807.

[2] Seung Hoon Hwang, Dong Ik Sun, Jeakweon Han, and **Wan-Soo Kim**. "Gait pattern generation algorithm for lower-extremity rehabilitation–exoskeleton robot considering wearer's condition". In: *Intelligent Service Robotics* (2021), pp. 1–11. DOI: 10.1007/s11370-020-00346-3.

[3] **Wansoo Kim**, Virginia Ruiz Garate, Juan Manuel Gandarias, Marta Lorenzini, and Arash Ajoudani. "A Directional Vibrotactile Feedback Interface for Ergonomic Postural Adjustment". In: *IEEE Transactions on Haptics* (2021). DOI: 10.1109/TOH.2021.3112795.

[4] **Wansoo Kim**, Luka Peternel, Marta Lorenzini, Jan Babic, and Arash Ajoudani. "A Human-Robot Collaboration Framework for Improving Ergonomics During Dexterous Operation of Power Tools". In: *Robotics and Computer-Integrated Manufacturing* 68 (2021), p. 102084. ISSN: 0736-5845. DOI: https://doi.org/10.1016/j.rcim.2020.102084.

[5] Leonardo Ventura, Marta Lorenzini, **Wansoo Kim**, and Arash Ajoudani. "A Flexible Robotics-Inspired Computational Model of Compressive Loading on the Human Spine". In: *IEEE Robotics and Automation Letters* 6.4 (2021), pp. 8229–8236. DOI: 10.1109/LRA.2021.3100936.

[6] Yuqiang Wu, Edoardo Lamon, Fei Zhao, **Wansoo Kim**, and Arash Ajoudani. "Unified Approach for Hybrid Motion Control of MOCA Based on Weighted Whole-Body Cartesian Impedance Formulation". In: *IEEE Robotics and Automation Letters* 6.2 (2021), pp. 3505–3512. DOI: 10.1109/LRA.2021.3062316.

[7] Ho-Jun Kim, Dong-Hwan Lim, **Wan-Soo Kim**, and Chang-Soo Han. "Development of a Passive Modular Knee Mechanism for a Lower Limb Exoskeleton Robot and Its Effectiveness in the Workplace". In: *International Journal of Precision Engineering and Manufacturing* 21.2 (2020), pp. 227–236. DOI: 10.1007/s12541-019-00217-7.

[8] Marta Lorenzini, **Wansoo Kim**, Elena De Momi, and Arash Ajoudani. "An Online Method to Detect and Locate an External Load on the Human Body with Applications in Ergonomics Assessment". In: *Sensors* 20.16 (2020), p. 4471. DOI: 10.3390/s20164471.

[9] Yuqiang Wu, Fei Zhao, **Wansoo Kim**, and Arash Ajoudani. "An Intuitive Formulation of the Human Arm Active Endpoint Stiffness". In: *Sensors* 20.18 (2020), p. 5357. DOI: 10.3390/s20185357.

[10] Sang-Ho Kim, Yong-Seok Lee, Dong-Ik Sun, Sang-Keun Lee, Bo-Hyun Yu, Sung-Hoon Jang, **Wansoo Kim**, and Chang-Soo Han. "Development of bulldozer sensor system for estimating the position of blade cutting edge". In: *Automation in Construction* 106 (2019), p. 102890. DOI: 10.1016/j.autcon.2019.102890.

[11] **Wansoo Kim**, Marta Lorenzini, Pietro Balatti, Phuong DH Nguyen, Ugo Pattacini, Vadim Tikhanoff, Luka Peternel, Claudio Fantacci, Lorenzo Natale, Giorgio Metta, and Arash Ajoudani. "Adaptable workstations for human-robot collaboration: A reconfigurable framework for improving worker ergonomics and productivity". In: *IEEE Robotics & Automation Magazine* 26.3 (2019), pp. 14–26. DOI: 10.1109/MRA.2018.2890460.

[12] Yuqiang Wu, Pietro Balatti, Marta Lorenzini, Fei Zhao, **Wansoo Kim**, and Arash Ajoudani. "A Teleoperation Interface for Loco-Manipulation Control of Mobile Collaborative Robotic Assistant". In: *IEEE Robotics and Automation Letters* 4.4 (2019). presented in IROS 2019, pp. 3593–3600. DOI: 10.1109/LRA.2019.2928757.

[13] **Wansoo Kim**, Jinoh Lee, Luka Peternel, Nikos Tsagarakis, and Arash Ajoudani. "Anticipatory Robot Assistance for the Prevention of Human Static Joint Overloading in Human–Robot Collaboration". In: *IEEE Robotics and Automation Letters* 3.1 (2018). presented in IROS 2017, pp. 68–75. DOI: 10.1109/LRA.2017.2729666.

[14] **Wansoo Kim**, Marta Lorenzini, Elena De Momi, and Arash Ajoudani. "A Synergistic Approach to the Real-Time Estimation of the Feet Ground Reaction Forces and Centers of Pressure in Humans With Application to Human–Robot Collaboration". In: *IEEE Robotics and Automation Letters* 3.4 (2018), pp. 3654–3661. DOI: 10.1109/LRA.2018.2855802.

[15] **Wansoo Kim**, Marta Lorenzini, Kagan Kapıcıoglu, and Arash Ajoudani. "Ergotac: A tactile feedback interface for improving human ergonomics in workplaces". In: *IEEE Robotics and Automation Letters* 3.4 (2018). presented in IROS 2018, pp. 4179–4186. DOI: 10.1109/LRA.2018.2864356.

[16] Dong-Hwan Lim, **Wan-Soo Kim**, Ho-Jun Kim, and Chang-Soo Han. "Development of real-time gait phase detection system for a lower extremity exoskeleton robot". In: *International Journal of Precision Engineering and Manufacturing* 18.5 (2017), pp. 681–687. DOI: 10.1007/s12541-017-0081-9.

[17] Seungnam Yu, Heedon Lee, **Wansoo Kim**, and Changsoo Han. "Development of an underactuated exoskeleton for effective walking and load-carrying assist". In: *Advanced Robotics* 30.8 (2016), pp. 535–551. DOI: 10.1080/01691864.2015.1135080.

[18] **WS Kim**, HD Lee, DH Lim, JS Han, KS Shin, and Chang-Soo Han. "Development of a muscle circumference sensor to estimate torque of the human elbow joint". In: *Sensors and Actuators A: Physical* 208 (2014), pp. 95–103. DOI: 10.1016/j.sna.2013.12.036.

[19] Hee-Don Lee, Byeong-Kyu Lee, **Wan-Soo Kim**, Jung-Soo Han, Kyoo-Sik Shin, and Chang-Soo Han. "Human–robot cooperation control based on a dynamic model of an upper limb exoskeleton for human power amplification". In: *Mechatronics* 24.2 (2014), pp. 168–176. DOI: 10.1016/j.mechatronics.2014.01.007.

[20] Heedon Lee, **Wansoo Kim**, Jungsoo Han, and Changsoo Han. "The technical trend of the exoskeleton robot system for human power assistance". In: *International Journal of Precision Engineering and Manufacturing* 13.8 (2012), pp. 1491–1497. DOI: 10.1007/s12541-012-0197-x.

[21] Heedon Lee, Byeongkyu Lee, **Wansoo Kim**, Myeongsoo Gil, Jungsoo Han, and Changsoo Han. "Human-robot cooperative control based on pHRI (Physical Human-Robot Interaction) of exoskeleton robot for a human upper extremity". In: *International Journal of Precision Engineering and Manufacturing* 13.6 (2012), pp. 985–992. DOI: 10.1007/s12541-012-0128-x.

[22] A Reum Seo, Hye Youn Jang, **Wan-Soo Kim**, Chang Soo Han, and Jung Soo Han. "Development and verification of a volume sensor for measuring human behavior". In: *International Journal of Precision Engineering and Manufacturing* 13.6 (2012), pp. 899–904. DOI: 10.1007/s12541-012-0117-0.

[23] SN Yu, HD Lee, SH Lee, **WS Kim**, JS Han, and Chang-Soo Han. "Design of an underactuated exoskeleton system for walking assist while load carrying". In: *Advanced Robotics* 26.5-6 (2012), pp. 561–580. DOI: 10.1163/156855311X617506.

International Conferences

[1] Luca Fortini, Marta Lorenzini, **Wansoo Kim**, Elena De Momi, and Arash Ajoudani. "A Real-time Tool for Human Ergonomics Assessment based on Joint Compressive Forces". In: *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. IEEE, pp. 1164–1170. DOI: 10.1109/RO-MAN47096.2020.9223565.

[2] Emir Mobedi, Nicola Villa, **Wansoo Kim**, and Arash Ajoudani. "An Adaptive Control Approach to Robotic Assembly with Uncertainties in Vision and Dynamics". In: *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. IEEE, pp. 144–150. DOI: 10.1109/RO-MAN47096.2020.9223515.

[3] Emir Mobedi, **Wansoo Kim**, Elena De Momi, Nikos G Tsagarakis, and Arash Ajoudani. "A Soft Assistive Device for Elbow Effort-Compensation". In: *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2021, pp. 9540–9547. DOI: 10.1109/IROS51168.2021.9636771.

[4] Luca Fortini, Marta Lorenzini, **Wansoo Kim**, Elena De Momi, and Arash Ajoudani. "A Framework for Real-time and Personalisable Human Ergonomics Monitoring". In: *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2020, pp. 11101–11107. DOI: 10.1109/IROS45743.2020.9341560.

[5] **Wansoo Kim**, Pietro Balatti, Edoardo Lamon, and Arash Ajoudani. "MOCA-MAN: A MObile and reconfigurable Collaborative Robot Assistant for conjoined huMAN-robot actions". In: *2020 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE. 2020, pp. 10191–10197. DOI: 10.1109/ICRA40945.2020.9197115.

[6] Edoardo Lamon, Fabio Fusaro, Pietro Balatti, **Wansoo Kim**, and Arash Ajoudani. "A visuo-haptic guidance interface for mobile collaborative robotic assistant (MOCA)". In: *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2020, pp. 11253–11260. DOI: 10.1109/IROS45743.2020.9341357.

[7] Edoardo Lamon, Mattia Lenori, **Wansoo Kim**, and Arash Ajoudani. "Towards an Intelligent Collaborative Robotic System for Mixed Case Palletizing". In: *2020 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE. 2020, pp. 9128–9134. DOI: 10.1109/ICRA40945.2020.9196850.

[8] **Wansoo Kim**, Marta Lorenzini, Pietro Balatti, Yuqiang Wu, and Arash Ajoudani. "Towards Ergonomic Control of Collaborative Effort in Multi-human Mobile-robot Teams". In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2019, pp. 3005–3011. DOI: 10.1109/IROS40897.2019.8967628.

[9] Marta Lorenzini, Fabio Fusaro, Pietro Balatti, Elena De Momi, Fulvio Mastrogiovanni, **Wansoo Kim**, and Arash Ajoudani. "Toward a Synergistic Framework for Human-Robot Coexistence and Collaboration (HRC2)". In: *Institute for Robotics and Intelligent Machines Conference (I-RIM)*. 2019, N–A. URL: http://hdl.handle.net/11311/1119859.

[10] Marta Lorenzini, **Wansoo Kim**, Elena De Momi, and Arash Ajoudani. "A New Overloading Fatigue Model for Ergonomic Risk Assessment with Application to Human-Robot Collaboration". In: *2019 International Conference on Robotics and Automation (ICRA)*. IEEE. 2019, pp. 1962–1968. DOI: 10.1109/ICRA.2019.8794044.

[11] Marta Lorenzini, **Wansoo Kim**, Elena De Momi, and Arash Ajoudani. "A Learning-based Approach to the Real-time Estimation of the Feet Ground Reaction Forces and Centres of Pressure in Humans". In: *Sixth National Congress of Bioengineering*. 2018.

[12] Marta Lorenzini, **Wansoo Kim**, Elena De Momi, and Arash Ajoudani. "A Real-time Graphic Interface for the Monitoring of the Human Joint Overloadings with Application to Assistive Exoskeletons". In: *International Symposium on Wearable Robotics*. Springer. 2018, pp. 281–285. DOI: 10.1007/978-3-030-01887-0_54.

[13] **Wansoo Kim**, Hojun Kim, Donghwan Lim, Hyungi Moon, and Changsoo Han. "Design and Kinematic Analysis of the Hanyang Exoskeleton Assistive Robot (HEXAR) for Human Synchronized Motion". In: *Wearable Robotics: Challenges and Trends*. Springer, 2017, pp. 275–279. DOI: 10.1007/978-3-319-46532-6_45.

[14] **Wansoo Kim**, Jinoh Lee, Nikos Tsagarakis, and Arash Ajoudani. "A Real-time and Reduced-Complexity Approach to the Detection and Monitoring of Static Joint Overloading in Humans". In: *Rehabilitation Robotics (ICORR), 2017 International Conference on*. London, UK: IEEE, 2017, pp. 828–834. ISBN: 9781538622957. DOI: 10.1109/ICORR.2017.8009351.

[15] **Wansoo Kim**, Luka Peternel, Jan Babic, and Arash Ajoudani. "Towards ergonomic control of human-robot co-manipulation and handover". In: *2017 IEEE-RAS 17th International Conference on Humanoid Robotics (Humanoids)*. 2017, pp. 55–60. DOI: 10.1109/HUMANOIDS.2017.8239537.

[16] **Wansoo Kim**, Donghwan Lim, Hyungi Moon, and Changsoo Han. "A Synchronization Index for Enhanced Human-Exoskeleton Interaction". In: *International Workshop on Human-Friendly Robotics, HFR 2016*. 2016.

[17] Ho Jun Kim, Hee Don Lee, **Wan-Soo Kim**, Dong Hwan Lim, and Chang Soo Han. "Design of roller-cam clutch mechanism for energy efficiency and high backdrivability of lower extremity exoskeleton". In: *Control, Automation and Systems (ICCAS), 2015 15th International Conference on*. IEEE. 2015, pp. 1144–1148. DOI: 10.1109/ICCAS.2015.7364799.

[18] Donghwan Lim, **Wansoo Kim**, Heedon Lee, Hojun Kim, Kyoosik Shin, Taejoon Park, JiYeong Lee, and Changsoo Han. "Development of a lower extremity Exoskeleton Robot with a quasi-anthropomorphic design approach for load carriage". In: *Intelligent Robots and Systems (IROS), 2015 IEEE/RSJ International Conference on*. IEEE. 2015, pp. 5345–5350. DOI: 10.1109/IROS.2015.7354132.

[19] **Wansoo Kim**, Heedon Lee, Donghwan Kim, Jungsoo Han, and Changsoo Han. "Mechanical design of the hanyang exoskeleton assistive robot (hexar)". In: *Control, Automation and Systems (ICCAS), 2014 14th International Conference on*. IEEE. 2014, pp. 479–484. DOI: 10.1109/ICCAS.2014.6988049.

[20] **WS Kim**, HD Lee, DH Lim, JS Han, and CS Han. "Development of the Hanyang Exoskeleton Assistive Robot (HEXAR) to Enhance Lower Body Strength". In: *International Workshop on Wearable Robotics, WeRob 2014*. 2014.

[21] **WS Kim**, HD Lee, DH Lim, CS Han, JS Han, et al. "Development of a lower extremity exoskeleton system for walking assistance while load carrying". In: *Proceedings of the Sixteenth International Conference on Climbing and Walking Robots*. 2013, pp. 35–42. DOI: 10.1142/9789814525534_0008.

[22] Kisung Kim, Kwangjin Ko, **Wansoo Kim**, Seungnam Yu, and Changsoo Han. "Performance comparison between neural network and SVM for terrain classification of legged robot". In: *SICE Annual Conference 2010, Proceedings of*. IEEE. 2010, pp. 1343–1348. URL: https://ieeexplore.ieee.org/abstract/document/5602459.

[23] **Wansoo Kim**, Seunghoon Lee, Minsung Kang, Jungsoo Han, and Changsoo Han. "Energy-efficient gait pattern generation of the powered robotic exoskeleton using DME". In: *Intelligent Robots and Systems (IROS), 2010 IEEE/RSJ International Conference on*. IEEE. 2010, pp. 2475–2480. DOI: 10.1109/IROS.2010.5649235.

[24] Seunghoon Lee, **Wansoo Kim**, Minsung Kang, Jungsoo Han, and Changsoo Han. "Optimal gait pattern generation for powered robotic exoskeleton and verification of its feasibility". In: *RO-MAN, 2010 IEEE*. IEEE. 2010, pp. 500–505. DOI: 10.1109/ROMAN.2010.5598675.

[25] **Wan-soo Kim**, Seung-hoon Lee, Hee-don Lee, Seung-nam Yu, Jung-soo Han, and Chang-soo Han. "Development of the heavy load transferring task oriented exoskeleton adapted by lower extremity using qausi-active joints". In: *ICCAS-SICE, 2009*. IEEE. 2009, pp. 1353–1358. URL: https://ieeexplore.ieee.org/abstract/document/5335254.

Patents

[1] "Wearable Robot for Assisting Muscular Strength of Lower Extremity" C. S. Han, J. S. Han, J. H. Jang, S. N. Yu, H. D. Lee, S. H. Lee, **W. S. Kim** US patent, Patent application No. 8702632, Apr. 22, 2014, WO/2010/079862

Organisations

IEEE IROS 2020 Workshop	**W. Kim**, et al. "Ergonomic Human-Robot Collaboration: Opportunities and Challenges", link
IEEE IROS 2019 Workshop	**W. Kim**, et al. "Progress in Ergonomic Physical Human-Robot Collaboration", link
IEEE ICRA 2018 Workshop	**W. Kim**, et al. "Ergonomic Physical Human-Robot Collaboration", link

Awards

Sep. 2020	Best Paper Award Finalist, **IEEE ROMAN 2020**
Mar. 2019	Premio Innovazione Robotica 2019 (Solution Award in Robotics 2019) Winner, **Comitato Tecnico Scientifico, Italy**
Apr. 2018	KUKA Innovation Award Winner, Innovation Award 2018, **KUKA**
Feb. 2015	Best Ph.D Thesis Award, Graduate School, **Hanyang University**
Oct. 2014	Best Presentation Award, 2014 14th International Conference on Control, Automation, and Systems (ICCAS), **ICROS**
Jun. 2011	Best Paper Award, Korean Society for Precision Engineering (KSPE) 2011 Autumn Conference, **KSPE**
Nov. 2010	Best Paper Award, Korean Society for Precision Engineering (KSPE) 2010 Spring Conference, **KSPE**