Estelle Shen

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EDUCATION

University of Pennsylvania | College of Art and Science *Class of 2024*
Major: Mathematics

Relevant Coursework: AMCS 602 Numerical Analysis, ESE 605 Convex Optimization, PHYS 585 Theoretical and Computational Neuroscience, BE 521 Brain Computer Interface, ESE 546 Principles of Deep Learning, ESE 530 Elements of Probability Theory, ESE 500 Linear System Theory, MATH 514 Advanced Linear Algebra, STAT 430 Probability, MATH 340 Discrete Mathematics I (Combinatorics), MATH 360/361 Real Analysis, MATH 410 Complex Analysis, MATH 370/371 Abstract Algebra, MATH 350 Number Theory, MATH 241 Partial Differential Equations, MATH 114 Multivariable Calculus, CIS 240 Computer System, CIS 120 Program Design, Data Structure, Deep Learning, Reinforcement Learning

RESEARCH INTERESTS

I'm interested in reverse-engineering how the brain solves computational challenges using the mathematical language and artificial intelligence algorithms. I'm fascinated by the bidirectional interplay between theoretical neuroscience and AI, leveraging deep learning advancements. I'm interested in both the mathematical and biological correctness of artificial neural networks and in addressing the science of learning in complex models with understanding of computational neuroscience.

PUBLICATIONS

Osbert Bastani, Jason Y. Ma, **Estelle Shen**, Wanqiao Xu. *Regret Bounds for Risk-Sensitive Reinforcement Learning*. (NeurIPS 2022)

Estelle Shen, Konrad Kording, Richard Lange, Ari Benjamin. *Balanced excitation and inhibition could help estimate gradients.* (COSYNE 2023) (TALK) (Preprint)

Estelle Shen, Kan Xu, Osbert Bastani. *Stochastic Bandits with Strongly Convex Model Families.* (2023) (In Submission)

CONFERENCE PRESENTATIONS

Estelle Shen, Yu Hao, Hyeokmoon Kweon, Lyle Ungar, Martha J. Farah. *Lower Memory Ability in Lower SES Is Not Explained by Smaller Hippocampi.* (APS 2023) (SFN 2023)

Estelle Shen, Konrad Kording, Richard Lange, Ari Benjamin. *Balanced excitation and inhibition could help estimate gradients.* (COSYNE 2023) (TALK)

RESEARCH EXPERIENCE

Kording's Lab
Research Assistant *Oct 2022 — Current*
Advisor: Konrad Kording

Balanced Excitation and Inhibition Could Help Estimate Gradients

- Implemented a biologically plausible gradient-based learning algorithm that assigns credit through multi-layer networks using pytorch, which promises to draw a throughline from the computational goal of credit assignment to its implementation in known physiology and plasticity rules.

Complexity of Local Learning Rules (In progress)

- Determined the time complexity in terms of operations and iterations of a set of recently proposed biologically plausible approximations of gradient descent, including feedback alignment, contrastive learning, predictive coding, attention-gated reinforcement learning, node perturbation, weight perturbation, and equilibrium propagation. Focusing on convergence rates in deep linear settings we argued that a range of proposed algorithms can not credibly be good models of credit assignment in the brain.

Center for Neuroscience and Society
Research Assistant *July 2022 — Dec 2022*
Advisor: Martha Farah
Heterogeneity in Brain Imaging of Depression Patients
- Utilized machine learning methods and whole brain structural ROIs and cognitive functional data to reveal heterogeneity of depression in relation to SES in middle and older adults with depression on the basis of clinical threshold.

Lower Memory Ability in Lower SES Is Not Explained by Smaller Hippocampi
- Tested the hypothesis of hippocampal mediation of the SES-memory relation with moderation of depression and obtained null result.

trustML@Penn
Research Assistant
Advisor: Osbert Bastani *Oct 2021 — Current*
Regret Bounds for Risk-Sensitive Reinforcement Learning
- Designed and ran experiments that show the first regret bounds converge for reinforcement learning under a general class of risk-sensitive objectives including the popular CVaR objective.

Interpretable Risk-Sensitive Reinforcement Learning
- Proposed an imitation learning algorithm for extracting risk-sensitive decision tree policies, bound the training loss of this algorithm, and used our algorithm to learn a provably robust decision tree policy for real GPU query tasks, which achieves performance equal to that of the original optimal policy.

Stochastic Bandits with Strongly Convex Model Families
- Generalized bandit problem from linear settings to non-linear settings with parametric model rewards and strongly convex loss functions, resulted in an algorithm that effectively achieves the square root of T regret.

SKILLS

Programming
- Knowledge of Python, Java, C/C++, C#, HTML, CSS, and Javascript
- Familiarity with deep learning frameworks including PyTorch and Tensorflow.