

# Hanseul Cho (조한슬)

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## Personal Profile

I am a Ph.D. student in the Optimization & Machine Learning (OptiML) Laboratory, advised by Prof. Chulhee Yun at Kim Jaechul Graduate School of AI (GSAI) in Korea Advanced Institute of Science and Technology (KAIST). Before this, I received my Bachelor's degree in Mathematical Sciences (major) and Computing Sciences (minor) at KAIST in 2022.

My primary research interests lie in optimization, machine learning, and deep learning, mainly focusing on both mathematical/theoretical analysis and empirical improvements (especially based on theoretical understanding). Recently, I have been into understanding and mitigating the fundamental limitations of modern language models (e.g., length generalization and compositional generalization problems). Moreover, I am always interested in topics on various constrained and multi-level optimization problems, including minimax optimization, fair machine learning, reinforcement learning, continual/incremental learning, and more, with particular interest.

## Publications

### PREPRINTS

- [Hanseul Cho\\*](#), Jaeyoung Cha\*, Srinadh Bhojanapalli, Chulhee Yun. "Arithmetic Transformers Can Length-Generalize in Both Operand Length and Count." *Under Review*. 2024.
- Hyunji Jung\*, [Hanseul Cho\\*](#), Chulhee Yun. "Convergence and Implicit Bias of Gradient Descent on Continual Linear Classification." *Under Review*. 2024.

### INTERNATIONAL CONFERENCES/JOURNALS

- [Hanseul Cho\\*](#), Jaeyoung Cha\*, Pranjal Awasthi, Srinadh Bhojanapalli, Anupam Gupta, Chulhee Yun. "Position Coupling: Leveraging Task Structure for Improved Length Generalization of Transformers." **NeurIPS 2024 & ICML 2024 Workshop** on Long-Context Foundation Models. [[arXiv](#)] [[OpenReview](#)]
- Baekrok Shin\*, Junsoo Oh\*, [Hanseul Cho](#), Chulhee Yun. "DASH: Warm-Starting Neural Network Training Without Loss of Plasticity Under Stationarity." **NeurIPS 2024 & ICML 2024 Workshop** on Advancing Neural Network Training: Computational Efficiency, Scalability, and Resource Optimization. [[OpenReview](#)]
- Lee, Jaewook\*, [Hanseul Cho\\*](#), Chulhee Yun. "Fundamental Benefit of Alternating Updates in Minimax Optimization." **ICML 2024 & ICLR 2024 Workshop** on Bridging the Gap Between Practice and Theory in Deep Learning (BGPT). [[OpenReview](#)] [[arXiv](#)]
  - **Spotlight at ICML 2024**. (Acceptance rate:  $(144+191)/9473 = 3.5\%$ )
- Lee, Junghyun\*, [Hanseul Cho\\*](#), Se-Young Yun, Chulhee Yun. "Fair Streaming Principal Component Analysis: Statistical and Algorithmic Viewpoint." **NeurIPS 2023**. [[OpenReview](#)] [[arXiv](#)]
- Lee, Hojoon\*, [Hanseul Cho\\*](#), Hyunseung Kim\*, Daehoon Gwak, Joonkee Kim, Jaegul Choo, Se-Young Yun, Chulhee Yun. "PLASTIC: Improving Input and Label Plasticity for Sample Efficient Reinforcement Learning." **NeurIPS 2023**. [[OpenReview](#)] [[arXiv](#)]
- [Cho, Hanseul](#) and Chulhee Yun. "SGDA with Shuffling: Faster Convergence for Nonconvex-P<sub>L</sub> Minimax Optimization." **ICLR 2023**. [[OpenReview](#)] [[arXiv](#)]

### DOMESTIC CONFERENCES/JOURNALS

- [Cho, Hanseul](#) and Chulhee Yun. "SGDA with Shuffling: Faster Convergence for Nonconvex-P<sub>L</sub> Minimax Optimization." Short version in 2022 *Korea AI Association + NAVER Autumnal Joint Conference (JKAIA 2022)*.
  - **NAVER Outstanding Theory Paper Award & Spotlight presentation**.

## Education

### Korea Advanced Institute of Science and Technology (KAIST)

Seoul, Republic of Korea

Ph.D. in Artificial Intelligence

Sept. 2023 – Current

- Advisor: Prof. [Chulhee Yun](#) (Optimization & Machine Learning (OptiML) Laboratory, Kim Jaechul Graduate School of AI (GSAI), KAIST)

### Korea Advanced Institute of Science and Technology (KAIST)

Seoul, Republic of Korea

M.Sc. in Artificial Intelligence

Mar. 2022 – Aug. 2023

- Advisor: Prof. [Chulhee Yun](#) (Optimization & Machine Learning (OptiML) Laboratory, Kim Jaechul Graduate School of AI (GSAI), KAIST)
- Thesis: "Improved Convergence Rate of SGDA by Shuffling: Focusing on the Nonconvex-P<sub>L</sub> Minimax Problems" (Approved by [Chulhee Yun](#), [Se-Young Yun](#), & [Donghwan Kim](#))
- GPA: 4.22/4.3

## Korea Advanced Institute of Science and Technology (KAIST)

B.Sc. in Mathematical Sciences

- Minor in Computer Sciences
- Summa Cum Laude (GPA: 4.05/4.3)

Daejeon, Republic of Korea

Mar. 2017 – Feb. 2022

## University of Twente

Exchange Student Program

- Major in Applied Mathematics

Enschede, Netherlands

Feb. 2020 – Jul. 2020

## Incheon Science High School

High School

- Early Graduation by One Year (i.e., two-year course)

Incheon, Republic of Korea

Mar. 2015 – Feb. 2017

# Ongoing Projects

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## Length Generalization in Language Models (e.g., Transformers)

Seoul, Republic of Korea

KAIST AI + Google

Nov. 2023 – Current

- Transformer (Vaswani et al., 2017) models have exhibited tremendous success in various areas of artificial intelligence such as natural language processing, computer vision, and reinforcement learning.
- However, Transformers often suffer from the impossibility of ‘length generalization’: they usually fail to extrapolate their performance onto longer sequences than those at the training time.
- We aim to come up with a unifying framework to solve the length generalization problem on several synthetic tasks and arithmetic tasks, such as addition,  $N \times 1$  multiplication, copying/reversing under the presence of duplicate tokens, and the parity task. The exact structures for those tasks are known, so we might be able to inject the structure into our Transformer model directly.
- Furthermore, we would like to find a method that automatically discovers the hidden structure of the tasks to apply our methodology for length generalization to general NLP tasks.

## Fair (Streaming) Principal Component Analysis - Complexity Lower Bound

Seoul, Republic of Korea

KAIST AI

Mar. 2023 – Current

- In Lee et al. (2023), we have studied the memory-efficient & group-wise fair principal component analysis (PCA) methodology called ‘Fair Streaming PCA’.
- We proved the upper bound of sample complexity of our main algorithm ‘Fair Noisy Power Method (FNPM)’ mainly exploiting matrix Bernstein inequality. However, the tightness of the bound has not been checked yet.

## Implicit Bias of Continual Learning in Logistic Regression

Seoul, Republic of Korea

KAIST AI

Jul. 2023 – Current

- Theoretical understanding of continual learning is mostly done in a simple regression setting, where the objective function is mostly based on a quadratic loss. In such a setting, gradient-based algorithms typically found a minimum for each task at a finite point.
- In contrast, however, the trajectory of continual learning has not been well understood in the classification setup, including even a logistic regression. In logistic regression, the iterates of the gradient-based algorithm diverge to infinity, which makes the theoretical analysis difficult.

## Overcoming Loss of Plasticity of Neural Network

Seoul, Republic of Korea

KAIST AI

Nov. 2023 – Current

- Neural networks often struggle with the problem called ‘loss of plasticity,’ which refers to the phenomenon that a model loses the ability to adapt to the shifts in data distribution, especially when new data points appear.
- Interestingly, re-initializing the model partially or entirely, so-called “re-learning,” greatly helps the model to recover its adaptability in practice.
- Why is it beneficial? Furthermore, can we develop a “smart” way of re-learning instead of re-initializing the whole model?

## Contextual Model-based Black-box Optimization

Seoul, Republic of Korea

KAIST AI

Nov. 2023 – Current

- Related Keywords: offline policy optimization, contextual optimization/recommendation, black-box optimization with side information

# Experiences

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## Machine/Deep Learning Theory + Physics (MDLTP) Seminar

Seoul, Republic of Korea

(Co-)Organizer

Jul. 2022 – Feb. 2023

- Homepage: [sites.google.com/view/mdlt-p](https://sites.google.com/view/mdlt-p)
- Jointly organized by OSI Lab, OptiML, and CSSPL
- Topics: Learning theory, loss landscape, trajectory analysis, (stochastic) optimization, high-dimensional statistics, statistical/mathematical physics, scientific machine learning, and more.

## KAIST 2021 Post-AI Research Project

Daejeon, Republic of Korea

Undergraduate Researcher

May 2021 – Dec. 2021

- Jointly advised by Prof. Sangyoon Yi (DS Lab, GSFS, KAIST) & Prof. Jinkyoo Park (Sys. Int. Lab, ISysE, KAIST)
- Project: Research on ‘AI-augmented Organizations’ of Collaborative Decision Making and Learning
- Contribution: (1) Devised a model-based randomized algorithm for a single-player finite-horizon NK landscape optimization game; (2) Conducted some experiments on human-AI cooperation based on the algorithm that I devised

## Korea Advanced Institute of Science and Technology (KAIST)

Daejeon, Republic of Korea

Individual Study

Mar. 2021 – Jun. 2021

- Advised by Prof. Jinwoo Shin (ALIN Lab, GSAI, KAIST)
- (1) gradient-based optimizers for large-batch setting (e.g., LARS & LAMB); (2) theoretical analysis on gradient clipping (paper reading)

## Korea Advanced Institute of Science and Technology (KAIST)

Daejeon, Republic of Korea

Individual Study

Sep. 2020 – Feb. 2021

- Advised by Prof. Jong-chul Ye (BISPL, BBE, KAIST)
- Assignment: Semantic Segmentation of Kidney Tumor with U-Net (with KiTS19 Challenge Dataset)

## Korea Advanced Institute of Science and Technology (KAIST)

Daejeon, Republic of Korea

Individual Study

Jun. 2020 – Aug. 2021

- Advised by Prof. Yeonseung Chung (MAS, KAIST)
- Statistical learning theory

## Services

### Reviewer

- NeurIPS 2024. (6 papers)
- ICLR 2024. (2 papers)
- NeurIPS 2023. (2 papers)

### GPU server manager of OptiML lab

- Be involved in installing new GPU servers, allocating GPU nodes to lab members, and managing errors occurred in the servers.
- June 2022 – Feb 2024

## Awards

2022	<b>NAVER Outstanding Theory Paper Award</b> , JKAIA 2022	Republic of Korea
2022	<b>Summa Cum Laude</b> , Bachelor's, KAIST	Republic of Korea
2017 – 2020	<b>The National Scholarship for Science and Engineering</b> , Korea Student Aid Foundation	Republic of Korea
2017 Fall	<b>Dean's List</b> , The School of Freshman, KAIST	Republic of Korea

## Skills

<b>Programming</b>	Familiar: Python (PyTorch, JAX, NumPy, Scikit-learn, Jupyter, Pandas, etc.), MATLAB. Novice: C, C++, R, HTML/CSS, Scala
<b>Computer Misc.</b>	Familiar: $\LaTeX$ (Overleaf/VSCode), Git, Microsoft Office. Novice: Adobe (Lightroom, Premiere Pro, After Effects, Photoshop)
<b>Music</b>	Playing the drums and percussions

## Languages

<b>English</b>	Professional Proficiency (i.e., sufficient for academic activities): TOEIC score 925 (LC 460, RC 465) (2021.04.11)
<b>Korean</b>	Native proficiency
<b>Others</b>	Had some introductory courses on French, German, Classical Latin, & Chinese.