Pengyuan Zhai

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Structural Software: app.fedeas.com

Education

University of California, Berkeley Berkeley, CA, USA
Graduated on December 18, 2020
B.S. in Industrial Engineering and Operations Research (Upper Division Major GPA: 3.97/4.00)
B.S. in Civil and Environmental Engineering (Upper Division Major GPA: 3.75/4.00)
Minor in Electrical Engineering and Computer Science (Minor GPA: 3.67/4.00)

- Research Keywords: Generative Adversarial Networks (GANs), Graph Attention Networks (GATs), Simulated Quantum Annealing (SQA), Path integral Monte Carlo (PIMC), Natural Language Processing (NLP), Discrete Optimization, Enterprise and Urban-scale Simulations, Structural Engineering, Structural Health Monitoring.
- Relevant Coursework: Optimization (mixed integer programming, second-order cone and robust models, semi-definite models, dynamic programming, network flow problems, etc.), Machine Learning (SVM, neural network, Bayes network), Stochastic Processes and Queuing Theory, Supply Chains, Enterprise-scale Simulations, Structural Analysis, System Optimization, Number Theory, Probability Theory, Cryptography, Data Structures, Machine Structures.

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

Research

Extreme-event Text Analytics and Multimodal Information Retrieval Ongoing
PI: Prof. Laurent El Ghaoui (EECS Dept., Berkeley Artificial Intelligence Research)

- Paper Title: *Text Analytics for Resilience-Enabled Extreme Events Reconnaissance [1]* (NeurIPS 2020 AI for Humanitarian Assistance and Disaster Response Workshop)
- Designed a semi-supervised GAN sentence classifier with Knowledge Distillation for automatic generation of natural disaster briefings.
- Co-presented at NeurIPS 2020 AI for Humanitarian Assistance and Disaster Response Workshop
- Currently working on a Generative Adversarial Network (GAN) based multimodal information retrieval model with Graph Attention Networks that finds semantically relevant multi-source image-text pairs across the internet related to a given extreme event.

Path Integral Monte Carlo and Simulated Quantum Annealing with GAN Ongoing
Independent Research

- Paper Title: *Simulated Quantum Annealing with GAN* [2] (in progress: design documents ready, conducting experiments and analyses)
- Introduced and designed a semi-supervised GAN that simulates quantum annealing Ising spin configurations (SQA-GAN). The model captures conditional distributions of quantum spins at given continuous transverse magnetic fields, which could then serve as a quantum annealing simulator; implemented quantum annealing path-integral Markov chain Monte Carlo (PIMC) to generate training and test data.

Balanced Semi-supervised GAN under Low Data and Extreme Class Imbalance 2018-2020
PI: Prof. Khalid M. Mosalam (CEE Dept., Director of Pacific Earthquake Engineering Research Center)

- Paper Title: "Balanced Semi-Supervised GAN in Structural Damage Assessment from Low-Data Imbalanced-Class Regime" (to be published in the journal of *Computer-Aided Civil and Infrastructure Engineering* [3]
- Paper Title: "Balanced Semi-supervised Generative Adversarial Network in Vision-based Structural Damage Assessment under Imbalanced-class and Low-data Regime" (to appear in *17th Word Conference on Earthquake Engineering Proceedings* [4]))

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

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) to be retrofitted to an old building. This algorithm contributed to 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).

R-Tree for Spatially Joining Urban Multi-polygon Data 2019-2020

Lawrence Berkeley National Laboratory

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

– Implemented the R-Tree algorithm to fast join building data records by matching geo-spatial multipolygons and develop building energy benchmark datasets for Lawrence Berkeley National Laboratory's City Building Energy Saver (CityBES).

Linear Programming in Plastic Structural Analysis 2018-2019

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

– Investigated the fundamental primal-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 [5])

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, M. Hwang, P. Zhai, C. Li, L. El Ghaoui, and K. Mosalam, "Text Analytics for Resilience-Enabled Extreme Events Reconnaissance", in *NeurIPS 2020: Artificial Intelligence for Humanitarian Assistance and Disaster Response Workshop*, 2020-12, https://arxiv.org/abs/2011.13087.

[3] Y. Gao, P. Zhai, and K. Mosalam, "Balanced semi-supervised gan in structural damage assessment from low-data imbalanced-class regime", *Computer-Aided Civil and Infrastructure Engineering*, 2020, (to be published).

[4] 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*, postponed to 2021-09, Index 9c–0024 in Section 9: Innovative Technology, (to appear).

Manuscripts

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

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

[7] P. Zhai, "What makes satires satirical? discover patterns from french revolution media with deep learning", 2020, submitted to French Historical Studies, Duke University Press.

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.