Xiaoqi (Shirley) Liu

I am a conscientious lifelong learner and a young researcher passionate about statistical learning and information theory. I have lived, studied and thrived in four cultures. Although I am introverted, I have a strong sense of empathy, and through my leadership roles, I work to foster connections within my community.

Education and Research

PhD, Signal Processing and Communications Lab, University of Cambridge Oct 2019–present
Supervisor: Dr Ramji Venkataramanan (Expected graduation: Mar 2024)

Focus: Algorithm design and analysis, statistical inference, random graphs, coding theory.
In particular: Message passing algorithms, low-rank matrix sketching/ compression, sparse graph codes.

Objective:

- Many modern datasets are inherently sparse. Most existing state-of-the-art algorithms for inference tasks on sparse data are based on convex optimization and they suffer from high complexities.
- The goal of my doctoral research is to leverage tools from modern coding theory (e.g. sparse graph codes) to design inference algorithms that explicitly exploit the sparsity structure of the data to achieve complexity savings.
- I also derive non-asymptotic performance guarantees of the algorithms.

Publication and preprint:

- X. Liu and R. Venkataramanan, "Sketching sparse low-rank matrices with near-optimal sample- and time-complexity".
- This paper studies the problem of sketching n-by-n rank-r matrices whose singular vectors are k-sparse where $k \ll n$. We propose a novel iterative algorithm based on sparse graph codes, which recovers the singular vectors with $O(rk^2)$ sample cost and $O(r^3k^3)$ runtime, which is the first scheme with complexities depending only on the sparsity k, and not on the ambient dimension n. Existing schemes have at least $O(polylog(n))$ sample cost and $O(poly(n))$ runtime.
- Manuscript published at 2022 IEEE International Symposium on Information Theory with highly positive reviews.
- Extended version in revision to appear in IEEE Transactions on Information Theory (arXiv:2205.06228).

Work in preparation:

- Extended Wormald's differential equation method for characterising random graph processes with higher rates of change. The extended method can be used to analyse a variety of randomised combinatorial algorithms, including the widely used message passing algorithms.
- Approximate Message Passing (AMP) algorithms for communication across multiple access channels.

Newnham College, University of Cambridge Oct 2015–Jun 2019
BA and MEng in 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.
- MEng thesis: Efficient Sparse Principal Component Analysis on low-rank matrices using linear codes (first class).
- Ranked 2nd in the cohort for 11 technical reports and oral presentations on information engineering subjects including Inference, Baseband Digital Transmission, and Sensory Information Processing in Neuroscience.

Overseas Family School, Singapore Aug 2013–Jun 2015
International Baccalaureate Diploma Programme 45/45 (Bilingual): Higher Level Mathematics, Physics, Economics, and English; Standard Level Business & Management, Chinese Language & Literature all with 7/7.

Scholarships and Awards

2020 British Education Award: One of the 5 winners selected across the UK in recognition of outstanding academic achievements. Congratulated by Number 10 Downing Street. (Nov 2019)
Schlumberger Cambridge International Scholar: Granted with one of the few full PhD studentships by the Cambridge Trust (£49,000 per year). (Oct 2019)
Best Presentation Prize: Awarded at the Engineering Department MEng thesis final presentations. (Jun 2019)
Best Technical Report of the Year: In a month-long control system project, coordinated a group of four to model and design a controller of an industrial evaporator in Simulink. Individual report described by Prof. Rodolphe Sepulchre as "exemplary, reflecting considerable effort and thinking beyond what was strictly asked". (Jun 2018)
Scholar of Newnham College (2016–2019); **recipient of a college major undergraduate research award** (2018)
UKMT Maths Challenge Gold (2013 & 2014); **the Principal's Award** (2013 & 2014)

Academic Responsibilities and Outreach

Organiser and speaker, 2022 Information Engineering Divisional Conference (Mar 2022): Responsible for publicising

the conference (~100 attendees), corresponding with internal and external speakers, booking venue and catering, and providing technical support, while 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 many students as an insightful and thoughtful supervisor who can unpack difficult topics in an easy-going yet rigorous way.

Postgraduate representative, Engineering Department (Oct 2020–present): Organise social events to nurture connections among postgraduates through the pandemic. Provide student feedback to departmental boards.

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

Presenter at Signal Processing Seminar on "Martingales & useful analysis tools related to martingales" (Nov 2019)

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

Invited guest and project leader at the 2019 Micro Distance International Youth Forum (Jul 2019): Designed and led a much-loved three-day project on visual information processing. Helped students (aged 14–18) to investigate and visualise the principles of compact coding and sparse coding via Matlab experiments.

Selected Project Experience

Computational neuroscience projects (Jan 2019–Mar 2019): Implemented the Temporal Difference learning algorithm and investigated how the brain may exploit it to make predictions. Simulated and analysed a neural network that implements autoassociative memory. Technical reports awarded first class.

Data analysis project (Apr 2018–Jun 2018): Designed and implemented non-parametric and parametric methods to denoise audio signals or conceal lost packets of an audio signal. Technical report awarded first class.

Data compression project (Nov 2017–Dec 2017): Designed and programmed a probabilistic adaptive text compression algorithm from scratch based on extensive literature review. Technical report awarded Distinction.

Multidisciplinary robot design group project (Jan 2017–Mar 2017): Built an autonomous robot in C++ to perform specified tasks, by integrating signals of light and temperature sensors. Group ranked 4/20 in the final competition.

Work Experience

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

- Data mining and test automation software development in C#, LINQ, SQL & XML.
- Built a GUI application to identify the locations where a mobile phone lost GPS coverage from logs and accurately restore the coordinates of those locations.
- Designed an algorithm to draw semi-convex bounding polygons to display the grouping of base stations in a cellular network into tracking areas. The algorithm served as a unique selling point of my team's application.
- Prototyped a smart kitchen device using sensors and an Arduino board.

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

- Designed 20+ pieces of steelwork and verified the designs based on first principles.
- Studied the design of reinforced concrete according to specifications. Developed a VBA program to systematically validate designs of reinforced concrete slabs, which proved to be highly useful for WSP engineers.

Extra-curricular Activities and Volunteering

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

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

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

Skills and Hobbies

- Proficient in MATLAB, Python. Familiar with C#, C++, VBA, HTML, CSS, LINQ, SQL & XML.
- Competent with LTspice for the design and analysis of electrical circuits.
- Competent with Tekla, Tedds and RAM for technical steelwork or concrete design.
- Familiar with Creo for mechanical design and drawing.
- Bilingual in Chinese and English. A sports lover: a half-marathon runner & a regular gym goer.

References available upon request