

# HONGCHAO ZHOU

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Dep. Information Science and Engineering  
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**EDUCATION**      **California Institute of Technology**, Pasadena, CA      2008 – 2012

*Ph.D. in Electrical Engineering*  
– Advisor: Prof. Jehoshua (Shuki) Bruck  
– Ranked first in Ph.D Qualification Exam, GPA 4.1/4.0  
– Charles H. Wilts Prize for the Best Ph.D. Thesis in EE  
*M.S. in Electrical Engineering*

**Tsinghua University**, Beijing, China      2004 – 2008

*M.S. in Control Science and Engineering*  
*B.S. in Physics and Mathematics*  
– Advisor: Prof. Xiaohong Guan

**Tsinghua High School**, Beijing, China      2001 – 2004

*National Science Experimental Class*

**WORKING EXPERIENCE**      **Shandong University**, Jinan, China      2015 – present

*Professor*  
Department of Information Science and Engineering

**Massachusetts Institute of Technology**, Cambridge, MA      2012 – 2015

*Postdoctoral Researcher* working with Prof. Gregory Wornell  
Signals, Information, and Algorithms Laboratory, RLE

**IBM China Research Lab**, Beijing, China      2006 – 2008

*Research Intern*

## HONORS AND AWARDS

Recipient of the China's Youth 1000-Talent Program, 2015  
Charles H. Wilts Prize for the Best Ph.D. Thesis in EE at Caltech, 2013  
Chinese Government Award for outstanding self-financed students abroad, 2011  
IEEE Presidents' Change the World Competition: 2nd Place (Team), 2010  
Best Student Paper Award Finalist in the IEEE Int. Symp. Inform. Theory, 2010  
Ranked 1st in the Ph.D. qualification exam, Caltech EE, 2009  
Atwood Fellowship, Caltech, 2008  
Academic Performance Scholarship, Tsinghua University, 2007  
Gold Medal in the 19th Chinese National Physics Olympic Competition, 2002

## RESEARCH INTERESTS

My research interests include information theory and coding, algorithms and complexity, and their applications in data storage systems, secure communication systems and biological computing systems.

**Data Storage:** coding and signal processing for storage devices, large-scale data storage systems

**Data Security:** random number generation, computing on encrypted data, quantum/optical communication

**Computing and Networks:** DNA computing, sensor networks, distributed systems, logic and circuits

**RESEARCH  
EXPERIENCE**

**Massachusetts Institute of Technology**

2012-present

*Encrypted Signal Processing*

- Invented an efficient homomorphic encryption framework that supports computations in the encrypted domain. It provides orders of magnitude improvement in computational time compared to existing methods.

*Distributed Data Storage*

- Proposed practical local-accessible compression schemes and data protection schemes for distributed data storage systems.

*Quantum Communication*

- Addressed critical coding challenges in high-dimensional quantum communication, based on which we built the first known practical quantum-communication system that achieves unprecedented performance: 7.1 secure bits per photon and 7.0 Mb/s throughput over 20 km of fiber transmission.

**California Institute of Technology**

2008 – 2012

*Emerging Data Storage*

- Invented new coding and signal processing techniques to improve the data capacity, reliability, accessibility, and endurance of emerging storage devices such as flash memories. Examples of my inventions include balanced modulation, nonuniform codes, systematic rank modulation, pattern cells, and variable-level cells.

*Digital Randomness*

- Solved a 40-year-old open question in randomness generation first proposed by Paul Samuelson, and proposed the first known optimal algorithm that generates random bits from an arbitrary Markov chain while operating in expected linear time.

*Stochastic Computing*

- Studied the synthesis of stochastic networks for stochastic computing or DNA computing, and introduced stochastic flow networks as the most powerful known model for probability synthesis.

**Tsinghua University, China**

2006 – 2008

*Wireless Sensor Networks*

- Developed efficient and reliable routing or transport layer protocols for wireless sensor networks. Built a sensor network for indoor localization, monitoring and control.

**IBM China Research Lab, China**

2006 – 2008

*Cloud Application*

- Designed and developed the early version of **IBM Docs** from scratch.

**DOCTORAL  
THESIS**

Randomness and Noise in Information Systems, California Institute of Technology, July 2012.

Thesis Committee: Jehoshua Bruck (advisor), Michelle Effros, Babak Hassibi, Chris Umans, and Erik Winfree.

**RESEARCH  
PROJECTS**

Information in A Photon Program (DARPA)

2012-present

– two collaborative projects at MIT and BBN Tech. to pursue the physical and mathematical principles that govern the information capacity of optical photons

Molecular Programming Project (NSF Expeditions in Computing) 2008 – 2012  
– a collaborative effort by researchers at Caltech and U Washington to develop new computer science principles for programming information-bearing molecules

Integrated Building Energy, Safety and Control Systems Project 2006 – 2008  
– a joint project with United Tech. Corp. for developing the next generation of buildings; I built a sensor network for indoor localization, monitoring and control

**SELECTED  
PUBLICATIONS  
(by topic)**

**Coding and Signal Processing for Data Storage**

- [1] **H. Zhou**, A. Jiang and J. Bruck, “Nonuniform codes for correcting asymmetric errors in data storage,” *IEEE Transactions on Information Theory*, May 2013; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2011.
- [2] **H. Zhou**, A. Jiang and J. Bruck, “Balanced modulation for nonvolatile memories,” arXiv:1209.0744, 2012; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2011.
- [3] A. Jiang, **H. Zhou** and J. Bruck, “Variable-level cells for nonvolatile memories,” in *Proc. IEEE Int. Symp. Inform. Theory*, 2011; in *Proc. Inform. Theory and Applications Workshop*, 2011.
- [4] A. Jiang, **H. Zhou**, Z. Wang and J. Bruck, “Patterned cells for phase change memories,” in *Proc. IEEE Int. Symp. Inform. Theory*, 2011.
- [5] **H. Zhou**, M. Schwartz, A. Jiang and J. Bruck, “Systematic error-correcting codes for rank modulation,” *IEEE Transactions on Information Theory*, 2014; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2012.
- [6] **H. Zhou**, D. Wang and G. Wornell, “A Simple Class of Efficient Compression Schemes Supporting Local Access and Editing,” in *Proc. IEEE Int. Symp. Inform. Theory*, 2014.

**Information Security, Quantum/Optical Communication**

- [8] **H. Zhou** and G. Wornell, “Efficient homomorphic encryption on integer vectors and its applications,” *Inform. Theory and Applications Workshop*, 2014.
- [9] T. Zhong, **H. Zhou**, R. Horansky, et al. “Photon-efficient high-dimensional quantum key distribution,” *New Journal of Physics*, 2015.
- [10] C. Lee, J. Mower, Z. Zhang, G. Steinbrecher, **H. Zhou**, et al. “High-dimensional time-energy entanglement-based quantum key distribution using dispersive optics,” *Physical Review A*, 2014.
- [11] **H. Zhou**, Y. Kochman and G. Wornell, “On-Off keying communication over optical channels with crosstalk,” *IEEE Journal on Selected Areas in Communications*, 2015; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2014.
- [12] **H. Zhou**, L. Wang and G. Wornell, “Layered schemes for large-alphabet secret key distribution,” in *Proc. Inform. Theory and Applications Workshop*, 2013.
- [13] **H. Zhou** and G. Wornell, “Adaptive pulse-position modulation for high-dimensional quantum key distribution,” in *Proc. IEEE Int. Symp. Inform. Theory*, 2013.
- [14] **H. Zhou**, V. Chandar and G. Wornell, “Low-density random matrices for secret key extraction,” in *Proc. IEEE Int. Symp. Inform. Theory*, 2013.

## Digital Randomness

- [15] **H. Zhou** and J. Bruck, “Efficiently generating random bits from finite state Markov chains,” *IEEE Transactions on Information Theory*, Apr. 2012; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2010. (Best Student Paper Award Finalist)
- [16] **H. Zhou** and J. Bruck, “A universal scheme for transforming binary algorithms to generate random bits from loaded dice,” *arXiv:1209.0726*, 2012.
- [17] **H. Zhou** and J. Bruck, “Streaming algorithms for optimal generation of random bits,” *arXiv:1209.0730*, 2012.
- [18] **H. Zhou** and J. Bruck, “Linear extractors for extracting randomness from noisy sources,” *arXiv:1209.0732*, 2012; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2011.
- [19] **H. Zhou** and J. Bruck, “Efficiently extracting randomness from imperfect stochastic processes,” *arXiv:1209.0734*, 2012; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2012.

## Biological Computing Networks and Sensor Networks

- [20] **H. Zhou**, H. Chen and J. Bruck, “Synthesis of stochastic flow networks,” *IEEE Transactions on Computers*, Dec. 2012; preliminary paper in *Proc. IEEE Int. Symp. Inform. Theory*, 2010.
- [21] W. Qian, M. Riedel, **H. Zhou** and J. Bruck, “Transforming probabilities with combinational logic,” *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems*, 2011.
- [22] **H. Zhou**, P. Loh, and J. Bruck, “The synthesis and analysis of stochastic switching circuits,” *arXiv:1209.0715*, 2012; two preliminary papers in *Proc. IEEE Int. Symp. Inform. Theory*, 2009.
- [23] **H. Zhou** and X. Guan, “Idle-listening reduction for data aggregation in distributed sensor networks,” *Technical Report*, Tsinghua University, 2009.
- [24] **H. Zhou**, X. Guan and C. Wu, “Reliable transport with memory consideration in wireless sensor networks,” in *Proc. IEEE Int. Conf. Communications*, 2008.
- [25] C. Wu, R. Yuan and **H. Zhou**, “A novel load balanced and lifetime maximization routing protocol in wireless sensor networks,” in *Proc. IEEE Vehicular Tech. Conf.*, 2008.
- [26] **H. Zhou**, F. Liu and X. Guan, “Critical communication radius for sink connectivity in wireless networks,” in *Proc. Allerton Conf. Communication, Control, and Computing*, 2007.

## PATENTS

- [1] “Code-based read control for data storage devices,” **H. Zhou**, US20150317203, Publication date 5 Nov 2015.
- [2] “Information representation and coding for nonvolatile memories,” A. Jiang, J. Bruck, Z. Wang and **H. Zhou**, US8780620 B2, Publication date 15 Jul 2014.

## INVITED TALKS

“From secure communication to secret computation,” California Institute of Technology, EE Department Seminar, March 2014.

“From secure communication to secret computation,” University of Southern California, EE Department Seminar, March 2014.

“Efficient homomorphic encryption on integer vectors and its applications,” Information Theory and Applications Workshop, Feb. 2014.

“Bits from physical systems: randomness and noise,” Columbia University, EE Department Seminar, May 2013.

“Stochasticity in molecular computer and memories,” Texas A&M University, ECE Department Seminar, March 2013.

“Bits from physical systems: randomness, noise and security,” University of Rochester, ECE Department Seminar, Feb. 2013.

“Layered schemes for large-alphabet secret key distribution,” Information Theory and Applications Workshop, Feb. 2013.

“Randomness and noise in information systems,” Massachusetts Institute of Technology, EECS, Apr. 2012.

“Randomness in computation and biology,” Johns Hopkins University, ECE Department Seminar, Feb. 2012.

“Random number generation and its connection with information theory,” Waterloo University Seminar, Canada, Oct. 2011.

“Synthesis of stochastic flow in networks,” The second annual molecular programming project workshop, California Institute of Technology, 2010.

## CONFERENCE TALKS

“On the limits of communication over optical on-off keying channels with crosstalk,” IEEE Int. Symp. Inform. Theory, 2014.

“A simple class of efficient compression schemes supporting local access and editing,” IEEE Int. Symp. Inform. Theory, July 2014.

“Adaptive pulse-position modulation for high-dimensional quantum key distribution,” IEEE Int. Symp. Inform. Theory, July 2013.

“Low-density random matrices for secret key extraction,” IEEE Int. Symp. Inform. Theory, July 2013.

“Systematic error-correcting codes for rank modulation,” IEEE Int. Symp. Inform. Theory, July 2012.

“Variable-length extractors,” IEEE Int. Symp. Inform. Theory, July 2012.

“Error-correcting schemes with dynamic thresholds in nonvolatile memories,” IEEE Int. Symp. Inform. Theory, July 2011.

“Nonuniform codes for correcting asymmetric errors,” IEEE Int. Symp. Inform. Theory, July 2011.

“Linear extractors for extracting randomness from noisy sources,” IEEE Int. Symp. Inform. Theory, July 2011.

“Generalizing the Blum-Elias method for generating random bits from Markov chains,” IEEE Int. Symp. Inform. Theory, June 2010.

“On the synthesis of stochastic flow networks,” IEEE Int. Symp. Inform. Theory, June 2010.

“On the expressibility of stochastic switching circuits,” IEEE Int. Symp. Inform. Theory, June 2009.

“Reliable transport with memory consideration in wireless sensor networks,” IEEE Int. Conf. Communications, July. 2008.

**TEACHING  
EXPERIENCE**

California Institute of Technology, Teaching Assistant

– Information and Logic (IST 4)

Spring 2012

– Information and Logic (IST 4)

Spring 2011

– Probabilistic Graphical Models (CS/CNS/EE 155)

Fall 2009

**SERVICES**

**Conference-related Duties**

Session Chair at IEEE International Symposium on Information Theory (ISIT), 2013

**Invited Referee for Journals and Conferences**

IEEE Transactions on Information Theory

IEEE Transactions on Communications

IEEE Transactions on Mobile Computing

EURASIP special issue on coding and signal processing for nonvolatile memories

IEEE Int. Symp. Inform. Theory (ISIT)

IEEE Global Comm. Conf. (Globecom)

IEEE Conf. Decision and Control (CDC)

American Control Conf. (ACC)

**Student Activities**

President of the Chinese Students and Scholars Association, Caltech, 2009 – 2010