Xiaoran Cheng

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EDUCATION

University of Chicago, Chicago, IL

- M.S. in Statistics — Sep 2022 – Jun 2024
  - Cumulative GPA: 3.89 / 4.0

Indiana University, Bloomington, IN

- B.S. in Finance, Minor in Mathematics & Statistics — Aug 2017 – Dec 2021
  - Graduated with Highest Distinction
  - Founders Scholar
  - Cumulative GPA: 3.94 / 4.00

RESEARCH INTERESTS

Machine learning
Data science
Machine learning and optimization, optimal control
Large scale optimization
Stochastic optimization
Scientific machine learning
AI for science: applications in finance, healthcare, computational biology

RESEARCH EXPERIENCE

Professor Dacheng Xiu Lab, University of Chicago — Jul 2023 – Present

Expected Returns and Large Language Models

- Enhanced and completed the section on stock return prediction for daily long-short portfolio performance in the paper titled "Expected Returns and Large Language Models"
- Achieved a 5 times higher accuracy compared to Ridge and Logistic Regression in the paper on out-of-sample return predictions based on newswire sentiment embeddings from LLMs, including OPT, GPT2, and Bert, using Multilayer Perceptron (MLP) and XGBoost
- Improved transaction information accuracy in newswire sentiment embeddings by shifting 30-minute pre-market news to subsequent trading data across 10+ countries. This adjustment enhanced the alignment with financial theory and market demand, optimizing portfolio performance
- Refined pre-existing code for preprocessing based on time series data properties and ensured that validation and out-of-sample predictions do not leak future data
- Implemented XGBoost on a massive dataset with 5 million rows and 3,000 features and utilized Bayesian optimization from Ray and Hyperopt for hyperparameter tuning, achieving 3 times higher accuracy in out-of-sample stock return predictions
- Developed a MLP model on the same dataset, achieving a 5 times improvement in out-of-sample return predictions. Incorporated techniques such as batch normalization, residual connection, L_1/L_2 regularization, and dropout to enhance model generalization
- Configured GPU settings in the Research Computing Center, implemented a TensorFlow data generator to fit GPU memory, and deployed a data parallelism mechanism for multi-GPU training

Professor Mladen Kolar and Dr. Sen Na ML Lab, University of Chicago — Jan 2023 – Present

Hard-constrained Neural Networks for PDE Solving

- Working on a paper that addresses the failures of soft-constrained methods like Physics-informed Neural Networks (PINNs) in solving complex PDEs, by employing various hard-constrained methods with NNs. Achieved an improvement in prediction accuracy ranging from 10 to 100 times using Trust Region Sequential Quadratic Programming (SQP)
- Implemented a variety of penalty methods with NNs: utilized the L_2^2 penalty method, non-differentiable exact penalty methods (L_1, L_2, L_∞), and differentiable exact penalties (Fletcher's and Pillo's). Also integrated the Augmented Lagrangian Method (ALM), differentiable exact ALM, and Trust Region SQP within the JAX and JAXopt frameworks
- Introduced a novel pre-training step that uses only physical data (IC, BC, PDE residuals) to address SQP's scaling issue, ensuring initial parameters are within the constraint region
- Conducted thorough experiments on three distinct problems: Transport, Reaction, and Reaction-diffusion equations. Moreover, six specific experiment types were performed for each problem, demonstrating Trust Region SQP-based NNs' robustness to both problem-specific parameters and hyperparameters of the algorithm
- Demonstrated Trust Region SQP-based NNs' ability to escape local minima and tackle PINNs' ill-conditioning issues, underscoring the profound impact of optimization in machine learning for superior accuracy and efficiency
- A paper detailing these results is in the works

Real-time Model-free Nonlinear Model Predictive Control

- Working on a paper that combines real-time model-free Nonlinear Model Predictive Control (NMPC) and NNs to solve optimal control problems

- Designed an algorithm that uses PINN to predict states of a dynamical system for the NMPC, shifting the previous output of NMPC to the next receding horizon as input for PINN. This improves state prediction and provides a warm start for solving NMPC using SQP as a real-time iterative approach
- Delved into relaxation strategies for inequality constraints in SQP. Reviewed techniques, including slack variables and Powell's method, to guarantee algorithmic robustness
- Established a benchmark using SQP-based NNs to solve PDE-constrained optimization, to observe the convergence of the real-time model-free NMPC parameters to this established standard
- The practical implementation of this proposed methodology is underway

Professor Preetesh Kantak, Indiana University May 2021 – Sep 2022

On-chain Bitcoin Volatility and Industrial Organization Analysis

- Downloaded a copy of the Bitcoin blockchain by using Singularity and Docker to run a full node on IU's supercomputer called Carbonate
- Decoded the structure of blocks of raw Bitcoin transactions on the blockchain by using BlockSci in Python and, in parallel, parsed around 3,000 raw blockchain blkXXXXX.dat files into transaction-based CSV files on Carbonate
- Identified that 90% of on-chain Bitcoin transactions are intra-entity. Utilized clustering techniques to map transactions to unique entities, yielding an entity-level dataset
- Constructed risk factors based on on-chain Bitcoin data and off-chain Bitcoin exchange data, using information from Cryptoquant and Glassnode, and the parsed results
- Completed a 40-page report, complemented by presentation slides, detailing the properties and problems of blockchain Bitcoin. Emphasized the clustering algorithms and heuristics implemented for excluding non-economic meaningful volume
- Demonstrated the mean-reverting effect and the informational advantage of on-chain players in the report using hierarchical clustering heatmap, graph analysis, GARCH, and factor model analysis
- Presented findings and potential research questions in Kelley School of Business finance department

PUBLICATIONS

[1] Cheng, X. et al., "Towards Resolving Failure Modes of PINN: A Numerical Optimization Approach," *In preparation*, 2023.

PROFESSIONAL EXPERIENCE

Deloitte, Shanghai, China Feb 2022 – Jul 2022

Quantitative risk analyst intern

- Developed a stock pledge rate prediction product using CART and XGBoost, which helped securities companies offer risk-controlled stock pledge rates to about 3,000 companies
- Performed feature engineering for more than 30 indicators with fundamental and alternative data and designed special dependent variables based on the stock pledging risk timeline to predict the pledge rate risk level of each Chinese stock
- Utilized the CART model to standardize and transform indicators to achieve a better AUC score
- Performed PSI, IV, and transformation matrix analyses on selected indicators to ensure a more stable model and, after trying various classification models, applied XGBoost for prediction
- Improved efficiency in feature calculation accuracy checking by developing a Python pipeline. This pipeline automatically calculates differences between my feature calculations and those of the software engineering team, contributing to further improvements in the APP product's implementation
- Independently wrote more than 10 reports with slides to demonstrate and explain model usage, validation, and backtesting to clients, and launched the model on clients' machine learning servers. The model was successfully commercialized and sold to several securities companies at a very competitive price

Civic Champs, Bloomington, IN May 2021 – Aug 2021

Data analyst intern

- Developed a PostgreSQL Restful API and a database-driven dynamic website using React JS for volunteer opportunity searching platform populated with 1.8M rows of IRS NGO data using self-implemented Python web scrapers and connected to the Firebase database
- Addressed data quality issues by designing an algorithm to handle missing fields and duplications; achieved 98% deduplication accuracy using fuzzy string matching and a supervised learning method
- Configured a web scraper for periodic data extraction, streamlining data cleaning, and deduping before database population and renewal of the webpage

PROJECTS

Wasserstein GAN, University of Chicago Nov 2023

- Investigated the Wasserstein distance and weight clipping for enforcing Lipschitz continuity of the critic described in the original Wasserstein GAN paper
- Performed experiments to verify the effect of the loss function used in the critic for approximating Wasserstein distance by replacing the loss function with binary cross-entropy loss and running for an increasing number of critic iterations on the MNIST dataset
- Gave a presentation on the findings that weight clipping contributed the most benefits for stabilizing Wasserstein GAN instead of the loss function used to approximate Wasserstein distance

Gated PixelCNN, University of Chicago Oct 2023

- Investigated the sigmoid "gate" and blind spot removal strategy described in the original Gated PixelCNN paper

- Implemented the corrected blind spot removal strategy by introducing two types of masks and performed experiments to verify the effect of the sigmoid “gate” by replacing the sigmoid with tanh, a randomized 0-1 “gate”, and without a “gate” on MNIST and CIFAR-10 datasets
- Presented findings that both the absence of a ’gate’ and the use of a tanh ’gate’ resulted in a lower test negative log-likelihood, which suggests that the improvements in Gated PixelCNN may stem from full dependence on previous pixels and the introduction of additional parameters
- Enhanced the model’s efficiency by integrating Skip Connection and Residual Connection, achieved a test negative log-likelihood of 0.23

Hierarchical Dirichlet Processes Model and Slice Sampler, University of Chicago May 2023

- Developed and implemented slice sampling methods to transform infinite mixtures in hierarchical dirichlet processes to manageable finite numbers, so that MCMC is possible
- Utilized the refined model to reveal the cluster membership of patients

R Linear Regression Modeling, Indiana University Nov 2022

- Performed exploratory data analysis and residual analysis to explore the inner connections of the dataset, enabling quicker and more effective determination of the most suitable regression model
- Utilized Box-Cox and shifted log transformation for fitting nonlinear trend and nonconstant variance
- Calculated studentized residuals and leverage scores of the data points to identify outliers and influential points
- Chose covariates based on ANOVA tables and performed a forward stepwise selection strategy based on F test for interaction terms with Bonferroni correction for solving multiple testing issues
- Built Ridge Regression due to high variance inflation factor scores to stabilize the model performance by allocating balance coefficients to those collinear columns, and performed cross-validation to choose the best lambda using cv.glmnet

R Bayesian Regression Modeling, Indiana University Nov 2021

- Performed EDA and residual analysis to explore the possible interaction terms and group differences
- Built a Bayesian Regression model with Zellner’s g-prior from the previous EDA process and performed the model selection process using Bayes Factors
- Specified priors for the model parameter(normal), created a model mapping, and had the MCMC algorithm draw samples from the posterior distribution for the model parameters

LANGUAGES Native: Mandarin, Chinese
Fluent: English

SKILLS Python, R, SQL, STATA, JAVA, Node JS, HTML, CSS, JavaScript, Microsoft Office, Pytorch, Tensorflow, Jax, Git, Linux Shell, LaTeX

INTERESTS Table tennis, Brazilian Jiu-Jitsu, hiking, road tripping, movies