

# Xiaoqi (Shirley) Liu

I have broad interests in **statistical learning** and **information theory**.  
I derive theoretical limits on the best possible algorithm performance in solving statistical inference problems, and develop mathematically principled, efficient algorithms that approach these limits.

## Contact information

Signal Processing and Communications Lab, Engineering Dept, Trumpington St, Cambridge CB2 1PZ, UK  
Phone: +44 07494 054968 Email: xl394@cam.ac.uk Website: <https://shirleyliuxq.github.io>

## Education and Research

**PhD, Trinity Hall college, University of Cambridge**

Oct 2019–present

**Supervisor: Professor Ramji Venkataramanan**

(Expected thesis submission: May 2024)

### Focus:

Design, analyse and implement efficient (e.g. polynomial time) and mathematically principled algorithms for a variety of high-dimensional statistical inference problems:

- compression (sketching) of large structured matrices (e.g. adjacency matrices of large social networks),
- changepoint detection (mixed linear regression) in heterogeneous data (e.g. genomics, financial data),
- reliable communications (encoding and decoding information) for large user networks.

### Approach:

- derive information-theoretic limits on algorithm complexity,
- devise Bayesian algorithms that approach these limits by characterising their performance rigorously and
- conduct extensive simulations in Python or MATLAB.

### Publications:

**X. Liu** and R. Venkataramanan, “Sketching Sparse Low-Rank Matrices With Near-Optimal Sample- and Time-Complexity Using Message Passing,” in *IEEE Transactions on Information Theory*, vol. 69, no. 9, pp. 6071-6097, Sept. 2023.

**X. Liu** and R. Venkataramanan, “Sketching sparse low-rank matrices with near-optimal sample- and time-complexity,” *2022 IEEE International Symposium on Information Theory*, Espoo, Finland, 2022, pp. 3138-3143.

Papers above study compression (sketching) of low-rank matrices with sparse singular vectors. Proposed first scheme with sample cost and runtime depending only on sparsity, and not on ambient dimension of matrix, providing improvement over existing methods by several orders of magnitude in many use cases.

### Work in preparation:

**X. Liu**, P. Cobo and R. Venkataramanan, “Many-user multiple access with random user activity” (poster at *2023 IEEE European School of Information Theory (ESIT)*), to be submitted to *IEEE International Symposium on Information Theory* by Jan 2024, and extended version to *IEEE Transactions on Information Theory*

**X. Liu**, K. Hsieh and R. Venkataramanan, “Coded many-user multiple access via Approximate Message Passing”, to be submitted to *IEEE International Symposium on Information Theory* by Jan 2024, and extended version to *IEEE Transactions on Information Theory*

G. Arpino, **X. Liu** and R. Venkataramanan, “Changepoints detection in high-dimensional linear regression”, to be submitted to *International Conference on Machine Learning (ICML)* by Jan 2024

**X. Liu** and R. Venkataramanan, “On generalising Wormald’s differential equation method for analysing random graph processes” (in progress)

**BA and MEng, Newnham College, University of Cambridge**

Oct 2015–Jun 2019

Major: Information and Computer Engineering (Honours with Distinction)

Simultaneously qualified in Electrical and Information Sciences; Instrumentation and Control

Ranked 3%, 7%, 4% and 3% (top first class) respectively each year in my cohort of 300+ people

**Overseas Family School, Singapore**

Aug 2013–Jun 2015

International Baccalaureate Diploma Programme 45/45 (Bilingual): High Level Mathematics, Physics,

Economics, English; Standard Level Business & Management, Chinese Language & Literature all with 7/7.

## Scholarships and Awards

**Schlumberger Cambridge International Scholar:** full PhD studentship by Cambridge Trust (£49,000/year)

**2020 British Education Award:** One of 5 winners selected across UK in recognition of outstanding academic achievements. Congratulated by Number 10 Downing Street (Nov 2019)

**Best Presentation Prize:** Awarded at Engineering Department MEng thesis final presentations (Jun 2019)

**Best Technical Report of the Year** (Jun 2018)

**Scholar of Newnham College** (2016–2019); **recipient of major undergraduate research award** (2018)

# Xiaoqi (Shirley) Liu

## Academic Responsibilities and Outreach

---

**Reviewer, 2023 IEEE International Symposium on Information Theory (ISIT), 2023 International Symposium on Topics in Coding (ISTC)**

**Organiser and speaker, 2022 Cambridge Information Engineering Divisional Conference** (Mar 2022): Oversaw logistics for 100-attendee conference, coordinated with speakers and concurrently prepared my talk

**Supervisor for Information Theory & Coding and Data Transmission** (Oct 2019–present): Arrange biweekly Q&A sessions with third-year undergraduates in groups of three. Described by students as insightful and thoughtful supervisor who can “explain complex topics in an easy-going manner”

**Co-supervisor of MEng projects** (Oct 2022–present): help students formulate research questions in statistical learning, conduct experiments and present results in verbal and written formats

**Postgraduate representative, Engineering Department** (Oct 2020–Oct 2022): Organised social events to foster connections among postgraduates through COVID; provided student feedback to departmental boards

**Teaching assistant, Electronic & Information Engineering Track at Cambridge AI+ Programme** (Feb 2022, 2023)

**Selected supervisor for maths tutorials for Newnham STEM first-years** (Oct 2017 & Oct 2019)

**Invited guest and project leader at 2019 Micro Distance International Youth Forum** (Jul 2019): Designed and led three-day project on visual information processing, guiding students aged 14–18 to explore compact coding and sparse coding principles through MATLAB experiments.

## Work Experience

---

**Microsoft Research (Cambridge, UK), researcher intern** Apr 2023–June 2023

- Designed and optimised novel error correction scheme for Project Silica (cloud data storage on glass)
- Clarified key information-theoretic performance metric for the team
- Proposed unifying workflow to systematically evaluate new data storage technologies
- Helped enhance image classification decoder in TensorFlow
- Final presentation praised for exceptional clarity and organisation

**MediaTek Inc (Cambourne, UK), software development summer intern** Jun 2017–Sep 2017

- Data mining and test automation software development in C#, LINQ, SQL & XML
- Created GUI application to identify locations with mobile phone GPS signal loss based on log data and accurately restore coordinates; and to display grouping of base stations in a cellular network into tracking areas
- Prototyped a smart kitchen device using sensors and an Arduino board

**WSP | Parsons Brinckerhoff (Cambridge, UK), structural design engineer** Jun 2016–Aug 2016

- Designed 20+ pieces of steelwork and verified designs from first principles
- Taught myself reinforced concrete design specifications and created VBA program to systematically validate reinforced concrete slab designs

## Extra-curricular Activities and Volunteering

---

**Cambridge University Synthetic Biology Society** (Oct 2017–Jun 2018): Member of computational modelling team. Simulated genetic construct in Python which allows bacterial colony to perform high-pass filtering (edge detection) in response to light patterns

**Impact Through Innovation Cambridge** (Oct 2017–Jun 2018): Prototyped circuit design of medical monitoring device dedicated to an HIV medication adherence study in Tanzania

**Flautist, Cambridge University Chinese Orchestra Society** (Oct 2016–Jun 2017): Flute Grade 9 (highest grade for non-professional flautists in China)

## Skills and Hobbies

---

- Proficient in MATLAB, Python (incl. JAX), Git, slurm. Familiar with C#, C++, VBA, HTML, CSS, LINQ, SQL, XML & R
- Competent with LTspice for electrical circuits design; Tekla, Tedds and RAM for technical steelwork or concrete design; Creo for mechanical design and drawing
- Bilingual in Chinese and English. Sports lover: half-marathon runner and regular gym goer

## Referees

---

**Prof Ramji Venkataramanan** (rv285@cam.ac.uk, Engineering Dept, Cambridge)

**Prof Ioannis Kontoyiannis** (ik355@cam.ac.uk, Maths Dept, Cambridge)

**Dr Ioan Stefanovici** (Ioan.Stefanovici@microsoft.com, Microsoft Research Cambridge)

**Dr Richard Black** (rjblack@microsoft.com, Microsoft Research Cambridge)