

# Ziyao (Richard) Cui

(919)943-1204 | [richard.cui@duke.edu](mailto:richard.cui@duke.edu) | [ziyao-cui.github.io](https://ziyao-cui.github.io)

## EDUCATION

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### Duke University

Durham, NC

*Bachelor of Science in Computer Science*

*Expected May 2026*

- GPA: 4.0/4.0
- Majors: Computer Science (Artificial Intelligence and Machine Learning Concentration), Statistical Science (Data Science Concentration), Economics (Minor)
- Advisors: Dr. Jian Pei, Dr. Cynthia Rudin, Dr. Edric Tam
- Honors: The Phi Beta Kappa Honor Society, Dean's List with Distinction
- Courses: Machine Learning Theory & Algorithm (Graduate), Real Analysis (Graduate), Data Science Competition, Deep Learning, Optimisation for Data Science, Bayesian and Modern Statistics, Statistical Learning & Inference

## PUBLICATIONS

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- **Ziyao Cui**, Minxing Zhang, and Jian Pei. On Membership Inference Attacks in Knowledge Distillation. *arXiv preprint arXiv:2505.11837*, 2025.

## PUBLICATIONS IN PREPARATION

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- Graph Learning with Missing Data via Generalized Spectral Embeddings (to be submitted to ICLR)
  - **Ziyao Cui**, Edric Tam
- Knowledge Distillation as Uncertainty Transformation
  - **Ziyao Cui**, Jian Pei
- Revisiting Broken Windows Theory (to be submitted to Harvard Data Science Review)
  - **Ziyao Cui**, Erick Jiang, Nicholas Sortisio, Haiyan Wang, Eric Chen, Cynthia Rudin
- Bayesian Small Area Estimation of Inadequate Micronutrient Intake (to be submitted to International Journal of Health Geographics)
  - Sahoko Ishida, Mohammed Aheed Osman, **Ziyao Cui**, Seth Flaxman
- FoodSat: Small Area Estimation for Food Security Analysis with Satellite Imagery
  - **Ziyao Cui**, Sahoko Ishida, Seth Flaxman
- Attacks via Machine Learning: Uncovering Privacy Risks in Sequential Data Releases
  - **Ziyao Cui**, Minxing Zhang, Jian Pei

## PROFESSIONAL SERVICE

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**Reviewer:** *NeurIPS* (2025)

## RESEARCH EXPERIENCE

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### Knowledge Distillation as Uncertainty Transformation

May 2025 – Present

*Student Researcher*

*Durham, NC*

- Advisor: Dr. Jian Pei, Duke University
- Conducted theoretical and empirical study on how knowledge distillation reshapes model uncertainty, introducing the concepts of inter-student and intra-student variance and identifying key sources of uncertainties in the knowledge distillation process.

- Demonstrated and proved that distillation systematically suppresses intra-student uncertainty while introducing inter-student uncertainty, revealing tradeoffs between fidelity and expressiveness.
- Discovered a novel choice overload effect in multi-response distillation, drawing parallels between LLM behavior and human cognitive biases.

## **Graph Learning with Missing Data via Generalized Spectral Embeddings**

May 2025 – Present

*Student Researcher*

*Durham, NC*

- Advisor: Dr. Edric Tam, Warren Alpert Fellow at Stanford University
- Designed and implemented a novel framework for augmenting graph neural networks with generalized spectral embeddings, enabling robust learning under sparse or missing node features.
- Developed theoretical analysis connecting spectral graph operators to structural phenomena (affinity vs. core-periphery), and proposed practical guidelines for operator selection.
- Conducted large-scale experiments on simulated, curated, and real-world datasets, including stochastic block models, Twitch Egos, and LastFM Asia datasets.

## **Bayesian Small Area Estimation of Inadequate Micronutrient Intake**

April 2025 – Present

*Student Researcher*

*Oxford, United Kingdom*

- Advisor: Dr. Seth Flaxman, Oxford University
- Developed and validated Bayesian small area estimation models to generate high-resolution maps of inadequate iron, folate, and vitamin B12 intake in low- and middle-income countries, enabling policy-relevant nutrition insights at subnational levels.
- Applied both area-level (Fay-Herriot extensions with variance smoothing) and unit-level (Beta-Binomial with spatial random effects) frameworks in a fully Bayesian setting, ensuring rigorous uncertainty quantification.
- Conducted validation with Rwanda's nationally representative EICV7 survey and extended methods to Nigeria's state-level data, demonstrating reliable estimation at finer administrative levels where direct survey data are sparse or unavailable.
- Collaborated with the World Food Programme to inform nutrition policy and program design, contributing methodological advances directly to global food security applications.

## **Small Area Estimation for Food Security Analysis with Satellite Imagery**

February 2025 – Present

*Student Researcher*

*Oxford, United Kingdom*

- Advisor: Dr. Seth Flaxman, Oxford University
- Developed a Bayesian small area estimation framework for food security analysis, validated using Zimbabwe's ZIMVAC survey with ground-truth Admin2-level data and extended to other African countries.
- Incorporated satellite imagery as auxiliary features, applying computer vision models like DINO to extract high-dimensional representations that improved predictive accuracy in data-sparse regions.

## **On Membership Inference Attacks in Knowledge Distillation**

January 2025 – May 2025

*Student Researcher*

*Durham, NC*

- Advisor: Dr. Jian Pei, Duke University
- Analyzed transferability of Membership Inference Attacks (MIAs) across different LLM architectures and dataset domains within the knowledge distillation pipeline, and proved that, contrary to the common intuition, student models can be more vulnerable to MIAs than teacher models under standard distillation.
- Proposed and implemented five novel privacy-preserving distillation methods to enhance student model privacy, including ensemble-based and soft-label smoothing approaches.
- Led writing and visualization of experimental results, including key tables demonstrating the effectiveness of proposed privacy-preserving distillation methods.

## **Uncovering Privacy Risks in Sequential Data Releases**

May 2024 – Present

*Student Researcher*

*Durham, NC*

- Advisor: Dr. Jian Pei, Duke University
- Demonstrate that existing privacy guarantees in individual data releases can be bypassed when sequences are jointly analyzed, revealing critical vulnerabilities in current privacy-preserving mechanisms.
- Design and implement a novel privacy attack framework in Python, combining Hidden Markov Models and reinforcement learning to exploit temporal dependencies in sequential data releases.
- Evaluated the proposed attack model on real-world datasets (Geolife and Adult), achieving significantly higher location inference accuracy than baseline models.

## **Revisiting Broken Windows Theory**

January 2024 – Present

*Student Researcher*

*Durham, NC*

- Advisor: Dr. Cynthia Rudin, Duke University
- Enrolled in Duke course CS 474: Data Science Competition.
- Presented at the American Statistical Association (ASA) Joint Statistical Meetings in August 2024.
- Awarded Honorable Mention in the 2024 ASA Data Expo Challenge Professional Category.
- Explore machine learning techniques such as DBSCAN and PaCMAP to analyze how urban structures influence both violent crime and perceptions of safety in New York City and Chicago, contributing insights into law enforcement strategies.
- Leverage observational causal inference techniques like Matching After Learning to Stretch (MALTS) to reassess Broken Windows Theory, disentangling structural effects from demographic confounders, producing robust tract-level and localized treatment effect estimates, and controlling for a significantly larger set of variables than previous works.
- Demonstrated that abandoned buildings and high-foot-traffic structures, like transit hubs and schools, are associated with elevated crime and heightened perceived danger, with heterogeneous effects across cities and subgroups—emphasizing the need for tailored urban policy interventions.

## Duke Impact Investment Group (Duke Student Organization)

September 2022 – Present

*Data Analyst*

*Durham, NC*

- Present solutions and key insights for business problems to clients from startups, including Aquatrax, LandUp, and ClassRanked, using data analysis and data mining.
- Employ machine learning techniques such as  $k$ -fold cross-validation and Adaboost in Python to classify degraded vs. non-degraded water meters with existing meter readings.
- Develop data pipelines in SQL and Python that extract US soil data from the USDA website to store and query within Google Cloud Platform, supporting future machine learning model developments.

## INTERNSHIP EXPERIENCE

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### Outlier AI

May 2024 - Present

*Coding Expert and Reviewer*

*Remote*

- Craft and answer questions in Python and Java related to computer science in order to help train AI models.
- Evaluate and rank code generated by AI models to help cutting-edge generative AI models write better code, and review responses by other analysts.

### Shanghai Research Institute of Computing Technology Co.

May 2024 - August 2024

*Research Product Development Intern*

*Remote*

- Designed and developed feedback models for health monitoring devices.
- Conducted comprehensive research on health monitoring equipment, analyzing data and refining design strategies.
- Gathered insights from over 80 health monitoring devices across 16 domestic and international companies to optimize model performance and enhance device feedback mechanisms.

## TEACHING EXPERIENCE

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### CS 671: Machine Learning Theory & Algorithm (Graduate)

August 2024 – December 2024

*Undergraduate Teaching Assistant*

*Durham, NC*

- Plan and lead weekly 50-student discussions of exemplary questions to supplement course material.
- Write and grade homework problems (theory and coding) to assess student understanding on machine learning topics including k-means clustering, boosting, and random forest.
- Host office hours open to 200+ students, assisting with questions from homework and lectures, and answer student questions on Ed discussion forum.
- Meeting weekly with professor and other teaching assistants to discuss course administration issues including verifying homework problems and progress made during discussion sections.

### Math 531: Real Analysis (Graduate)

January 2025 – May 2025

*Undergraduate Teaching Assistant*

*Durham, NC*

- Evaluated and provided detailed feedback on weekly Real Analysis homework assignments for a graduate-level course with 20+ students, ensuring clarity, rigor, and consistency.

## SKILLS & INTERESTS

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**Languages:** English, Mandarin, Spanish, German

**Technical Skills:** Python,  $\text{\LaTeX}$ , Java, C, R, SQL, MATLAB, Excel, PowerPoint, Undergraduate Responsible Conduct of Research

**Activities:** HackDuke, Duke Chronicle, Duke Sports Analytics Club, Carnegie Mellon Sports Analytics Conference

**Interests:** Photography, Kyokushin Karate, Piano, Skiing, Soccer, Basketball, Boston Celtics

**Professional Memberships:** American Statistical Association (ASA), Royal Statistical Association (RSS), Institute of Mathematical Statistics (IMS)