

# Inrak Choi

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## Education

### Ph.D. in Mechanical Engineering

2016 – 2019

Stanford University (Stanford, CA)

- Thesis: Handheld Haptic Feedback for Grasping in Virtual Reality
- Thesis Committee: Sean Follmer (advisor), Mark Cutkosky, Allison Okamura, Ken Salisbury
- Cumulative GPA: 3.93 / 4.0

### M.S. in Mechanical Engineering

2013 - 2016

Stanford University (Stanford, CA)

- Concentration: Dynamics, Robotics, and Research (Haptics)
- Cumulative GPA: 3.95 / 4.0

### B.S. in Mechanical Engineering

2009 - 2013

Korea University (Seoul, Korea)

- Cumulative GPA: 4.23 / 4.5

## Professional Employment

### Systems Analyst (Robotic Algorithms and Control Engineer)

Dec 2022 – present

Intuitive Surgical, Inc. (Sunnyvale, CA)

Supervised by Saleh Tabandeh, Ph.D.

- Develop control algorithms to improve the performance and safety of Da Vinci Single Port.
- Measure and characterize the mechanical performance, such as friction and range of motion, of the new instruments and endoscope under development.
- Develop software that evaluates the performance of manufactured instruments
- Analyze the kinematic/dynamic/event data of the Da Vinci system in the field and the surgeon behavior to improve the instrument design and robot algorithm.

### Postdoctoral Research Fellow (Mandatory Military Service)

Nov 2019 – Nov 2022

Seoul National University Soft Robotics & Bionics Lab (Seoul, Korea)

Advised by Yong-Lae Park, Ph.D.

- This three-year research position replaces actual mandatory military service in South Korea. While I much focused on haptics in the PhD years, I developed various actuation and sensing mechanisms that can be widely applied to robots/devices.
- Designed pneumatic jamming-based cellular composites having exceptional strength/stiffness densities for selectively stiffening garments.
- Designed a submillimetre-thick linear three-phase electrostatic actuator package with a hybrid configuration with an electrostatic clutch. The actuator is also capable of noise-free high-resolution position sensing and proprioceptive force sensing utilizing the Moiré effect.
- Developed a robotic tadpole capable of agile escape maneuvers using an inertia-driven actuation.

**Graduate Research Assistant**

June 2015 – Sep 2019

Stanford University SHAPE Lab (Stanford, CA)

Advised by Sean Follmer, Ph.D.

- Developed handheld/wearable haptic interfaces using various novel kinesthetic and vibrotactile feedback mechanisms and investigated additional pseudo haptic effects through user studies for more realistic VR/AR interaction. Won several awards in top HCI conferences and filed six patents.
- Investigated passive & energy-dissipative mechanisms, such as jamming, braking, and clutching, for lightweight and power-efficient wearable haptic interfaces.
- Led multidisciplinary team collaboration with researchers at MIT Media Lab, Facebook Reality Labs, and Google Research, and Hyundai Motor Company.

**Research Intern**

Summer 2017

Microsoft Research (Redmond, WA)

- Mentor: Mike Sinclair, Hrvoje Benko, Ph.D., Eyal Ofek, Ph.D., Christian Holz, Ph.D.
- Developed a multifunctional VR haptic controller, CLAW, and quantitatively validated the effectiveness of the device in VR scenarios through human-subject studies. The work has been published to a top HCI conference, CHI, and patented.

**Research Intern**

Summer 2015

Hansen Medical, Inc. (Mountain View, CA)

Advised by June Park, Ph.D.

- Devised new active guidewire manipulation mechanisms for the Sensei robotic catheter system.
- Wrote two invention disclosures in three months then applied for a patent.

**Graduate Research Assistant**

Jan 2014 – May 2015

Stanford University Artificial Intelligence Laboratory (Stanford, CA)

Advised by Oussama Khatib, Ph.D.

- Human-friendly robot project. Designed and assembled a wrist and a gripper.
- Implemented macro-mini force control with the hybrid actuation system of pneumatic artificial muscles and electrical dc motors.

## Research Interests

I am interested in designing interfaces that can physically help people in their daily lives. Past projects include physical user interfaces for VR/AR/Automotive applications, human augmentation with robotic systems, and surgical robots. I often analyze the human perception and existing systems in nature and apply the results to interface design.

keywords: human-computer interaction, haptics, robotics

## Publications

Google Scholar: [https://scholar.google.com/citations?user=zHH\\_LwkAAAAJ&hl=ko&oi=ao](https://scholar.google.com/citations?user=zHH_LwkAAAAJ&hl=ko&oi=ao)

## Journal Articles

- [J.1] C. Ha\*, **I. Choi\***, J.-K. Lee, J. Oh, W. Ahn, and S.-H. Han. Anterolateral Dual Plate Fixation for Distal Metaphyseal Diaphyseal Junction Fracture of the Humerus: Biomechanical Finite Element Analysis with Clinical Results. *Clinics in Orthopedic Surgery*. 2024. (Accepted)  
**\* equally contributed.**
- [J.2] **I. Choi\***, S.J. Yoon\*, and Y.-L. Park. Linear electrostatic actuators with Moiré-effect optical proprioceptive sensing and electroadhesive braking. *International Journal of Robotics Research*. 2023.  
**\* equally contributed.**
- [J.3] G. Shin, Y.J. Choi, B.J. Jeon, **I. Choi**, S. Song, and Y.-L. Park. Soft Electromagnetic Artificial Muscles Using High-Density Liquid-Metal Solenoid Coils and Bistable Stretchable Magnetic Housings. *Advanced Functional Materials*. 2023.
- [J.4] B. Do, **I. Choi**, and S. Follmer. An All-Soft Variable Impedance Actuator Enabled by Embedded Layer Jamming. *IEEE/ASME Transactions on Mechatronics*. 2022.
- [J.5] J. Kwon\*, **I. Choi\***, M. Park, J. Moon, B. Jeong, P. Pathak, J. Ahn, and Y.-L. Park. Sandwich Jamming Structures with Cellular Cores and Rubber-Laminated Face Sheets for Assistive and Protective Wearables. *Advanced Materials Technologies*. 2022.  
**\* equally contributed.**
- [J.6] **I. Choi**, E. J. Gonzalez, and S. Follmer. Hybrid Actuation with Unidirectional Clutches for Handheld Haptic Controllers. *IEEE Robotics and Automation Letters*, 2021.
- [J.7] **I. Choi**, Y. Zhao, E. J. Gonzalez, and S. Follmer. Augmenting Perceived Softness of Haptic Proxy Objects through Transient Vibration and Visuo-Haptic Illusion in Virtual Reality. *IEEE Transactions on Visualization and Computer Graphics*, 2020.
- [J.8] A. Dementyev, J. Hernandez, **I. Choi**, S. Follmer, and J. Paradiso. 2018. Epidermal Robots: Wearable Sensors That Climb on the Skin. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2.3: 1-22, 2018. **Distinguished Paper Award (Top 4%)**
- [J.9] **I. Choi**, N. Corson, L. Peiros, E. W. Hawkes, S. Keller, and S. Follmer. A Soft, Controllable, High Force Density Linear Brake Utilizing Layer Jamming. *IEEE Robotics and Automation Letters*, 2018.

## Journal Articles (in preparation or under review)

- [J.10] S. J. Yoon\*, **I. Choi\***, and Y.-L. Park. Modeling Linear Sliding Electrostatic Motors with Skewing. *(Written for IEEE Transactions on Industrial Electronics)*  
**\* equally contributed.**
- [J.11] J. Choi\*, **I. Choi\***, S. J. Yoon\*, J. Kim, and Y.-L. Park. Inertia-Driven Swimming Robot with Agile Maneuvers Inspired by C-start Motion. *(In preparation for Science Robotics)*  
**\* equally contributed.**

- [J.12] **I. Choi**, S. Song, S. Chang, J. Cho, H. Yoo, T. Kim, K. Kim, S. Ahn, K.J. Cho, Y.-L. Park. Proprioception in Soft Actuators: A Review. (*In preparation*)

### Refereed Conference Articles

*\* Top conferences in the research area of Human Computer Interaction. Papers in these conferences have an acceptance rate of 15-25%, refereed by 4-5 experts.*

- [C.1] **I. Choi**, E. Ofek, H. Benko, M. Sinclair, and C. Holz. CLAW: A Multifunctional Handheld Haptic Controller for Grasping, Touching, and Triggering in Virtual Reality. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Montreal, QC, Canada, 2018. \*
- [C.2] **I. Choi**, H. Culbertson, M. R. Miller, A. Olwal, and S. Follmer. Gravity: A Wearable Haptic Interface for Simulating Weight and Grasping in Virtual Reality. In Proceedings of the 30th Annual ACM Symposium on User Interface Software & Technology, 2017. **Best Paper Award (Top 1%)** \*
- [C.3] H.-L. C. Kao, D. Ajilo, O. Anilonyte, A. Dementyev, **I. Choi**, S. Follmer, and C. Schmandt. Exploring interactions and perceptions of kinetic wearables. In Proceedings of the 2017 Conference on Designing Interactive Systems, 2017.
- [C.4] A. Dementyev, H.-L. C. Kao, **I. Choi**, D. Ajilo, M. Xu, J. A. Paradiso, C. Schmandt, and S. Follmer. Rovables: Miniature On-Body Robots as Mobile Wearables. In Proceedings of the 29th Annual ACM Symposium on User Interface Software & Technology, 2016. **Best Paper Award (Top 1%)** \*
- [C.5] **I. Choi**, E. W. Hawkes, D. L. Christensen, C. J. Ploch, and S. Follmer. Wolverine: A Wearable Haptic Interface for Grasping in Virtual Reality. In Proceedings of the 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems, 2016.

### Demos & Posters

- [D.1] **I. Choi**, E. Ofek, H. Benko, M. Sinclair, and C. Holz. Demonstration of CLAW: A Multifunctional Handheld VR Haptic Controller. In Adjunct proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Montreal, QC, Canada, 2018.
- [D.2] M. Sinclair, E. Ofek, C. Holz, **I. Choi**, E. Whitmire, E. Strasnick, H. Benko. Three Haptic Shape-Feedback Controllers for Virtual Reality. IEEE Virtual Reality, 2018
- [D.3] A. Dementyev, J. Hernandez, S. Follmer, **I. Choi**, and J. Paradiso. SkinBot: A Wearable Skin Climbing Robot. In Adjunct proceedings of the 30th Annual ACM Symposium on User Interface Software & Technology, 2017.
- [D.4] **I. Choi** and S. Follmer. Wolverine, ACM Interactions, Demo Hour, Jan/Feb 2017.
- [D.5] **I. Choi** and S. Follmer. Wolverine: A Wearable Haptic Interface for Grasping in Virtual Reality. In Adjunct proceedings of the 29th Annual ACM Symposium on User Interface Software & Technology (UIST 2016) **Best Demo Award (Top 3)**

## Patents

- [P.1] S. Lee, S. Follmer, and **I. Choi**, "Vehicle and Method of Controlling the same," 2023. (U.S. Patent: 11,667,196)
- [P.2] S.-M. Park, T. H. Kwon, J. Lee, I. Choi, S. Kim, "Smart Toilet System with Automatic Stool Collection Process," 2023. (Submitted to Stanford OTL)
- [P.3] B. H. Do, **I. Choi**, S. Follmer, "Soft Variable Impedance Actuator Using Embedded Jamming Layer," 2023. (U.S. Appl. No.: 18/109,432)
- [P.4] S. Lee, S. Follmer, and **I. Choi**, "Input Device and Vehicle Including the same, and Method of Controlling Input Device," 2022. (U.S. Patent: 11,377,044)
- [P.5] **I. Choi**, J. Park, and A. Kokish, "Active Drive for Guidewire Manipulation," 2022. (U.S. Patent: 11,241,559)
- [P.6] Y.-L. Park, G.W. Shin, Y. Choi, B.J. Jeon, and **I. Choi**, "Bi-stable Soft Electromagnetic Actuator," 2022. (U.S. Appl. No.: 17/896,987)
- [P.7] C. Holz, E. Ofek, M. J. Sinclair, H. Benko, **I. Choi**, and E. Whitmire, "Controller with haptic feedback," 2020. (U.S. Patent: 10,617,942)
- [P.8] **I. Choi**, H. Culbertson, and S. Follmer, "Grability: A Wearable Haptic Interface for Simulating Weight and Grasping in Virtual Reality," 2020. (U.S. Patent: 10,852,872)
- [P.9] E. W. Hawkes, **I. Choi**, and S. Follmer, "Wolverine: A Wearable Haptic Interface for Grasping in Virtual Reality," 2019. (U.S. Patent: 10,248,201)
- [P.10] Y.-L. Park, G. Shin, Y. Choi, B. Jeon, and **I. Choi**, "Bi-stable Soft Electromagnetic Actuator," 2021. (Korea Appl. No.:10-2021-0113744)
- [P.11] Y.-L. Park, J. Kwon, **I. Choi**, M. Park, and B. Jeong, "Variable Stiffness Structure with Sandwich Structure," 2021. (Korea Appl. No: 10-2021-0115721)
- [P.12] **I. Choi**, "A Device for Removing the Snow of Vinyl House," 2008. (Korea Utility Model Appl. No. 20-2008-0000167)

## Honors and Awards

<b>Best Paper Award.</b> UIST 2017.	2017
<b>Best Paper Award.</b> UIST 2016.	2016
<b>Best Demo Award.</b> UIST 2016.	2016
<b>Distinguished Paper Award.</b> IMWUT 2018 Vol. 2.	2018

<b>AO Trauma Asia Pacific Research Grants.</b> Project member.	2022
<b>Honorable Mention.</b> Fast Company Innovation by Design Awards.	2017
<b>Young Engineers Honor Society.</b> The National Academy of Engineering of Korea.	2011-present
<b>Great Honor Student for Academic Achievement.</b> Korea University.	2009-2013
<b>Presidential Science Scholarship.</b> Korea	2009-2013

## Teaching Experience

<b>Dynamic Systems, Vibrations and Control (ME 161/261)</b> Stanford University (Stanford, CA) Course Assistant with instructor Paul Mitiguy, Ph.D.	2014, 2015, and 2016
<b>Advanced Dynamics &amp; Computation (ME 331A)</b> Stanford University (Stanford, CA) Course Assistant with instructor Paul Mitiguy, Ph.D.	2014 and 2015
<b>Advanced Dynamics, Simulation &amp; Control (ME 331B)</b> Stanford University (Stanford, CA) Course Assistant with instructor Paul Mitiguy, Ph.D.	2014 and 2015
<b>Experimental Robotics (CS 225A)</b> Stanford University (Stanford, CA) Course Assistant with instructor Oussama Khatib, Ph.D.	2015
<b>Introduction to Robotics (CS 223A)</b> Stanford University (Stanford, CA) Course Assistant with instructor Oussama Khatib, Ph.D.	2015

## Academic Service

### Reviewer

More than 40 papers in HCI / VR / Haptics / Robotics such as CHI, UIST, IEEE VR, ToH, SoRo, TMECH, Actuators, ICRA, IROS, RA-L, IJHCI, Haptics Symposium, Eurohaptics, TOMM, BioRob, ISMAR, IMWUT.

## Selected Media Coverage

**BBC Click** "Robot seeks out skin cancer with suction" October 15, 2018  
**Digital Trends** "MIT's Creepy-crawly Robot can Help Monitor Your Health" October 1, 2018  
**New Scientist** "This robot crawls over your body and scans your skin with a microscope" September 28, 2018  
  
**Gizmodo** "Microsoft Wants You to Touch the VR World With a Giant CLAW." March 12, 2018  
**The Register** "Microsoft floats feelers for fake worlds." March 8, 2018  
**Engadget** "Microsoft's mad scientists are making AR more tactile." March 12, 2018

**Co.Design Fast Company** "Crazy Microsoft Is The Best Microsoft." March 9, 2018  
**Road to VR** "Microsoft Shows New Research in Haptics With 'CLAW' VR Controller Prototype." March 13, 2018

**Recode** "These tiny, wearable robots can cling to your clothes and drive around your body." October 19, 2016

**The Verge** "These robots will crawl over your clothes for some reason." October 21, 2016

**Engadget** "Tiny body-roaming robots could be the future of wearables." October 19, 2016

**Digital Trends** "Get a grip, bub: Wolverine haptic device lets you grasp objects in VR." October 27, 2016

**Futurism** "Meet Wolverine, the Tech That Lets You Grab Objects in Virtual Reality." October 26, 2016

**Motherboard** "Haptic Feedback Prototype Lets You Grasp Objects in VR" October 23, 2016

**IEEE Spectrum** "Video Friday: Robot Toes, Wolverine Haptic Hand, and More From IROS 2016" October 21, 2016

## Skills

- Experience & interaction prototyping (Unity, Adobe CC)
- User study (quantitative & qualitative study design, statistical analysis using R)
- Programming (C, Python, MATLAB)
- Simulation (COMSOL, MATLAB, LTspice, non-linear pneumatic actuators, electromagnetic actuators, multi-layer composites, non-linear dynamic systems including friction and damping, analog circuits)
- Theoretical modelling (pneumatic, electrostatic, and electromagnetic actuators made of soft/flexible materials, kinematics and dynamics of multi-linkage robotic systems)
- Mechatronics (circuits, PCB, closed-loop control, actuators and sensors)
- Hardware design (rapid prototyping, CAD, machining, system-level design of haptic interfaces and robotic systems)
- Spoken languages (Korean - native, English – Fluent)

## References

- **Sean Follmer, PhD** (PhD Advisor)  
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- **Yong-Lae Park, PhD** (Postdoc Advisor)  
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