Yue Song

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Biography

I am a Computing & Mathematical Sciences postdoctoral research associate at Caltech, supervised by Yisong Yue, Pietro Perona, and Max Welling. I pursued doctoral studies under European Laboratory for Learning and Intelligent Systems (ELLIS), where I was affiliated with Multimedia and Human Understanding Group (MHUG) at the University of Trento, Italy and Amsterdam Machine Learning Lab (AMLab) at University of Amsterdam, the Netherlands, advised by Nicu Sebe and Max Welling. Prior to my Ph.D. studies, I received the B.Sc. *cum laude* from KU Leuven, Belgium and the joint M.Sc. *summa cum laude* from the University of Trento, Itatly and KTH Royal Institute of Technology, Sweden, co-advised by Nicu Sebe and Kevin Smith. Besides the technical master's degree, I received an Innovation & Entrepreneurship minor degree from European Institute of Innovation and Technology (EIT Digital).

Research Interests

I research structured representation learning — I am devoted to leveraging beneficial inductive biases from scientific disciplines such as math, physics, and neuroscience to improve and explain machine learning models. My current research is not task-oriented; I do not focus on a particular ML task. Instead, I am interested in developing structured methods and finding their appropriate usage in the wide application domain.

The specific deep learning fields I have worked on include high-order representation learning, decorrelated representation learning, equivariant representation learning, disentangled representation learning, and detecting/handling distribution shifts. On a theoretical aspect, the developed methodologies involve numerical and statistical matrix analysis, computational methods of matrix functions/decompositions, physics-inspired deep learning, variational inference, and matrix manifold learning.

Appointment

California Institute of Technology — **Pasadena, California**
Position: Post-doctoral Research Associate — 2024–2026
Adviser: Yisong Yue, Pietro Perona, & Max Welling

Education

University of Amsterdam — **Amsterdam, the Netherlands**
ELLIS visiting Ph.D. student — 2022–2024
Adviser: Max Welling

University of Trento — **Trento, Italy**
Ph.D. student in Information Communication and Engineering — 2020–2024
Adviser: Nicu Sebe
Dissertation: Numerical Methods in Deep Learning and Computer Vision
Thesis Committee: Yisong Yue, Vitorrio Murino, & Paolo Rota

University of Trento & KTH Royal Institute of Technology — **Trento, Italy & Stockholm, Sweden**
M.Sc. summa cum laude in Electrical Engineering — 2018–2020
Adviser: Nicu Sebe & Kevin Smith
Examiner: Prof. Danica Kragic

KU Leuven — **Leuven, Belgium**
B.Sc. cum laude in Electrical Engineering — 2014–2018

Selected Publications

My research in structured representation learning draws inspiration from diverse fields — such as matrix manifolds, neuroscience, and physics — and spans the following topics:

– **Matrix Manifold Learning**:
- **Yue Song**, Nicu Sebe, and Wei Wang. "Why Approximate Matrix Square Root Outperforms Accurate SVD in Global Covariance Pooling?" ICCV 2021.
- **Yue Song**, Nicu Sebe, and Wei Wang. "Fast Differentiable Matrix Square Root." ICLR 2022.
- **Yue Song**, Nicu Sebe, and Wei Wang. "Fast Differentiable Matrix Square Root and Inverse Square Root." IEEE T-PAMI 2022.
- **Yue Song**, Nicu Sebe, and Wei Wang. Batch-efficient Eigendecomposition for Small and Medium Matrices." ECCV 2022.
- **Yue Song**, Nicu Sebe, and Wei Wang. "Improving Covariance Conditioning of the SVD Meta-layer by Orthogonality." ECCV 2022.
- Ziheng Chen, **Yue Song**, Gaowen Liu, Ramana Rao Kompella, Xiaojun Wu, Nicu Sebe. "Riemannian Multinomial Logistics Regression for SPD Neural Networks." CVPR 2024.
- Ziheng Chen, **Yue Song**, Yunmei Liu, Nicu Sebe. "A Lie Group Approach to Riemannian Batch Normalization." ICLR 2024.
- Ziheng Chen, **Yue Song**, Rui Wang, Xiaojun Wu, Nicu Sebe. "RMLR: Extending Multinomial Logistic Regression into General Geometries." NeurIPS 2024. - Ziheng Chen, **Yue Song**, Yunmei Liu, Nicu Sebe. "A Lie Group Approach to Riemannian Batch Normalization." ICLR 2024.
- Ziheng Chen, **Yue Song**, Xiaojun Wu, Gaowen Liu, Nicu Sebe. "Understanding Matrix Function Normalizations in Covariance Pooling from the Lens of Riemannian Geometry." ICLR 2025.
- Ziheng Chen, **Yue Song**, Xiaojun Wu, Nicu Sebe. "Gyrogroup Batch Normalization." ICLR 2025.

– **Equivariant and Disentangled Representation Learning**:
- **Yue Song**, Nicu Sebe, and Wei Wang. "Orthogonal SVD Covariance Conditioning and Latent Disentanglement." IEEE T-PAMI 2022.
- **Yue Song**, Jichao Zhang, Nicu Sebe, Wei Wang. "Householder Projector for Unsupervised Latent Semantics Discovery." ICCV 2023.
- **Yue Song**, T. Anderson Keller, Nicu Sebe, Max Welling. "Latent Traversals in Generative Models as Potential Flows." ICML 2023.
- **Yue Song**, T. Anderson Keller, Nicu Sebe, Max Welling. "Flow Factorized Representation Learning." NeurIPS 2023.
- Guanghao Wei, Yining Huang, Chenru Duan, **Yue Song***, Yuanqi Du*. "Navigating Chemical Space with Latent Flows." NeurIPS 2024. (* denotes equal supervision)

– **Safe and Reliable Machine Learning**:
- **Yue Song**, Nicu Sebe, Wei Wang. "RankFeat: Rank-1 Feature Removal for Out-of-distribution Detection." NeurIPS 2022.
- **Yue Song**, Wei Wang, Nicu Sebe. "RankFeat&RankWeight: Rank-1 Feature/Weight Removal for Out-of-Distribution Detection." T-PAMI 2024.
- Lingkai Kong, Haorui Wang, Wenhao Mu, Yuanqi Du, Yuchen Zhuang, Yifei Zhou, **Yue Song**, Rongzhi Zhang, Kai Wang, Chao Zhang. "Aligning Large Language Models with Representation Editing: A Control Perspective." NeurIPS 2024.

💼 Professional Activity

Regularly serve as reviewers for T-PAMI, NeurIPS, ICLR, ICML, CVPR, ICCV, and ECCV.