Kyunghwan Choi

Assistant Professor, School of Mechanical Engineering, Gwangju Institute of Science and Technology
123 Cheomdangwagi-ro, Buk-gu, Gwangju, 61005, Korea
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Research Interests

Principle

- Control theory x AI for future mobility

Application 1. Mobility

- Predictive energy management of a connected, automated, and electrified vehicle (CAEV)
- Optimal coordination control of CAEVs under various traffic conditions
- Electronic stability control of a CAEV

Application 2. Electric drive

- Optimal torque control of a synchronous machine (SM)

Application 3. Robotics

- Impedance control of redundant manipulators for human-robot interaction

Education

Korea Advanced Institute of Science and Technology — *Daejeon, Korea*

Ph.D., Mechanical Engineering — *Feb 2020*

- **Thesis:** Real-time optimal torque control of permanent magnet synchronous motors
- **Advisor:** Prof. Kyung-Soo Kim

M.S., Mechanical Engineering — *Feb 2016*

- **Thesis:** Electrotactile sensory feedback for myoelectric forearm prostheses
- **Advisor:** Prof. Kyung-Soo Kim

B.S., Mechanical Engineering, *magna cum laude* — *Feb 2014*

Professional Experience

Gwangju Institute of Science and Technology — *Gwangju, Korea*

Adjunct Professor - AI Graduate School — *Sep 2022 - Present*

Assistant Professor - School of Mechanical Engineering — *Mar 2022 - Present*

Korea Advanced Institute of Science and Technology — *Daejeon, Korea*

Research Assistant Professor - Research Center for Eco-Friendly & Smart Vehicles — *Jan 2021 - Feb 2022*

Postdoctoral Fellow - Research Center for Eco-Friendly & Smart Vehicles — *Mar 2020 - Jan 2021*

Publications

* corresponding author

Journal Papers under Review (International)

5. **K. Choi**, J. Kim, and K.-B. Park*, "Generalized Model Predictive Torque Control of Synchronous Machines," *IEEE Transactions on Mechatronics* (uploaded on TechRxiv).
4. **K. Choi**, H. Lee, and W. Kim*, "Using Deep Reinforcement Learning for Dynamic Gain Adjustment of a Disturbance Observer," *IEEE Control Systems Letters (with CDC Option)* (uploaded on arXiv).
3. M. Ryu and **K. Choi***, CNN-based End-to-End Adaptive Controller with Stability Guarantees," *IEEE Control Systems Letters (with CDC Option)* (uploaded on arXiv).
2. **K. Choi**, G. Park, and D. Kum*, "An Analytical Approach to the Predictive Energy Management of Connected HEVs: What Information Do We Need to Guarantee Global Optimality?," *IEEE Transactions on Intelligent Transportation Systems*.
1. G. Park, **K. Choi**, and D. Kum*, "Predictive Control of a Dog-clutch Transmission via a Transformer-based Velocity Prediction," *IEEE Transactions on Vehicular Technology*.

Journal Papers (International)

16. W. Kim, K. Na, and **K. Choi***, "A Current Sensor Fault-detecting Method for Onboard Battery Management Systems of Electric Vehicles Based on Disturbance Observer and Normalized Residuals," *International Journal of Control, Automation, and Systems*, vol. 21, No. 11, pp. 3563-3573, 2023.
15. M. Choi, **K. Choi**, M. Cho, M. Lee, and K.-S. Kim*, "Chattering reduction of sliding mode control via nonlinear disturbance observer for anti-lock braking system and verification with CarSim simulation," *International Journal of Automotive Technology*, vol. 24, No. 4, pp. 1141-1149, 2023.
14. **K. Choi** and W. Kim*, "Real-time Predictive Energy Management Strategy for Fuel Cell-powered Unmanned Aerial Vehicles Based on the Control-oriented Battery Model," *IEEE Control Systems Letters*, vol. 7, pp. 943-948, 2023 (The contents of this paper were also selected by ACC 2023 Program Committee for presentation at the Conference).
13. W. Kim and **K. Choi***, "Current sensorless state of charge estimation approach for onboard battery systems with an unknown current estimator," *Journal of Energy Storage*, vol. 52, pp. 104726, 2022.
12. **K. Choi**, Y. Kim, S.-K. Kim*, and K.-S. Kim*, "Computationally efficient model predictive torque control of permanent magnet synchronous machines using numerical techniques," *IEEE Transactions on Control Systems Technology*, vol. 30, no. 4, pp. 1774-1781, 2022.
11. **K. Choi**, J. Byun, S. Lee, and I. G. Jang*, "Adaptive equivalent consumption minimization strategy (A-ECMS) for the HEVs with a near-optimal equivalent factor considering driving conditions", *IEEE Transactions on Vehicular Technology*, vol. 71, no. 3, pp. 2538-2549, 2022.
10. J. H. Kim, **K. Choi**, and I. G. Jang*, "Model predictive control-based time-optimal trajectory planning of the distributed actuation mechanism augmented by the maximum performance evaluation," *Applied Sciences*, vol. 11, No. 16, pp. 7513, 2021.
9. J. Byun and **K. Choi***, "Effects analysis of light-duty diesel truck hybrid conversion depending on driving style," *Transportation Research Part D: Transport and Environment*, vol. 97, pp. 102958, 2021.
8. **K. Choi**, Y. Kim, K.-S. Kim*, and S.-K. Kim*, "Real-time optimal torque control of interior permanent magnet synchronous motors based on a numerical optimization technique," *IEEE Transactions on Control Systems Technology*, vol 29, no. 4, pp. 1815-1822, 2021.
7. **K. Choi**, Y. Kim, S.-K. Kim*, and K.-S. Kim*, "Current and position sensor fault diagnosis algorithm for PMSM drives based on robust state observer," *IEEE Transactions on Industrial Electronics*, vol. 68. no. 6, pp. 5227-5236, 2021.
6. **K. Choi**, Y. Kim, S.-K. Kim*, and K.-S. Kim, "Auto-calibration of position offset for PMSM drives with uncertain parameters," *Electronics Letters*, vol 56, no. 20, pp. 1048-1051, 2020.
5. **K. Choi**, D. S. Kim, and S.-K. Kim*, "Disturbance observer-based offset-free global tracking control for input-constrained LTI systems with DC/DC buck converter applications," *Energies*, vol. 13, no. 16, p. 4079, 2020.
4. **K. Choi**, Y. Kim, K.-S. Kim, and S.-K. Kim*, "Output voltage tracking controller embedding auto-tuning algorithm for DC/DC boost converters," *IET Power Electronics*, vol. 12, no. 14, pp. 3767-3773, 2019.
3. **K. Choi**, K.-S. Kim*, and S.-K. Kim*, "Proportional-type sensor fault diagnosis algorithm for DC/DC boost converters based on disturbance observer," *Energies*, vol. 12, no. 8, p. 1412, 2019.
2. **K. Choi**, Y. Kim, K.-S. Kim*, and S.-K. Kim*, "Using the stator current ripple model for real-time estimation of full parameters of a permanent magnet synchronous motor," *IEEE Access*, vol. 7, pp. 33369-33379, 2019.
1. **K. Choi**, P. Kim, K.-S. Kim*, and S. Kim, "Mixed-modality stimulation to evoke two modalities simultaneously in one channel for electrocutaneous sensory feedback," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 25, no. 12, pp. 2258-2269, 2017.

Journal Papers (Domestic)

4. K.-S. Kim* and **K. Choi**, "Current Status and Future Trends in Synchronous Machine Control Technologies: A Focus on Torque Control," *Journal of Institute of Control, Robotics and Systems*, vol. xx, no. xx, pp. xx-xx, 2024.
3. K. Na, **K. Choi**, and W. Kim*, "A Current Sensor Fault-detecting Method for Electric Vehicle Battery Systems Based on Disturbance Observer," *Journal of Institute of Control, Robotics and Systems*, vol. 29, no. 12, pp. 1052-1059, 2023.
2. **K. Choi** and D. Kum*, "Current Status and Future Trends of Electrified Powertrain Technologies," *Mobility Research*, vol. 2, no. 1, pp. 23-43, 2022.
1. J.-W. Hwang, **K. Choi**, H.-T. Seo, K.-S. Kim*, and S. Kim, "Controller design for motion stabilization of a turret on a moving platform," *Journal of Institute of Control, Robotics and Systems*, vol. 23, no. 10, pp. 816-824, 2017.

Conference Proceedings (International)

12. **K. Choi** and C. M. Hackl*, "A Lyapunov-based Approach to Nonlinear Programming and Its Application to Nonlinear Model Predictive Torque Control," Under review for IEEE CDC 2024 (uploaded on TechRxiv).
11. G. Park, **K. Choi**, and D. Kum*, "Stack Degradation Protection of FCEVs Via Predictive Energy Management Strategy with Segmented Roads," in *2024 American Control Conference (ACC)*, 2024: IEEE.
10. S. Jang and **K. Choi***, "Stator Flux Linkage Estimation of Synchronous Machines Based on Integration Error Estimation for Improved Transient Performance," in *2023 IEEE 62nd Conference on Decision and Control (CDC)*, 2023: IEEE, pp. 4197-4202.
9. M. Ryu, J. Ha, M. Kim, and **K. Choi***, "A Comparative Study of Reinforcement Learning and Analytical Methods for Optimal Control," in *2023 International Workshop on Intelligent Systems (IWIS)*, 2023: IEEE.
8. M. Seo, S. Shin, K. Kim, and **K. Choi***, "Reinforcement learning-based collision avoidance of a connected and automated vehicle at merging roads," in *2023 International Workshop on Intelligent Systems (IWIS)*, 2023: IEEE.
7. **K. Choi** and K.-B. Park*, "Model Predictive Torque Control of Synchronous Machines Without a Current or Stator Flux Reference Generator," in *2023 IEEE 32nd International Symposium on Industrial Electronics (ISIE)*, 2023: IEEE.
6. J. Kim, Y. Lee, **K. Choi**, J. Song, and K.-B. Park*, "Performance Comparison of Long-Horizon FCS-MPC for IPMSM Considering THDi and Inverter Loss," in *2023 11th International Conference on Power Electronics and ECCE Asia (ICPE 2023-ECCE Asia)*, 2023: IEEE, pp. 1680-1685.
5. J. Kim, J. Song, **K. Choi**, and K.-B. Park*, "A Comparison of DPWM and Inverter Loss Energy Based FCS-MPC for IPMSM," in *2022 IEEE 20th International Power Electronics and Motion Control Conference (PEMC)*, 2022: IEEE, pp. 709-714.
4. **K. Choi**, Y. Kim, S.-K. Kim, and K.-S. Kim*, "Proportional-type current control of permanent magnet synchronous motor with improved transient performance over a wide speed range", in *2020 20th International Conference on Control, Automation and Systems (ICCAS)*, 2020: IEEE, pp. 60-63.
3. **K. Choi**, Y. Kim, K.-S. Kim*, and S.-K. Kim, "A fast and accurate numerical method for optimal torque control of interior permanent magnet synchronous motors," in *2019 19th International Conference on Control, Automation and Systems (ICCAS)*, 2019: IEEE, pp.12-16.
2. Y. Kim, **K. Choi**, S.-K. Kim*, and K.-S. Kim, "A disturbance observer based approach to current control of PMSM drives for torque ripple reduction," *IFAC-PapersOnLine*, vol. 52, no. 4, pp. 206-209, 2019.
1. **K. Choi**, P. Kim, K.-S. Kim*, and S. Kim, "Two-channel electrotactile stimulation for sensory feedback of fingers of prosthesis," in *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2016: IEEE, pp. 1133-1138.

Conference Proceedings (Domestic)

13. M. Seo and **K. Choi***, "Path Control of a Connected and Automated Vehicle at Intersections and Merging Zones Using Attention Mechanism-Based Reinforcement Learning," in *2023 KSAE Autumn Conference*, Ulsan Metropolitan City, Korea, Nov 15-18, 2023.
12. S. Shin and **K. Choi***, "Speed Control of a Connected and Automated Vehicle at Merging Zones Using Reinforcement Learning of Intelligent Driver Model," in *2023 KSAE Autumn Conference*, Ulsan Metropolitan City, Korea, Nov 15-18, 2023.
11. S. Jeong and **K. Choi***, "Tire Model-free Traction Control System Control," in *2023 KSAE Autumn Conference*, Ulsan Metropolitan City, Korea, Nov 15-18, 2023.
10. M. Ryu and **K. Choi***, "Integrated Motion Control of Four in-Wheel Motor Actuated Vehicles Considering Path Tracking, Ride Comfort, and Energy Efficiency," in *2023 KSAE Autumn Conference*, Ulsan Metropolitan City, Korea, Nov 15-18, 2023.
9. S. Kim and **K. Choi***, "Null-space Impedance Control of Redundant Manipulator Using Reinforcement Learning," in *2023 38th ICROS Conference*, Samcheok-si, Korea, Jun 21-23, 2023.
8. J. Park and **K. Choi***, "Enhancing Computational Efficiency of Model Predictive Control for Minimizing Energy Consumption of Electric Vehicle," in *2023 38th ICROS Conference*, Samcheok-si, Korea, Jun 21-23, 2023.
7. W. Kim*, K. Na and **K. Choi**, "A Current Sensor Fault-Detecting Method for Electric Vehicle Battery Management Systems based on Nonlinear Battery Cell Model and Disturbance Observer," in *2023 38th ICROS Conference*, Samcheok-si, Korea, Jun 21-23, 2023.
6. M. Ryu and **K. Choi***, "Data-driven Modeling of Model Residuals for Linear Model Predictive Control of Nonlinear Systems," in *2023 38th ICROS Conference*, Samcheok-si, Korea, Jun 21-23, 2023.
5. S. Jang and **K. Choi***, "Stator Flux Linkage Estimation Method of Synchronous Machines Based on Integration Error Estimation," in *2023 38th ICROS Conference*, Samcheok-si, Korea, Jun 21-23, 2023.
4. **K. Choi*** and W. Kim, "Using the Control-Oriented Battery Model to Convexify the Optimal Energy Control Problem of Electrified Powertrains," in *2022 37th ICROS Conference*, Geoje-si, Korea, Jun 22-24, 2022.
3. **K. Choi**, J. Byun, S. Lee, and I. G. Jang*, "Adaptive equivalent consumption minimization strategy for the HEVs with a near-optimal equivalent factor considering driving conditions," in *2021 KSAE Autumn Conference*, Yeosu-si, Korea, Nov 17-20, 2021.
2. J. Kim, **K. Choi**, J. Song, and K.-B. Park*, "Comparative analysis of inverter for IPMSM of hybrid electric propulsion system: PI-SVPWM vs. FCS-MPC," in *2021 52nd KIEE Summer Conference*, Pyeongchang-gun, Korea, Jul 15-17, 2021.
1. J.-W. Hwang, **K. Choi**, H.-T. Seo, K.-S. Kim*, and S. Kim, "Dual-stage robust controller design for motion stabilization of turret system," in *2017 32nd ICROS Conference*, Sokcho-si, Korea, May 11-13, 2017.

Research Grants

Research on steering control technology for autonomous driving PBV
Sponsored by the Electronics and Telecommunications Research Institute (₩30,000,000) *Aug 2023 - Nov 2023*
- **Role:** Principal Investigator

Development of inverters for traction and PTO motors of hydrogen fuel cell tractors
Sponsored by the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, and Forestry (₩400,000,000) *Jan 2023 - Dec 2024*
- **Role:** Researcher

Ultra-realistic infantry fighting skills training skills
Sponsored by the Korea Research Institute for Defense Technology Planning and Advancement (₩500,000,000) *Dec 2022 - Nov 2027*
- **Role:** Principal Investigator

Development of a chassis platform for electric vehicles with software open API to support autonomous driving functions
Sponsored by the Korea Automotive Technology Institute (₩50,000,000) *Jun 2022 - May 2023*
- **Role:** Principal Investigator

Basic research I on optimal power distribution and recovery strategies for electric vehicles
Sponsored by Future EV (₩40,000,000) *May 2022 - Apr 2023*
- **Role:** Principal Investigator

Development of Generalized Model Predictive Torque Control for Synchronous Machines
Sponsored by GIST (₩70,000,000) *Mar 2022 - Feb 2024*
- **Role:** Principal Investigator

Development of Technology and Equipment for Evaluating the Performance of Hydrogen Bus Driving Systems
Sponsored by the Korea Transportation Safety Authority (₩50,000,000) *Jan 2021 - Dec 2021*
- **Role:** Principal Investigator

Development of Real-Time Fuel Efficiency Optimization Technology for Light-Duty Hybrid Electric Trucks
Sponsored by the KAIST G-CORE Research Project (₩91,000,000) *Jul 2020 - Jun 2021*
- **Role:** Principal Investigator

Development of Hybrid Electric Vehicle Conversion Kit for Diesel Delivery Trucks and its Commercialization for Parcel Services
Sponsored by the Korea Agency for Infrastructure Technology Advancement (₩5,005,000,000) *Jul 2017 - Mar 2021*
- **Role:** Researcher

Feasibility Study on Eco-friendly Hybrid Diesel-Electric Trucks for Parcel Delivery Service
Sponsored by the Korea Agency for Infrastructure Technology Advancement (₩90,000,000) *Aug 2016 - Feb 2017*
- **Role:** Researcher

Patents

Patent Registration (International)

1. I. G. Jang, D. Kum, K.-S. Kim, K. Jang, C. Lee, J.H. Kim, **K. Choi**, and M. Kim, "Apparatus and method for operating accessories of vehicle during engine stop using one-way clutch pulley," US, 11607944 B2, 2023.

Patent Application (International)

2. K.-S. Kim, **K. Choi**, and I. G. Jang, "Method and apparatus for controlling power of hybrid vehicle considering driving environment," US pending, 17583312, 2022.
1. K.-S. Kim, **K. Choi**, and S.-K. Kim, "Method and apparatus for real-time estimation of full parameters of permanent magnet synchronous motor," US pending, 17324215, 2021.

Patent Registration (Domestic)

4. K.-S. Kim, **K. Choi**, and I. G. Jang, "Method and apparatus for controlling power of hybrid vehicle considering driving environment," KR, 10-2508409, 2023.
3. K.-S. Kim, **K. Choi**, and S.-K. Kim, "Method and apparatus for real-time estimation of full parameters of permanent magnet synchronous motor," KR, 10-2437244, 2022.
2. I. G. Jang, D. Kum, K.-S. Kim, K. Jang, C. Lee, J.H. Kim, **K. Choi**, and M. Kim, "Apparatus and method for operating accessories of vehicle during engine stop using one-way clutch pulley," KR, 10-2053538, 2019.
1. K.-S. Kim, M.-R. Lim, **K. Choi**, and D. Kum, "Method for controlling hybrid powertrain based on electrified manual transmission using a planetary gear," KR, 10-2044210, 2019.

Patent Application (Domestic)

2. K.-S. Kim, **K. Choi**, and I. G. Jang, "Method and apparatus for controlling power of hybrid vehicle considering transient characteristics," KR pending, 10-0144773, 2021 (**US patent application in progress**).
1. K. Jang, D. Kum, I. G. Jang, K.-S. Kim, J. Byun, **K. Choi**, Y. Kim, and W. Kim, "Hybrid electric vehicle conversion kit and conversion method for internal combustion engine vehicle, and control method for converted vehicle," KR pending, 10-0044517, 2021.

Professional Memberships and Services

Memberships

- Institute of Control, Robotics and Systems (ICROS), 2022 - Present
- Korean Society of Automotive Engineers (KSAE), 2021 - Present

Journal Editors

- Associate editor of the Journal of Mechanical Science and Technology (JMST), Jun 2023 - Present
- Associate editor of the International Journal of Control, Automation, and Systems (IJCAS), Mar 2023 - Present

Journal Reviewers

- IEEE Transactions on Industrial Electronics
- IEEE Transactions on Vehicular Technology
- IEEE Transactions on Control Systems Technology
- IEEE Transactions on Mechatronics
- IEEE Transactions on Energy Conversion
- International Journal of Control, Automation, and Systems (IJCAS)

Conference Reviewers

- IEEE Conference on Decision and Control (CDC)
- IEEE International Conference on Industrial Electronics, Control, and Instrumentation (IECON)
- American Control Conference (ACC)
- International Conference on Control, Automation, and Systems (ICCAS)

Conference Organizing Committee

- Organizing Committee of the ICROS 2024
- Special Session Vice Chair of the IFAC 2026

Industry Advisors

- Outside director, Future EV, Feb 2024 - Present

Teaching Experience

Gwangju Institute of Science and Technology *Gwangju, Korea*

Assistant Professor *Mar 2022 - Present*

- Introduction to Mobility Engineering (ME5164/AI5216)
- Nonlinear Control (ME7101)
- Microprocessor and Application (MC3205/EC3214/IR3203)

Korea Advanced Institute of Science and Technology *Daejeon, Korea*

Guest Lecturer *Spring 2021*

- Preparation and lecture on vehicle dynamics and control in the graduate-level class, “GT640: Green Railway System Engineering”

Invited Seminars

Gwangju National Science Museum *Gwangju, Korea*

”Future Vehicles and AI” *Dec 20, 2023*

Available: https://youtu.be/Oll98exbtnE?si=FNeeYY9x6e9hCS-J

MERRIC *Webinar*

”Control of Connected and Automated Vehicles” *Dec 20, 2023*

Available: https://youtu.be/WPMqe5EkWmg?si=LF1fDzvjeHszybnS

YEONGGWANG e-MOBILITY EXPO *Yeonggwang, Korea*

”About future mobility: Connected, Automated, and Electric Vehicles” *Oct 8, 2023*

Daedong *Webinar*

”Introduction to vehicle control unit (VCU) design for autonomous electric vehicles” *Sep 20, 2023*

LG Electronics Home Appliance & Air Solution *Webinar*

”Energy management control of e-Mobility” *Jul 17, 2022*

Incheon National University — *Online*
"Predictive energy management of electrified vehicles" — *Apr 24, 2023*

emotion — *Daegu, Korea*
"Introduction to vehicle control unit (VCU) design for autonomous electric vehicles" — *Feb 14 - Feb 28, 2023*

emotion — *Daegu, Korea*
"Introduction of vehicle control technology for autonomous electric vehicles" — *Oct 20, 2022*

Electronics and Telecommunications Research Institute (ETRI) — *Daegu, Korea*
"Control Theory X AI for Future Mobility" — *Oct 18, 2022*

The Cho Chun Shik Graduate School of Mobility, Korea Advanced Institute of Science and Technology (KAIST) — *Webinar*
"Control Theory X AI for Future Mobility" — *Sep 29, 2022*

Daedong — *Changnyeong, Korea*
"Introduction of integrated vehicle control technology for electric vehicles" — *Jul 21, 2022*

LG Electronics Home Appliance & Air Solution — *Webinar*
"Intelligent Optimal Torque Control of Synchronous Machines" — *May 26, 2022*

Department of Smart Industrial Machine Technologies, Korea Institute of Machinery & Materials (KIMM) — *Daejeon, Korea*
"Real-time optimal control of mechatronics systems" — *Apr 12, 2022*

The Cho Chun Shik Graduate School of Green Transportation, Korea Advanced Institute of Science and Technology (KAIST) — *Daejeon, Korea*
"Hybrid conversion technology for light-duty diesel trucks" — *May 20, 2021*

NMC — *Busan, Korea*
"State-of-the-art control techniques for automotive traction drives" — *May 7, 2021*

Department of Smart Industrial Machine Technologies, Korea Institute of Machinery & Materials (KIMM) — *Daejeon, Korea*
"Dynamic programming for HEV control" — *Jan 14, 2020*

Honors & Awards

Outstanding Young Researcher Award
The 23rd International Conference on Control, Automation, and Systems — *Oct 19, 2023*

One Best Paper Award, Two Undergraduate Paper Awards
2023 The 38th Institute of Control, Robotics and Systems (ICROS) Annual Conference — *Jun 22, 2023*

Best Paper Award
2021 Korean Society of Automotive Engineers (KSAE) Autumn Conference — *Dec 16, 2021*

Best Paper Award
2021 The 52nd Korean Institute of Electrical Engineers (KIEE) Summer Conference — *Sep 13, 2021*

Outstanding Achievement *Summa Cum Laude* Award

Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST)

2011