Pengyuan Zhai

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GitHub: github.com/BILLYZZ
Structural Software: app.fedeas.com

Education

University of California, Berkeley Berkeley, CA, USA
2016-2020 (expected)

B.S. in Industrial Engineering and Operations Research (Upper Division Major GPA: 4.00/4.00)
B.S. in Civil and Environmental Engineering (Upper Division Major GPA: 3.75/4.00)
Minor in Electrical Engineering and Computer Science (Minor GPA: 3.85/4.00)

- Relevant Coursework: Optimization (convex, discrete, mixed integer programming, SVD, dynamic programming, etc.), Machine Learning Models (SVM, CNN, Ensemble Learning, etc.), Artificial Intelligence Methods (tree searches, Markov Decision Processes, Bayesian networks, etc.), Stochastic Processes, Queuing Networks, Supply Chains, Enterprise-scale Simulations, Structural Analysis, System Optimization, Number Theory, Probability Theory, Cryptography, Data Structures, Machine Structures.
- Research Keywords: Generative Adversariabl Network (GAN), Simulated Quantum Annealing (SQA), Path integral Monte Carlo (PIMC), Natural Language Processing (NLP), Discrete Optimization, Structural Engineering, Structural Health Monitoring.

Please visit my personal website at billyzz.github.io to view papers, code, and research details.

Research

Semi-supervised Knowledge Distillation GAN for Sentence Classification Summer 2020-Now
Project Name: Text Analytics for Resilience-Enabled Extreme Events Reconnaissance (TAR)
PI: Prof. Laurent El Ghaoui (EECS Dept., Berkeley Artificial Intelligence Research)

- Designed a semi-supervised learning Generative Adversarial Network (GAN) with knowledge distillation (where the Generator learns smooth vector representations of sentences in the same embedding manifold as the Discriminator to enable the flow of differentiable gradients through back-propagation) for text classification, as an intermediate pipeline for automatic generation of natural disaster briefings.
- Paper Title: *Text Analytics for Resilience-Enabled Extreme Events Reconnaissance* (workshop version[1])

Path Integral Monte Carlo and Simulated Quantum Annealing with GAN Summer 2020-Now
Independent Research

- Proposed and designed a semi-supervised SQA-GAN for learning simulated quantum Ising spin configurations, whose architecture is inspired by Conditional GAN and Reg-GAN: conditional labels are input to the Generator to direct the generation of realistic Ising spin configurations at given transverse field strengths (continuous labels), and a regression output is added to the Discriminator for learning the continuous-label distribution.
- Implemented a Markov chain Monte Carlo (MCMC) quantum annealing simulator via the path-integral method (PIMC), which supplies the training and test data for the SQA-GAN, whose Generator ultimately learns the spin distribution and acts as an efficient, pre-trained quantum annealing Ising simulator.
- Paper Title: *Simulated Quantum Annealing with GAN* (in progress: design docs ready, conducting experiments and analyses)

Balanced Semi-supervised GAN under Low Data and Extreme Class Imbalance 2018-Now
PI: Prof. Khalid M. Mosalam (CEE Dept., Director of Pacific Earthquake Engineering Research Center)

- Designed a semi-supervised learning GAN with the balanced-batch sampling technique during training for vision-based infrastructure damage detection, which was proven to be robust under extreme class imbalance (32:2:1 class ratio for "Undamaged", "Cracking", and "Spalling" categories).

– Paper Title: *Balanced Semi-supervised Generative Adversarial Network in Vision-based Structural Damage Assessment under the Low-data and Imbalanced-class Regime* (conference[2] and journal[3] versions)

Discrete Optimization of Energy Conservation Measures for LBNL CBES 2019-2020

Lawrence Berkeley National Laboratory

PI: Dr. Tianzhen Hong (Deputy Head of the Building Technologies Department, LBNL)

– Designed a mixed integer programming (MIP) optimization algorithm with dynamic constraint generation that finds the top N best combinations of building energy conservation measures (ECMs) that can be retrofitted to an old building. This algorithm serves as an intermediate process to the building energy optimization engine of LBNL's Commercial Building Energy Saver (CBES) software.

– Implemented the ECM algorithm on two optimization platforms: Gurobi with Python and GNU Linear Programming Kit with Ruby (refer to GitHub).

Linear Programming in Plastic Structural Analysis 2018-2019

Mentored by Prof. Filip C. Filippou (Structural Engineering Chair, CEE Dept.)

– Investigated the fundamental dual relationship between the upper and lower bound methods in plastic structural analysis and connected these methods to the linear programming simplex algorithm by providing a step-to-step analysis of a 3-element plane truss model.

– Manuscript Title: *A Linear Programming View on Plastic Structural Analysis* (manuscript [4])

Structural Solver Web Application Development 2018-2019

Mentored by Prof. Filip C. Filippou (Structural Engineering Chair, CEE Dept.)

– Migrated the linear structural solver of Prof. Filippou's FEDEASLab software (Finite Elements for Design, Evaluation and Analysis of Structures) from Matlab to Java and developed a web application named FEDEASWeb, which supports linear truss solving with force and displacement methods, real-time graphics and matrix outputs.

– Web Application Link: app.fedeas.com

Publications

[1] A. Tsai, S. Gunay, P. Zhai, C. Li, M. Hwang, L. El Ghaoui, and K. Mosalam, "Text Analytics for Resilience-Enabled Extreme Events Reconnaissance", in *Artificial Intelligence for Humanitarian Assistance and Disaster Response Workshop*, Oct. 2020, (submitted).

[2] Y. Gao, K. Mosalam, and P. Zhai, "Balanced Semi-supervised Generative Adversarial Network in Vision-based Structural Damage Assessment under Imbalanced-class and Low-data Regime", in *17th Word Conference on Earthquake Engineering Proceedings*, Sep. 2020, Index 9c–0024 in Section 9: Innovative Technology.

[3] Y. Gao, P. Zhai, and K. Mosalam, "Balanced semi-supervised generative adversarial network in vision-based structural damage assessment under imbalanced-class and low-data regime", *Computer-Aided Civil and Infrastructure Engineering*, (submitted).

Manuscripts in Preparation

[4] P. Zhai, "A Linear Programming View on Plastic Structural Analysis", 2018.

[5] P. Zhai, "Simulated Quantum Annealing with GAN", 2020, in progress.

Lecture Material

[6] K. Mosalam, Y. Gao, and P. Zhai, "Part 4: Data-driven Vision-based Structural Health Monitoring", in *Cyber-Physical Modeling and Machine- Learning Towards Smart Electrical Equipment Systems*, pp. 19–23.