Eric Qu

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Education

University of California, Berkeley *Sep 2023 -*
Ph.D. in Computer Sciences (advisor: Aditi S. Krishnapriyan) Berkeley, USA
Member of Berkeley AI Research Lab

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)

Research Interest

My research interest mainly falls on **Geometric Deep Learning** and **AI for Science**. I also have experience in LLMs, sequence modeling, and graph neural networks. 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, Luo, Xufang, Li, Dongsheng. "Data Continuity Matters: Improving Sequence Modeling with Lipschitz Regularizer" *International Conference on Learning Representations (ICLR)* **Spotlight** (Notable Top 25%) (2023).

Qu, Eric, Wang, Yansen, He, Wenqiang, Luo, Xufang, Li, Dongsheng. "CNN Kernels Can Be the Best Shapelets" *Preprint* (2023).

Qu, Eric, Zou, Dongmian. "Hyperbolic Convolution via Kernel Point Aggregation" *arXiv:2306.08862*.

Qu, Eric, Zou, Dongmian. "Autoencoding Hyperbolic Representation for Adversarial Generation" *arXiv:2201.12825*.

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

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 - May 2023*
Adviser: Dongmian Zou *Jiangsu, China*

- Autoencoding Hyperbolic Representation for Adversarial Generation *Submitted to JMLR*
  - We propose a generative model (HAEGAN) in hyperbolic space that is capable of generating complex data.
  - 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 TPAMI*
  - 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 - Sept 2022*
Adviser: Dongsheng Li, 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 *ICLR 2023 Spotlight*
  - 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 most of the sequence models.
  - We empirically discovered 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, e.g. Transformers for Time series, Audio, Vision; S4 for Text.
- CNN Kernels Can Be the Best Shapelets *Submitted to NeurIPS 2023*
  - We introduce ShapeConv, a CNN layer offering an interpretable time-series modeling approach.
  - It bridges the gap between traditional shapelets and CNNs by acting as shapelet-style kernels, enhancing efficiency and accuracy while retaining interpretability.
  - The model's performance improves with human knowledge input, achieving top performance in benchmarks without compromising interpretability or controllability.

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.

Honors & Awards

Graduation with Distinction (Top 5%) - Duke Kunshan University	*May 2023*
Graduation with Latin Honors *cum laude* - Duke Kunshan University	*May 2023*
Zu Chongzhi Math Signature Work Award - Duke Kunshan University Zu Chongzhi Math Center	*May 2023*
Conference Travel Grant (ICLR 2023) - Duke Kunshan University	*May 2023*
Conference Travel Grant (NeurIPS 2022) - Duke Kunshan University	*Dec 2022*
Summer Research Scholar - Duke Kunshan University	*Jun 2020, Jun 2022*
Dean's List with Distinction - Duke Kunshan University	*Fall 2019, Spring 2022*
Dean's List - Duke Kunshan University	*Fall 2020, Sring 2021, Fall 2021*