Narayanan Rengaswamy

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EDUCATION

Ph.D. in Electrical Engineering, Jan. 2016 – Present
Duke University, Durham, NC, USA

Research: Quantum Computing and Algorithms, Coding Theory, Inference Problems
Advisors: Prof. Henry D. Pfister and Prof. Robert Calderbank
Coursework: Compressed Sensing, Information Theory and Statistical Mechanics, Detection and Estimation Theory, Machine Learning, Basic Analysis, Convex Optimization
Cumulative GPA: 3.86 out of 4

M.S. in Electrical Engineering, Dec. 2015
Texas A&M University, College Station, TX, USA

Thesis: On Cyclic Polar Codes and the Burst Erasure Performance of Spatially-Coupled LDPC Codes
Advisors: Prof. Henry D. Pfister and Prof. Krishna R. Narayanan
Coursework: Channel Coding, Statistical Communication Theory, Information Theory, Advanced Channel Coding, Computer Communication and Networking, Wireless Communications
Cumulative GPA: 3.875 out of 4

B.Tech. in Electronics and Communication Engineering, May 2013
Amrita University, Coimbatore, Tamilnadu, India

Project: Wireless Electrocardiogram Monitoring for Cardiac Patients on Android Platform
Advisor: Prof. E. P. Sumesh
Advanced Coursework: OFDM for Broadband Wireless Communications, Agent Based Modeling, Pattern Recognition, Convex Optimization
Cumulative GPA: 9.70 out of 10 (3.88/4)

HONORS

Graduate Student Member of IEEE, since Nov. 2015

DAAD RISE Professional Scholarship, 2015
German Academic Exchange Service (DAAD), Bonn, Germany
– One among the 34 scholarship recipients selected among the 184 applicants by the committee
– Funded the 3-month summer research internship in Alcatel-Lucent Bell Labs, Stuttgart, Germany

Top Rank in Undergraduate Studies, May 2013
Amrita University, Coimbatore, Tamilnadu, India

– Ranked 1st in the college, 3rd in the university (among 3 engineering campuses)

Ericsson Excel Certification in Telecommunications, 2012
Amrita University, Coimbatore, Tamilnadu, India
– Attended Ericsson leading researcher's lectures, passed exam and completed internship

Central Board of Secondary Education (CBSE) Merit Scholarship 2010-11 & 2011-12

Amrita TIDE Best Innovation Award, 2011-12
Amrita University, Coimbatore, Tamilnadu, India
– As a team, developed an Integrated Village Development System
– Used Software Defined Radio (SDR) to demonstrate connectivity between places, with only partial dependence on the internet
– Created a web portal (using JSP language) for Job Classifieds System

RESEARCH

Research Assistant, Prof. Henry Pfister's Group, Jan. 2016 – Present
Duke University, Durham, NC, USA
– Currently working on problems in quantum computing and quantum communications
– Conducted research on construction of deterministic compressed sensing matrices and recovery of large supports of unknown sparse vectors

Research Assistant, Prof. Gregory Huff's Group, Jan. 2014 – Aug. 2014
Texas A&M University, College Station, TX, USA
– Worked on the MUSIC algorithm to triangulate and localize the origin of a wave through its interception with a network of buoy sensors
– Developed a C++ utility with Qt Creator IDE for field sensing and analysis

SKILLS

Core: Information and Coding Theory, Signal Processing, Quantum Computing, Graphical Models and Inference, Linear Algebra, Combinatorics, Probability, Wireless Communication
General: Theoretical Research, Teaching, Programming, Technical and Formal Writing
Languages: MATLAB, C, C++, Arduino, Mathematica

TEACHING

Teaching Assistant, Error Correcting Codes, Fall 2017
Duke University, Durham, NC, USA
– Prepared several homework and exam problems inspired from research
– Delivered two lectures on quantum error correcting codes, circuits and logical operators

Teaching Assistant, Digital Audio Processing, Spring 2017
Duke University, Durham, NC, USA
– Developed several assignments, labs and exam problems
– Prepared and presented notes and associated MATLAB/Simulink tutorials on some topics

– Delivered two lectures on Fourier transforms, frequency domain processing and DSP flow diagrams

Teaching Assistant, Senior Capstone Design, Spring and Fall 2015
Texas A&M University, College Station, TX, USA
– Assisted undergraduate students in their senior design project; mentored 8 teams in total
– Developed and delivered tutorials on essential hardware, software, and their integration

Student Lectures, Channel Coding, Fall 2015
Texas A&M University, College Station, TX, USA
– Along with two more students, prepared notes and lectured to a small group of interested students
– This was a students-led initiative since the course was not offered that semester

INDUSTRY EXPERIENCE

Graduate Research Intern, June – Aug. 2015
Alcatel-Lucent Bell Labs, Stuttgart, Germany
– Analyzed Spatially-Coupled Regular LDPC codes on burst erasure channels
– Rigorously proved that removal of 4-cycles and increasing left-degree can guarantee block erasure rates of $O(10^{-15})$ for some code ensembles
– Published in two IEEE conferences and in the IEEE Transactions on Information Theory

Undergraduate Summer Intern, June – July 2012
Ericsson India Global Services Private Limited, Chennai, India
– Developed, with 5 fellow interns, a web portal (using Drupal and PHP) to facilitate the internal processing system of Ericsson's Revenue Management Division
– Prepared extensive documentation for the developed system

SELECTED PROJECTS

Synthesis of Logical Clifford Operators, Nov. 2017 – Present
Duke University, Durham, NC, USA
– Exploited the binary symplectic geometry connection of Clifford operators to efficiently synthesize logical Clifford operators for stabilizer codes
– Using symplectic transvections, developed algorithms for enumerating all symplectic matrices satisfying a system of linear equations
– Developed a full package of MATLAB code and released it open-source on GitHub. Available at: https://github.com/nrenga/symplectic-arxiv18a
– Paper accepted for the 2018 IEEE International Symposium on Information Theory
– Preprint of longer paper posted to arXiv and submitted to the Quantum journal

Quantum Channels, Quantum Message Passing, Mar. 2017 – Present
Duke University, Durham, NC, USA
– Studied and prepared notes for understanding duality of channels and codes, based on a recent paper
– Performed analysis on a recent quantum belief propagation algorithm

Deterministic Compressed Sensing and Support Recovery, May – Dec. 2016
Duke University, Durham, NC, USA

– Studied the performance of deterministic compressed sensing matrices for support recovery
– Demonstrated empirically that matrices based on Kerdock codes can recover large supports under a recently proposed reformulation of the compressed sensing problem

Spatially-Coupled LDPC Codes on Burst Erasure Channels, June – Aug. 2015
Alcatel-Lucent Bell Labs, Stuttgart, Germany
– Analyzed Spatially-Coupled Regular LDPC codes on burst erasure channels
– Rigorously proved that removal of 4-cycles and increasing left-degree can guarantee block erasure rates of $O(10^{-15})$ for some code ensembles
– Used the developed analyses on simple channel models to closely estimate performance on the more realistic block erasure channel (BLEC) model
– Published in two IEEE conferences and in the IEEE Transactions on Information Theory

Cyclic Polar Codes, M.S. Thesis, Sep. 2014 – Dec. 2015
Texas A&M University, College Station, TX, USA
– Modified polar codes to produce cyclic codes over suitable Galois fields
– Achieved higher rates on the erasure channel than binary polar codes for a target block erasure rate
– Paper presented in the 2015 IEEE International Symposium on Information Theory

Hands On, "Sensing, Acquisition and Innovation Lab" Course Project, Fall 2013
Texas A&M University, College Station, TX, USA
– As a team, developed a device for testing coordination of both hands simultaneously
– Developed a GUI using Qt Creator IDE to receive and visualize IMU data
– Performed real-time testing on participants on Demo Day

Wireless Electrocardiogram (ECG) Monitoring, B.Tech. Project, Jul. 2012 – May 2013
Amrita University, Coimbatore, Tamilnadu, India
– As a team, built hardware to transmit ECG (input from any reliable, mobile ECG extraction hardware) to the patient's phone over Bluetooth
– Developed an Android application to receive signals from the hardware in real-time and display it along with key parameters
– Processed the signals using the Pan-Tompkins algorithm to detect key parameters, and raised alerts when necessary via the Short Message Service (SMS)

Integrated Village Development System, Aug. 2011 – June 2012
Amrita University, Coimbatore, Tamilnadu, India
– As a team, used Software Defined Radio (SDR) to demonstrate connectivity between places, with only partial dependence on the internet
– Created a web portal (using JSP language) for Job Classifieds System

PROFESSIONAL ACTIVITIES

Project Manager for Duke Opportunities in Math (DOmath), June 2018 – Present
Duke University, Durham, NC, USA
– A Department of Mathematics initiative to provide research experience for math undergraduates
– Mentoring 3 students in a two-month project on synthesizing fault-tolerant logical operators for quantum computing. Project lead by Prof. Robert Calderbank and Prof. Henry Pfister

Quantum Group Meetings, Mar. 2017 – Present
Duke University, Durham, NC, USA
– Organizing weekly meetings on topics related to quantum computing, communications, algorithms
– Presented papers and my notes on several topics of common interest
– Collaborated with professors to produce work on synthesis of logical Clifford operators

North American School of Information Theory, June 2016
Duke University, Durham, NC, USA
– Assisted in organizing the summer school, handled monetary responsibilities
– Developed an information theory crossword with a colleague

Workshop on Software Defined Radio, Aug. 2012
Amrita University, Coimbatore, Tamilnadu, India
– Learned to work with the Universal Software Radio Peripheral (USRP) Kit
– Developed simple communications system modules in GNU Radio Companion software

THESES

1. N. Rengaswamy, "On Cyclic Polar Codes and the Burst Erasure Performance of Spatially-Coupled LDPC Codes," Master's thesis, Texas A&M University, 2015. http://hdl.handle.net/1969.1/156244.

PEER-REVIEWED JOURNAL PAPERS

1. V. Aref, **N. Rengaswamy**, and L. Schmalen, "Finite-Length Analysis of Spatially-Coupled Regular LDPC Ensembles on Burst-Erasure Channels," *IEEE Trans. Inform. Theory*, vol. 64, no. 5, pp. 3431 – 3449, 2018. [Online]. Available at: https://arxiv.org/abs/1611.08267.

PREPRINTS

1. **N. Rengaswamy**, R. Calderbank, S. Kadhe, and H. D. Pfister, "Synthesis of Logical Clifford Operators via Symplectic Geometry," *submitted to Quantum, arXiv preprint arXiv:1803.06987*, 2018. [Online]. Available at: https://arxiv.org/abs/1803.06987.

PEER-REVIEWED CONFERENCE PAPERS

4. **N. Rengaswamy**, R. Calderbank, S. Kadhe, and H. D. Pfister, "Synthesis of logical Clifford operators via symplectic geometry," accepted for *IEEE Int. Symp. Inform. Theory*, 2018.

3. V. Aref, **N. Rengaswamy**, and L. Schmalen, "Spatially coupled LDPC codes affected by a single random burst of erasures," in *Proc. Int. Symp. on Turbo Codes & Iterative Inform. Proc.*, pp. 166–170, IEEE, 2016. [Online]. Available at: https://arxiv.org/abs/1607.00918.

2. **N. Rengaswamy**, L. Schmalen, and V. Aref, "On the burst erasure correctability of spatially coupled LDPC ensembles," in *Proc. IEEE Intl. Zurich Seminar on Commun.*, pp. 155–159, 2016.

1. **N. Rengaswamy** and H. D. Pfister, "Cyclic polar codes," in *Proc. IEEE Int. Symp. Inform. Theory*, pp. 1287–1291, June 2015.

TALKS, POSTERS AND WORKSHOPS

9. Poster – **N. Rengaswamy**, R. Calderbank, S. Kadhe, and H. D. Pfister, "Synthesis of Logical Operators for Quantum Computers using Stabilizer Codes", *North American School of Information Theory*, Texas A&M University, May 20-23, 2018.

8. Talk – "Synthesis of Logical Operators for Quantum Computers using Stabilizer Codes", *Seminar, Department of Electrical Engineering*, Indian Institute of Technology at Madras, Apr. 26, 2018.

7. Poster – **N. Rengaswamy**, H. D. Pfister, and R. Calderbank, "Logical Operators for CSS Codes: A Binary Perspective", *Duke IBM Day*, Duke University, Oct. 31, 2017.

6. Workshop (participant) – *Beyond I.I.D. in Information Theory*, National University of Singapore, July 24-28, 2017.

5. Poster – **N. Rengaswamy** and H. D. Pfister, "Deterministic Compressed Sensing and Recovery of Large Supports", *North American School of Information Theory*, Georgia Institute of Technology, June 6-9, 2017.

4. Workshop (participant) – *Communications, Inference, and Computing in Molecular and Biological Systems*, University of Southern California, Dec. 3-4, 2015.

3. Talk – "The Burst Erasure Correctability of Spatially Coupled LDPC Ensembles", *Information Sciences and Systems Seminar*, Texas A&M University, Nov. 4, 2015.

2. Talk – "Cyclic Polar Codes", *Information Sciences and Systems Symposium*, Texas A&M University, Oct. 19, 2015.

1. Poster – **N. Rengaswamy** and H. D. Pfister, "Cyclic Polar Codes: How to Achieve Higher Rates than Binary Polar Codes at Finite Blocklengths?", *Eighth Annual Winedale Workshop*, Round Top, Texas, Oct. 9, 2015.

REFERENCES

1. **Prof. Henry D. Pfister**
   Associate Professor
   Department of Electrical and Computer Engineering
   Duke University, Durham, NC, USA
   http://pfister.ee.duke.edu
   henry.pfister@duke.edu, +1 (919) 660-5288

2. **Prof. Robert Calderbank**
   Charles S. Sydnor Professor
   Department of Computer Science
   Duke University, Durham, NC, USA
   http://ece.duke.edu/faculty/robert-calderbank
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3. **Prof. Jean-Francois Chamberland-Tremblay**
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4. **Dr. Samuel Villareal**
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5. **Dr. Laurent Schmalen**
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