

Dr. Hao-Chung Cheng

Curriculum Vitae

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AFFILIATION

Dr. Hao-Chung Cheng (鄭皓中) is a scientist and engineer in the quantum information frontier. He is currently an Assistant Professor at the Department of Electrical Engineering, and the Graduate Institute of Communication Engineering, National Taiwan University.

RESEARCH FIELDS

PRIMARY FIELDS Quantum Information Processing
 Quantum Machine Learning
SECONDARY FIELDS Communication Engineering
 Statistical Inference, Matrix Analysis

POSTDOCTORAL EXPERIENCE

University of Cambridge (Nov 2018 – Jul 2020)
Department of Applied Mathematics and Theoretical Physics

EDUCATION

SEP 2011 – FEB 2018 **Doctor of Philosophy in Engineering**
Graduate Institute of Communication Engineering
National Taiwan University
FEB 2016 – JUL 2018 **Doctor of Philosophy in Computer Science**
Centre for Quantum Software and Information
School of Computer Science
University of Technology Sydney
SEP 2006 – JUN 2010 **Bachelor of Engineering**
Department of Electrical Engineering
National Taiwan University

DOCTORAL RESEARCH

“Error Exponent Analysis in Quantum Information Theory”

My Ph.D. research studied the trade-off between the performance of quantum information-theoretic tasks, the required resources, and the system size needed in achieving the task. The established analysis characterizes the efficiency of the underlying system. This hence allows us to take a step from theory toward practice, and lay foundation for designing the next-generation quantum information technology.

For the task of quantum learning, I proposed a unified framework to determine how much training samples is required to learn an unknown quantum state or quantum measurement. For fundamental quantum information-theoretic tasks, I studied data compression with quantum side information, and data transmission through quantum channels, and characterized the trade-off between the incurred error probability, the compression or transmission rate, and the associated coding size. This study can be extended to further quantum information processing protocols such as channel synthesis, state simulation, privacy, networking, sample complexities in machine learning and resource theory.

RESEARCH EXPERIENCE

University of Cambridge (Advisor: Nilanjana Datta)

- In 2018 November, I joined the Department of Applied Mathematics and Theoretical Physics as a Postdoctoral Researcher. The field of my research includes quantum network information processing, distributed quantum statistical inference, quantum machine learning theory, and quantum functional inequalities.

- I studied the statistical inference of information embedded in quantum system, in the distributed scenario, and established the optimal decision rules and the optimal trade-off between the performance and the required resources. This study is substantial because only small to immediate scale quantum computers are available in the near term future. Hence, local quantum operation and limited communications are allowed in decentralized laboratories. How to design the associated system for quantum information processing becomes a pressing matter. Moreover, I demonstrated a phenomenon of quantum advantage when using quantum instruments to infer classical under certain distributed circumstances.

- The previous study can potentially facilitate designing the next generation quantum network communication systems.
- I proposed an efficient algorithm to learn quantum Clifford circuits with T -depth one. The established result is important since any quantum circuit can be expressed as such the circuits with different amount of T gates. Hence, this can be used for circuit tomography and verification.

University of Technology Sydney

(Advisor: Min-Hsiu Hsieh; Co-advisor: Marco Tomamichel)

- In 2014, my research direction turned to quantum information theory (error analysis of quantum information protocols), quantum machine learning, quantum Markov semigroups, matrix entropy functionals, and matrix concentration inequalities (please see the Doctoral Research).

National Taiwan University (Advisor: Ping-Cheng Yeh)

- In 2011-2013, my main research field was statistical communication engineering.
- I joined the HTC-NTU project on 3GPP LTE-advanced system design. By applying statistical inference and coding theory techniques into LTE-advanced systems, we develop considerable technical contributions and intellectual property rights.
- I joined the National Science Council Project on asthma risk analysis using machine learning techniques.
- For the academic research part, I used the statistical inference techniques to developed a new framework for non-cryptographic cross-layer authentication which significantly improves the past results.
- I introduced a novel approach by using machine learning techniques on channel decoding to find error patterns.

RESEARCH GRANT AND SCHOLARSHIP

2020 – 2025	Yushan Young Scholar Program <i>Ministry of Education, Taiwan</i> (Grant: 109V0904) 教育部玉山青年學者
2020 – 2024	Young Scholar Fellowship Program (Einstein) <i>Ministry of Science and Technology, Taiwan</i> (Grant: 109WXA0310019) 科技部年輕學者養成方案「愛因斯坦培植計畫」
2019 – 2020	University of Cambridge Fellowship <i>DAMTP, University of Cambridge</i>
2019 – 2019	Postdoctoral Research Abroad Program <i>Ministry of Science and Technology, Taiwan</i> (Grant: 108-2917-I-564-042)
2018 – 2018	Post Thesis Publication Scholarship <i>University of Technology Sydney</i>
2016 – 2018	QCIS Scholarship <i>FEIT, University of Technology Sydney</i>
2016 – 2016	Overseas Project for Post Graduate Research <i>Ministry of Science and Technology, Taiwan</i> (Grant: 105-2917-I-002-028)
2015 – 2015	Outstanding Management Personnel Scholarship <i>E.SUN Commercial Bank</i>
2015 – 2015	Irving T. Ho Scholarship <i>Irving T. Ho Memorial Foundation</i>
2014 – 2016	Hsing Tian Kong Superior Students Scholarship <i>Hsing Tian Kong Education Foundation</i>
2014 – 2016	The Seed of Hope Scholarship <i>Huaku Education Foundation</i>
2013 – 2014	National Science Council Fellowship <i>National Taiwan University</i> (Grant: 104-2221-E-002-072)
2010 – 2012	Academia-Industry Collaboration Fellowship <i>HTC Corporation</i>

TEACHING EXPERIENCE

2021-	Quantum Information and Computation (NTUEE)
2020-	Communication System Lab (NTUEE)
2019	Quantum Information and Computation (Lecture Supervision at Cambridge University)

SYNERGISTIC ACTIVITIES

LOCAL ORGANIZER	Beyond IID in Information Theory 18th Annual Conference on Quantum Information Processing (QIP 2015)
PC MEMBERS	Theory of Quantum Computation, Communication, and Cryptography (TQC 2021)
REVIEWER	Communications in Mathematical Physics, IEEE Transactions on Information Theory, Nature Communications, Quantum, npj Quantum Information

PRESENTATION

AUG 2020	Workshop on Quantum Science and Technology
JUN 2020	International Symposium on Information Theory (ISIT), 2 talks
NOV 2019	Institute of Information Science, Academia Sinica
NOV 2019	Graduate Institute of Communication Engineering National Taiwan University
NOV 2019	Department of Mathematics Technical University of Munich
JUL 2019	International Symposium on Information Theory (ISIT) International Symposium on Information Theory (ISIT), 2 talks
JUL 2019	Beyond IID Conference, 2 talks
NOV 2018	Graduate Institute of Communication Engineering National Taiwan University
JUN 2018	International Symposium on Information Theory (ISIT)
JAN 2018	Department of Applied Mathematics and Theoretical Physics, University of Cambridge
JAN 2018	21st Annual Conference on Quantum Information Processing (QIP)
NOV 2017	IEEE Information Theory Workshop (ITW) (Invited Talk)
AUG 2017	Beyond IID Conference
JUN 2017	International Symposium on Information Theory (ISIT)
JUN 2017	The Theory of Quantum Computation, Communication and Cryptography (TQC)
JUN 2017	International Symposium on Information Theory (ISIT), 3 talks
JAN 2017	Institute for Quantum Information and Matter California Institute of Technology
DEC 2016	Institute of Information Science, Academia Sinica
SEP 2016	Asian Quantum Information Science Conference
APR 2016	Sydney Information Technology Workshop: Celebration of Shannon's 100th Birthday, Sydney
JAN 2016	Joint Center for Quantum Information and Computer Science, University of Maryland
DEC 2015	Sydney Quantum Information Theory Workshop
DEC 2015	Institute of Information Science, Academia Sinica
NOV 2013	Cross-Strait Forum on Postgraduate Education
OCT 2013	The 8th Asia-Oceania Top University League on Engineering (AOTULE) Meetings and Conference
SEP 2013	Asia-Pacific Radio Science Conference

ACADEMIC PUBLICATIONS

Hao-Chung Cheng, Barış Nakiboğlu, “On The Existence of The Augustin Mean,” *IEEE Information Theory Workshop (ITW)*, 2021.

Hao-Chung Cheng, Nilanjana Datta, and Cambyse Rouzé, “Strong converse bounds in quantum network information theory,” *IEEE Transactions on Information Theory*, vol. 67, no. 4, Apr. 2021.

DOI: [10.1109/TIT.2021.3058166](https://doi.org/10.1109/TIT.2021.3058166)

Hao-Chung Cheng, Eric P. Hanson, Nilanjana Datta, and Min-Hsiu Hsieh, “Non-Asymptotic Classical Data Compression with Quantum Side Information,” *IEEE Transactions on Information Theory*, vol. 67, no. 2, pp. 902–930, Feb. 2021. DOI: [10.1109/TIT.2020.3038317](https://doi.org/10.1109/TIT.2020.3038317)

Hao-Chung Cheng, Nilanjana Datta, and Cambyse Rouzé, “Strong Converse Bounds in Quantum Network Information Theory,” *IEEE Symposium on Information Theory (ISIT)*, 2020.

DOI: [10.1109/ISIT44484.2020.9174427](https://doi.org/10.1109/ISIT44484.2020.9174427)

Hao-Chung Cheng, Barış Nakiboğlu, “Refined Strong converses for Constant Composition Codes,” *IEEE Symposium on Information Theory (ISIT)*, 2020. DOI: [10.1109/ISIT44484.2020.9174315](https://doi.org/10.1109/ISIT44484.2020.9174315)

Hao-Chung Cheng, Li Gao, and Min-Hsiu Hsieh, “Properties of Scaled Noncommutative Rényi and Augustin Information,” *IEEE Symposium on Information Theory (ISIT)*, 2019. DOI: [10.1109/ISIT.2019.8849281](https://doi.org/10.1109/ISIT.2019.8849281)

Hao-Chung Cheng, Eric P. Hanson, Nilanjana Datta, and Min-Hsiu Hsieh, “Duality between source coding with quantum side information and c-q channel coding,” *IEEE Symposium on Information Theory (ISIT)*, 2019. DOI: [10.1109/ISIT.2019.8849457](https://doi.org/10.1109/ISIT.2019.8849457)

Hao-Chung Cheng, Min-Hsiu Hsieh and Marco Tomamichel, “Quantum Sphere-Packing Bounds with Polynomial Prefactors,” *IEEE Transactions on Information Theory*, vol. 65, no. 5, pp. 2872–2898, May 2019. DOI: [10.1109/TIT.2019.2891347](https://doi.org/10.1109/TIT.2019.2891347)

Hao-Chung Cheng and Min-Hsiu Hsieh, “Matrix Poincaré, Φ -Sobolev Inequalities, and Quantum Ensembles,” *Journal of Mathematical Physics*, vol. 60, no. 3, p. 032201, 2019. DOI: [10.1063/1.5035381](https://doi.org/10.1063/1.5035381)

Hao-Chung Cheng, Eric P. Hanson, Nilanjana Datta, and Min-Hsiu Hsieh, “Error Exponents and Strong Converse Exponents for Classical Data Compression with Quantum Side Information,” *IEEE Symposium on Information Theory (ISIT)*, 2018. DOI: [10.1109/ISIT.2018.8437348](https://doi.org/10.1109/ISIT.2018.8437348)

Hao-Chung Cheng, Min-Hsiu Hsieh, “Moderate Deviation Analysis for Classical-Quantum Channels and Quantum Hypothesis Testing,” *IEEE Transactions on Information Theory*, vol. 64, no. 2, page 1-19, Feb 2018. DOI: [10.1109/TIT.2017.2781254](https://doi.org/10.1109/TIT.2017.2781254)

Hao-Chung Cheng, Min-Hsiu Hsieh, and Marco Tomamichel, “Exponential Decay of Matrix Φ -Entropies on Markov Semigroups with Applications to Dynamical Evolutions of Quantum Ensembles,” *Journal of Mathematical Physics*, vol. 58, no. 9, p. 092202, 2017.

DOI: [10.1063/1.5000846](https://doi.org/10.1063/1.5000846)

Hao-Chung Cheng, Min-Hsiu Hsieh, and Marco Tomamichel, “Sphere-Packing Bound for Classical-Quantum Channels,” *IEEE Information Theory Workshop (ITW)*, 2017 DOI: [10.1109/itw.2017.8278039](https://doi.org/10.1109/itw.2017.8278039)

Hao-Chung Cheng, Min-Hsiu Hsieh, and Marco Tomamichel, “Sphere-Packing Bound for Symmetric Classical-Quantum Channels,” *IEEE Symposium on Information Theory (ISIT)*, 2017.

DOI: [10.1109/isit.2017.8006535](https://doi.org/10.1109/isit.2017.8006535)

Hao-Chung Cheng, and Min-Hsiu Hsieh, “Moderate Deviations for Quantum Hypothesis Testing and a Martingale Inequality,” *IEEE Symposium on Information Theory (ISIT)*, 2017. DOI: [10.1109/isit.2017.8006875](https://doi.org/10.1109/isit.2017.8006875)

Hao-Chung Cheng, and Min-Hsiu Hsieh, “Moderate Deviations for Classical-Quantum Channels,” *IEEE Symposium on Information Theory (ISIT)*, 2017.

DOI: [10.1109/isit.2017.8006537](https://doi.org/10.1109/isit.2017.8006537)

Hao-Chung Cheng, and Min-Hsiu Hsieh, “On the Concavity of Auxiliary Function in Classical-Quantum Channels,” *IEEE Transactions on Information Theory*, vol. 62, no. 10, Oct 2016. DOI: [10.1109/TIT.2016.2598835](https://doi.org/10.1109/TIT.2016.2598835)

Hao-Chung Cheng, and Min-Hsiu Hsieh, “Characterizations of Matrix and Operator-Valued Φ -Entropies, and Operator Efron-Stein Inequalities,” *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Science*, vol. 472, no. 2187, p. 20150563, Mar 2016.

DOI: [10.1098/rspa.2015.0563](https://doi.org/10.1098/rspa.2015.0563)

Hao-Chung Cheng, Min-Hsiu Hsieh, and Ping-Cheng Yeh, “The Learnability of Unknown Quantum Measurements,” *Quantum Information and Computation*, vol. 16, no. 7&8, pp. 0615–0656, 2016. URL

Hao-Chung Cheng, Sheng-Yi Ho, Ping-Cheng Yeh, “Collaborative Non-Cryptographic Physical Layer Authentication Schemes in Wireless Networks,” *Radio Science Bulletin of International Union of Radio Science*, no. 349, pp. 18–31, 2014. URL

Hao-Chung Cheng, Sheng-Yi Ho, Ping-Cheng Yeh, “Collaborative Non-Cryptographic Physical Layer Authentication Schemes in Wireless Networks,” *Asia-Pacific Radio Science Conference*, 2013.

Unpublished Pre-Prints

Hao-Chung Cheng, Andreas Winter and Nengkun Yu, “Discrimination of quantum states under locality constraints in the many-copy setting,” [arXiv:2011.13063](https://arxiv.org/abs/2011.13063) [quant-ph]

AWARD

2020 **Yushan Young Scholar Program**
教育部玉山青年學者

2013 **Asia-Pacific Radio Science Conference**
Student Paper Competition Award

INTELLECTUAL PROPERTY

US Intellectual Property Rights

Hao-Chung Cheng, Jhe-Syong Jiang, Ling-San Meng, Ping-Cheng Yeh, Yu-Chih Jen, “Method of Handling Coordinated Scheduling for Base Stations and Mobile Devices and Related Communication Device,” [US20130016671A1](https://patents.google.com/patent/US20130016671A1), 2013.