Elioth Sanabria - https://eliotho.github.io

Contact Information

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Research Interests

Applied Probability, Optimization, Machine Learning and Reinforcement Learning with Applications to Operations Management. Ph.D. Thesis: "On the Misclassification Cost Problem and Dynamic Resource Allocation Models for EMS".

Education

Columbia University, New York, NY

Ph.D., Operations Research, September 2017 - October 2022
M.Phil., Operations Research, September 2017 - February 2020
M.Sc., Operations Research, September 2014 - December 2015

Universidad de los Andes, Bogota, Colombia

B.A., Economics, August 2009 - December 2012

Professional Experience

Staffing Analytics LLC, New York, NY
Chief Executive Officer - Chief Scientist, June 2023 - Present

- Developing custom-made data-driven optimization applications for large scale government and private projects. Including dynamic pricing, resource scheduling optimization, vehicle routing optimization and other applications. All this by leveraging big data and AI with state-of-the-art mathematical/statistical optimization models.
- Developing of a data analytics platform [Predictheus] for retail businesses doing demand forecasting, optimal pricing, inventory management and staff scheduling using data-driven models.
- Developing of a data-fusion platform to synthetize multi-modal data (video, audio and text) into data-driven knowledge graphs with applications to large scale data processing (for example, running analytics on thousands of traffic cameras to perform computer vision tasks). Combining signal reconstruction principles from Compressive Sensing as well as other ML techniques (CNNs, Small Language Models, etc).

The City of New York, New York, NY
Assistant Commissioner of Operations Research and Chief Efficiency Officer - DOC, September 2022 - June 2023

- Provided data analytic and mathematical modeling optimization tools for optimal scheduling of +5000 staff, with the objective of reducing of overtime and increasing scheduled appearances of staff using Stochastic Discrete Optimization. Forecasting of average daily population using Econometric and Queuing Theory techniques to inform operational needs related to supply-chain management. Implementation of Computer Vision algorithms for tracking humans and objects on live-video feed to track attendance using Convolutional Neural Networks. Lead a team of scientists and data analysts to deliver time-sensitive quantitative solutions and analyses.
- Built and deployed web based applications used by non-technical stakeholders to inform decision making using mathematical optimization and assessment of what-if scenarios for multiple projects including: jail population forecast, optimal hiring and promotion schedules, intake process optimization based on Queuing Theory and Second-Order Cone Programing.

Deputy Director of Operations Research - FDNY, June 2022 - September 2022

- Provided data analytic and mathematical modeling optimization tools for the department to improve ambulance dispatching, call center staffing, and scheduling risk-reduction fire inspections while aiming to improve key performance metrics leading a team of scientist to deliver time-critical solutions.
- Built and deployed web based applications used by non-technical stakeholders to inform decision making using mathematical optimization and assessment of what-if scenarios for multiple projects including: call center staffing, ambulance scheduling and risk-reduction based fire inspections.

Columbia University, New York, NY

Staff Research Assistant, July 2016 - September 2017

- Altair Engineering Inc., PG-008663, "Studies on Innovation Intelligence Quotient (IIQ) – A Data Analytic Approach" (PI: David D. Yao). Implemented stochastic modeling, machine learning and optimization techniques to identify key contributors and drivers that make a firm innovative. Developed a data-driven latent variable factor model to estimate an innovation index (Innovation IQ) for each company in the S&P 500. Identified KPI using LASSO and L-2 constrained regression on large databases (e.g. USPTO, COMPUSTAT, KLD, etc). Used Natural Language Processing techniques such as Latent Dirichlet Allocation and PageRank to build an innovation keyword dictionary.

Quantil — Applied Mathematics, Bogota, Colombia

Quantitative Analyst, August 2012 - August 2014

Implemented the following projects for different financial entities including a stock brokerage and a major pension fund in Colombia:

- "Portfolio Optimization". Developed a portfolio optimization paradigm using integer programming, clustering techniques and bayesian statistics to include opinions of an investment board into the optimization of the portfolio.
- "Basket of bonds valuation". Calibrated a multi-factor HJM model to value derivatives on a basket of bonds.
- "Swaps Porftfolio Optimization". Optimized a risk management model for a portfolio of swaps where the objective risk measure was the exposition to 'tranches' of a forward curve weighted by liquidity and preference.

Research Experience

Staffing Analytics, New York, NY

Principal Investigator, June 2023 - Present

Grant writer as Principal Investigator and research for the following projects:

- Development of a price and staff scheduling optimization algorithm/software powered by fundamental research advances in non-linear stochastic optimization targeting high-throughput labor-intensive businesses (ranging from call centers to retail businesses, facing a time-varying and price-elastic demand function) using Machine Learning, Queuing Theory and Stochastic Optimization.
- AI-Driven Cost-Sensitive Product Obsolescence Prediction and Replacement Scheduling. Development of a data-driven mis-classification cost model that estimates the obsolescence risk over time and also considers the tradeoff between the obsolescence probability vs the costs of re-procurement and outage. Hedging these risks optimally in a data-driven manner using stochastic optimization and machine learning.
- Event Based Light-weight Compressive Sensing Algorithms for Tracking in Space: Development of a sensing paradigm for Event Based Cameras using Compressive Sensing combined with machine learning to engineer "physics informed basis" to reconstruct signals sampled by the EBS for satellite applications.

- Reinforcement Learning Based Optimal Dynamic Control of Hot-walled CVD-SiC Epitaxy Process: Development of an optimal control algorithm based on Reinforcement Learning for a single-wafer epi reactor to maximize wafer throughput and minimize wafer surface defects (including morphology, nucleation or poor electrical conductivity) depending on the specific characteristics of the substrate by exploiting Design of Experiment (DOE) data.

Columbia University, New York, NY

Graduate Research Assistant, July 2016 - July 2022

Research under the supervision of Prof. David D. Yao, Henry Lam and Jay Sethuraman in the following projects:

- Google, FDNY and Tides Foundation "EMS Resource Deployment Modeling" (PI Henry Lam). Building of forecasting models for incident prediction in space and time adaptive to unexpected surges in intensity. Modeling and optimization of a simulation model to redesign and improve ambulance response times in EMS deployment in NYC. Modeling optimal scheduling of ambulance deployment to satisfy random incident demand in space and time using integer programing, convex optimization and RL. Modeling of optimal staffing of a EMS call center with varying call volume satisfying incident demand using second-order cone programming.
- AHRQ-R01-HS024915-01 "Nursing Intensity of Patient Care Needs and Rates of Healthcare-Associated Infections (NIC-HAI)" (PI: Elaine Larson). Built a simulation model using recurrent neural networks to forecast and identify risk factors in Healthcare-Associated Infections. Developed a ML-based algorithm to optimally give targeted preventive intervention to patients while minimizing mis-classification costs and infection rates.
- NSF-CMMI-1462495, "A Dynamic Model for Systemic Risk in Networks Subject to Contagion" (PI: David D. Yao). Implemented a time-dynamic default banking network model with illiquid assets. Studied the topology of worst-case banking networks when only marginal liabities are known in the Eisenberg-Noe model. Developed a formulation for optimal bail-outs in a time-dynamic banking network model with a bail-out budget.

City University of Hong Kong, Hong Kong, China

Visiting Fellow, Institute for Advanced Study. Summer, 2017-2018

Columbia University, New York, NY

Graduate Research Assistant, July 2015 - May 2016

Applied and computational research with Prof. Jose Blanchet in the following projects:

- NSF-CMMI-1436700, "Collaborative Research: Modeling and Analyzing Extreme Risks in Insurance and Finance" (PI: Jose Blanchet). Implemented Robust Performance Analysis for Actuarial Applications. Valued an insurance claim under a robust worst-case joint-distribution while preserving the marginal distributions, and also the robust case for uncertainty only in the marginals.
- "Steady-state simulation of reflected Brownian motion and related stochastic networks". Implemented parallel computing simulation of the stationary distribution of multidimensional Reflected Brownian Motions in Matlab.
- "Modeling and Analysis of Rogue Targets Avoiding a Detection". Implemented importance sampling techniques to estimate the energy of self-attractive multidimensional random walks in c++ via simulation.

Quantil — Applied Mathematics, Bogota, Colombia

Quantitative Analyst, August 2012 - August 2014

Worked under the supervision of Prof. Diego Jara in the following projects:

- "Portfolio Optimization". Developed a portfolio optimization paradigm using integer programming, clustering techniques and bayesian statistics to include opinions of an investment board into the optimization of the portfolio.
- "Basket of bonds valuation". Calibrated a multi-factor HJM model to value derivatives on a basket of bonds.
- "Swaps Porftfolio Optimization". Optimized a risk management model for a portfolio of swaps where the objective risk measure was the exposition to 'tranches' of a forward curve weighted by liquidity and preference.

Central Bank of the Republic of Colombia, Bogota, Colombia

Research Assistant, 2012

Research under the supervision of Prof. Jose Eduardo Gomez in the following projects:

- "Long Term Relation of Emerging Market Indexes". Estimated ARFIMA models to find evidence of fractional co-integration among emerging market indexes.
- "Non-Parametric and Semi-Parametric Asset Pricing: An Application to the Colombian Stock Exchange". Estimated a non-linear CAPM model using non-parametric and semi-parametric regression techniques and statistics.

Honors and Awards

Finalist **Doing Good with Good OR Paper Competition** INFORMS 2021.

Finalist **U.S. Army xTechLive Competition** "Software-based AI-powered fusion engine" DEF CON 33, 2025.

Research Papers

Sanabria E, Yao D.D and Lam H. Decision Tree Algorithms for MDP. (In preparation).

Lam H, Lelo de Larrea E, Sanabria E, Sethuraman J. et al. Hospital Load Balancing: A Data-Driven Approach to Optimize Ambulance Transports during the COVID-19 Pandemic in New York City. Management Science (Submitted) 2021. **Finalist Doing Good with Good OR Paper Competition INFORMS 2021.**

Sanabria E, Lam H, Lelo de Larrea E, Sethuraman J. et al. Short-Term Adaptive Emergency Call Volume Prediction. WSC 2021.

Lelo de Larrea E, Lam H, Sanabria E, Sethuraman J. et al. Simulating New York City Hospital Load Balancing During COVID-19. WSC 2021.

Sanabria E., and Yao D.D. Generalization Bounds for Classification on Finite Support (In preparation).

Calfee D, Cohen B, Larson E, Sanabria E., Shang J, and Yao D.D. Predicting Healthcare-associated Infections, Length of Stay, and Mortality with the Nursing Intensity of Care Index. (Accepted to Infection Control & Hospital Epidemiology). 2021.

Zachariah P, Sanabria E, Liu J, Cohen B, Yao D.D, Larson E. Novel Strategies for Predicting Healthcare-Associated Infections at Admission: Implications for Nursing Care. Nurs Research. 2020; 69(5):399-403.

Sanabria E, and Yao D.D. Minimizing Misclassification Cost in Machine Learning, with Applications to HAI Prediction. R&R Management Science (2019-).

Gomez J, and Sanabria E. Non-parametric and semi-parametric asset pricing: An application to the Colombian stock exchange. Economic Systems 38.2 2014: 261-268.

Invited Talks

Ph.D. Student Seminar, Columbia University, July 2018.

INFORMS Annual Meeting, Phoenix, Arizona, November 2018.

Nursing School Doctoral Seminar Series, Columbia University Medical Center, April 2019.

Quantil Research Seminar, Bogota, Colombia, August 2019.

INFORMS Annual Meeting, Anaheim, California, October 2021.

Amazon Tech Talk (Virtual), February 2024.

NYC Department of Transportation - DCAS, November 2024.

Urban Mobility AI Workshop, Columbia University, November 2024.

Quantil Research Seminar (Virtual), April 2025.

Poster Presentations

Financial and Business Analytics - DSI capstone poster presentation, Columbia University, November 2018.

NYC Operations Day, Columbia University, March 2019.

Data Science Day, Columbia University, April 2019.

Teaching Experience

Columbia University, New York, NY

Teaching Assistant — Fall 2017

IEOR 4106 Stochastic Models (CVN).

IEOR 4524 Analytics in Practice.