Eric Qu

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Education

Duke Kunshan University / Duke University dual degree UG program *Sep 2019 - May 2023*
B.S. in Data Science (by Duke Kunshan) Kunshan, China / Durham, USA
B.S. in Interdisciplinary Studies (Subplan: Data Science; by Duke) GPA 3.88/4 Major GPA 3.98/4

Research Interest

My research interest mainly falls on **Geometric Deep Learning**, **Representation Learning**, and **Graph Neural Networks**. I also have experience in sequence modeling, reinforcement learning, and (3D) computer vision. In general, I am interested in combining ideas from mathematics with machine learning, and using machine learning to solve interdisciplinary problems.

Publications & Manuscripts

Qu, Eric, Zou, Dongmian. "Hyperbolic Convolution via Kernel Point Aggregation" *Preprint* (2022) (Under review).

Qu, Eric, Zou, Dongmian. "Autoencoding Hyperbolic Representation for Adversarial Generation" *arXiv:2201.12825* (2022) (Under review).

Qu, Eric, Zou, Dongmian. "Lorentz Direct Concatenation for Stable Training in Hyperbolic Neural Networks" *NeurIPS Symmetry and Geometry in Neural Representations Workshop* **Poster** (2022).

Qu, Eric, Luo, Xufang, Li, Dongsheng. "Data Continuity Matters: Improving Sequence Modeling with Lipschitz Regularizer" *Preprint* (2022) (Under review).

Qu, Eric, Jimenez, Andrew, Kumar, Sanat K., Zhang, Kai. "Quantifying Nanoparticle Assembly States in a Polymer Matrix through Deep Learning." *Macromolecules* 54, no. 7 (2021): 3034-3040.

Bornani, K., Mendez, N. F., Altorbaq, A. S., Müller, A. J., Lin, Y., **Qu, Eric**, Zhang, K., Kumar, S. K., Schadler, L. S. (2022). "*In Situ* Atomic Force Microscopy Tracking of Nanoparticle Migration in Semicrystalline Polymers." *ACS Macro Letters*, 2022, 11, 6, 818–824.

Experiences

Research Assistant - Duke Kunshan University *Mar 2021 - Present*
Adviser: Dongmian Zou *Jiangsu, China*

- Autoencoding Hyperbolic Representation for Adversarial Generation *Submitted to ICLR 2023*
  - We propose a generative model (HAEGAN) in hyperbolic space that is capable of generating complex data.
  - HAEGAN contains three parts: (1) a hyperbolic autoencoder (AE) that produces hyperbolic embedding; (2) a novel hyperbolic GAN that is trained to generate the hyperbolic embedding of AE from simple noise; (3) a generator that inherits the decoder from the AE and the generator from the GAN.
  - Many specific operations and layers were proposed to ensure numerical stability.
  - HAEGAN achieves SOTA in the molecular generation experiment with a hyperbolic version of JTVAE as the AE.
- Lorentz Direct Concatenation for Stable Training in Hyperbolic Neural Networks *NeurIPS Workshop Poster*
  - We discussed an operation proposed in the HAEGAN paper, the Lorentz Direct Concatenation. Compared with concatenating in the tangent space, our method is more stable and better at preserving the hyperbolic distance.
- Hyperbolic Convolution via Kernel Point Aggregation *Submitted to AISTATS 2023*
  - We constructed a novel hyperbolic convolution operation (HKConv), which first correlates trainable local hyperbolic features with fixed hyperbolic kernel points, then aggregates the output features within a local neighborhood.
  - HKConv enjoys equivariance to permutation of input and invariance to parallel transport of a local neighborhood.
  - Based on HKConv, we designed HKNet and it could outperformed the SOTA in graph related and NLP tasks.

Research Intern - Microsoft Research Aisa, Shanghai AI/ML Group *May 2022 - Present*
Adviser: Xufang Luo *Shanghai, China*

- Building a more efficient and accurate model for Gene Expression Prediction *In Progress*
  - We developed a new architecture for Gene Expression Prediction (GEP) that has a mutation-accommodated encoder, and a modified S4 model as backbone for better long-range dependency and efficient space complexity.
  - A more comprehensive dataset for GEP is also constructed that has doubled sample size than the current dataset.
- Data Continuity Matters: Improving Sequence Modeling with Lipschitz Regularizer *Submitted to ICLR 2023*
  - During the exploration of the GEP project, we discovered a way to increase the performance of the S4 model, and it could be generalized to all sequence models.
  - First, we discovered empirically and theoretically proved that many sequence models have different assumptions about the continuity of the input sequence, e.g. Transformer prefers discrete input, S4 prefers continuous input.
  - To utilize this property, we designed a regularizer that could alter the continuity of the input sequence and showed its effectiveness in various sequence models.

Research Assistant - Duke Kunshan University *Nov 2019 - Present*
Adviser: Kai Zhang *Jiangsu, China*

- Quantifying Nanoparticle Assembly States in a Polymer Matrix through Deep Learning *Published in Macromolecules*
  - We develop and apply a deep-learning based image analysis method to quantify the distribution of spherical NPs in a polymer matrix directly from their real-space TEM images.
- Solving Sticky Hard Sphere Packing Problem through Deep Learning *In Progress*
  - Sticky hard sphere packing is a challenging problem in physics. In our method, we first map the packing state into a graph and use a modified Graph Isomorphism Network (GIN) to identify the valid packing with high accuracy. Then, a Mento Carlo Search Tree is trained to generate new packings with the reward based on the GIN.
- Finding Optimal Order Parameter for Monodisperse Systems *In Progress*
  - Order parameter of a particle system describes whither it is more crystal-like or glass-like. The packing state could be represented by 3D point cloud. We proposed a novel Kernel Point Autoencoder model using KPConv as encoder and our Kernel Point Generator as decoder. Then, the bottleneck activation is extracted to be the order parameter.

Teaching Assistant - Duke Kunshan University *Jan 2022 - May 2022*
Course: STATS 303 Statistical Machine Learning & STATS 403 Deep Learning *Jiangsu, China*

- Weekly recitations to teach practice problems. Lecture Notes
- Serve as the Student Assistant in Textbook Preparation for STATS 403 Deep Learning.

Selected Coursework

Machine Learning: DKU STATS 302 Principles of Machine Learning (A+); DKU STATS 403 Deep Learning (A); DKU STATS 303 Statistical Machine Learning (A+); Duke STA 465 (MATH 765) High Dimensional Data Analysis.

Mathematics: DKU MATH 305 Advanced Linear Algebra (A); DKU MATH 303 ODE and Dynamic Systems (A-); DKU MATH 408 Differential Geometry (A) My Notes; Duke MATH 412 (MATH 713) Topological Data Analysis.

Honors & Awards

Dean's List with Distinction - Duke Kunshan University *Fall 2019, Spring 2022*
Dean's List - Duke Kunshan University *Fall 2020, Sring 2021, Fall 2021*
Summer Research Scholar - Duke Kunshan University *Jun 2020, Jun 2022*
Mathematical Contest In Modeling - Honorable Mention *Apr 2020*

Skills

Programming: Proficient in Python, C++, C for CUDA, R, MATLAB, Mathematica, LaTeX
Frame: Pytorch, TensorFlow, Keras, Gym for RL
English: GRE 324 (V 156, Q 168), TOEFL 108