# Hyemin Gu

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## Projects

**Generative Particles Algorithm** Link to Demo

Developed a generative model for high-dimensional scarce data ($28 \times 28$ MNIST 200 samples) which is mathematically formulated by gradient flows of probability distributions and corresponding particle dynamics. A choice of learning loss as **Wasserstein-1 proximal regularized $f$-divergence** leads to stabilizing the dynamics and helps finding low-dimensional data manifolds, leading to various applications introduced in Hyemin Gu, Panagiota Birmpa, et al. (2024). "Lipschitz-Regularized Gradient Flows and Generative Particle Algorithms for High-Dimensional Scarce Data". In: *SIAM J.Data Science, to appear*. URL: https://arxiv.org/abs/2210.17230.

**Wasserstein-1/Wasserstein-2 proximal generative flow** Link to Demo

Formulated and implemented a generative model with **continuous-time adversarial flow** architecture for learning distributions that are supported on low-dimensional manifolds. Our formulation is analyzed via Mean Field Game theory and ensures good properties of the learned flow such as **uniqueness** of solution and **optimal (linear) paths**. See more in Hyemin Gu, Markos A. Katsoulakis, et al. (2024). *Combining Wasserstein-1 and Wasserstein-2 proximals: robust manifold learning via well-posed generative flows*. arXiv: 2407.11901 [stat.ML]. URL: https://arxiv.org/abs/2407.11901.

**Wasserstein proximal generative models** Link to Demo

Learning objectives for generative models such as generative adversarial networks and normalizing flows have their Wasserstein-$p$ proximal regularized counterparts with $p = 1, 2$ which can be finitely evaluated even for comparing distributions with disjoint supports and therefore stabilizes their training processes. In addition, learning objectives for the state-of-art score-based generative models contain a type of Wasserstein-2 proximal regularization. We compared the **influences of Wasserstein-$p$ proximal regularizations with** $p = 1, 2$ on these generative models for learning **polynomially-tailed distributions**. See more in Ziyu Chen et al. (2024). *Learning heavy-tailed distributions with Wasserstein-proximal-regularized $\alpha$-divergences*. arXiv: 2405.13962 [stat.ML]. URL: https://arxiv.org/abs/2405.13962.

## Work Experience

***Graduate teaching assistant*** at University of Massachusetts - Amherst, MA, USA Feb 2021 - Dec 2021

– Graded assignments for undergraduate mathematics classes: Nonlinear dynamics and chaos with applications (with **tutorials for Python ODE solving**), Linear algebra, Linear algebra for applied mathematics (with discussion sessions)

***Statistics specialist*** at Ewha Womans University Seoul Hospital, Seoul, South Korea Jul 2020 - Dec 2020

– Developed a **pipeline for acquiring, analyzing, and visualizing** gene expression data from open repositories using R; authored a **tutorial book** on the process.

– Conducted **training sessions on statistical analysis using R** for colleagues.

***Graduate teaching assistant*** at Ewha Womans Universiy, Seoul, South Korea Mar 2018 - Dec 2019

– Graded assignments and arranged office hours for undergraduate mathematics classes: Numerical analysis (**linear system solving, power method, numerical integration/differentiation**), Numerical differential equations (**numerics for ODE/PDE, Monte-Carlo, optimization**), Calculus 2 (**multivariate calculus**), Finite mathematics and programming (**Matlab programming, mathematical logic, combinatorics**)

## Education

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| 2020 - present | PhD (Mathematics) at University of Massachusetts - Amherst, MA, USA<br>Research interest: dynamical transport, gradient flows, particle transport, Wasserstein proximal regularization, entropic regularization, generative modeling |
| 2018 - 2020 | Master (Mathematics)'s degree at Ewha Womans University, Seoul, South Korea<br>Thesis: *Convolutional Neural Network for 2D Flow Estimation Problem* |
| 2014 - 2018 | Bachelor's degree at Ewha Womans University, Seoul, South Korea<br>Major in *Mathematics* and *Computational science*, minor in *Statistics*<br>Dean's list 5 semesters<br>Thesis: *Low cost training of a classification Neural Network with respect to Weight Selection* |

## Training

**Industrial Mathematics Academy** from National Institute for Mathematical Sciences, South Korea Jun 2018

- Presented a final result of a group project for solving industrial problem.
- Proposed a **Convolutional Neural Network for classifying** infected individual from images.
- Coordinated team efforts for the group project.
- Attended tutorials on **Python data analysis and Keras**, lectures on **matrix based data analysis, linear programming theory and practice**.

**Industrial Mathematics Academy** from National Institute for Mathematical Sciences, South Korea Dec 2017

- Proposed a **model for assessing safe driving scores** from On-board diagnostic data based on Poisson process.
- Attended tutorials on **basics to neural networks**.