Shouvik Ganguly

9500 Gilman Drive, La Jolla, California 92093, USA
shgangul@eng.ucsd.edu • +1 (515) 708-7861

EDUCATION

University of California, San Diego

- Ph.D. in Electrical and Computer Engineering — Oct 2014 – present
  - Advisor: Prof. Young-Han Kim
  - Focus: Network Information Theory

Indian Institute of Technology, Kanpur

- B.Tech. in Electrical Engineering — Jul 2009 – May 2013

RESEARCH INTERESTS

- Network Information Theory and Wireless Communications
- Information Theory and Statistics

RESEARCH EXPERIENCE

University of California, San Diego

- Research Assistant — Jul 2015 – present
  - Advisor: Prof. Young-Han Kim

  My research looks into applying information theory to diverse problems ranging from information flow over wireless networks, to learning properties of probability distributions from samples. Studying uplink and downlink communications over next-generation cloud radio access networks through the lens of information theory, I have derived fundamental bounds on data rates achievable over these networks. I have characterized the capacities of these networks to within a constant gap and studied the capacity scaling (with network size) under rich scattering network models. In collaboration with ETRI (Korea), I have also performed extensive simulation studies to evaluate the capacity scaling under more realistic channel models. My ongoing work looks at ways to bring some of the coding schemes from information theory textbooks into the practical domain, so that these theoretical bounds can be approached in practice using popular channel codes as black boxes. On the distribution learning front, I have discovered a general recipe for coming up with easily computable nearest-neighbor distance based estimators for functionals of probability densities, which include differential entropy and Kullback–Leibler divergence as special cases, and established finite-sample ensemble behaviors of these estimators theoretically.

Qualcomm, Inc., San Diego, CA

- Interim Engineering Intern — Jun 2019 – Sep 2019
  - Supervisor: Dr. Raghu Challa

  I studied various UE beam pairing algorithms for 5G mmWave downlink and evaluated performance in terms of SNR and spectral efficiency. In addition, I modified these algorithms for maximizing SNR under maximum permissible exposure (MPE) regulatory constraints on 5G systems. Performance of these algorithms was evaluated under perfect beam knowledge (ideal scenario), as well as under incomplete knowledge based on periodic beam sweeps. Both synthetic and real-world data on beam gains were used.

  Key expertise gained: Comprehensive understanding of the interplay between various components of UEs.

Samsung Research America, Richardson, TX

- R & D Intern — Jun 2018 – Sep 2018
  - Supervisor: Dr. Young-Han Nam

  I studied channel estimation and prediction for downlink MU-MIMO using frequency-hopped SRS (sounding reference signals). I evaluated performances of prediction methods such as sample-and-hold (using the most recent SRS sample), linear extrapolation, 1D (time) and 2D (time–frequency) MMSE prediction through Wiener filtering, theoretically. I also implemented these approaches and evaluated throughput performance on a MATLAB-based system-level simulator (SLS). Estimation of channel parameters (using a simplified channel model to satisfy wide-sense stationarity) for Wiener filtering was performed on the fly, using the same SRS. To better model the real-life scenario, noisy SRS was considered, with noise levels set according to uplink SINR.

  Key expertise gained: Nested functional programming in MATLAB, comprehensive understanding of the interplay between various components of a modern communication system (through study of the SLS), using Python as a scripting language for OS tasks, understanding of the 3GPP channel model.

Samsung Research America, Richardson, TX

- R & D Intern — Jul 2017 – Oct 2017
  - Supervisor: Dr. Boon Loong Ng

  I looked at nonlinear precoding methods for co-located as well as distributed downlink multiuser MIMO systems. I performed theoretical and link- and system-level simulation studies to ascertain the improvement in throughput over linear precoding and the accompanying increase in processing complexity. These studies were performed on each added layer of sophistication (optimizing the linear precoder numerically to maximize minimum SINR, changing encoding order, adding offset to constellation) and on several scenarios such as low vs high BS antenna number, crowded vs low UE density, and fast- vs slow-moving UE.

Indian Institute of Science, Bangalore, India

- Research Assistant — Aug 2013 – Dec 2013
  - Supervisor: Prof. Vinod Sharma

  I looked into nonparametric hypothesis testing problems, where the alternative hypothesis is compound and the distributions under the alternative are not known except for some divergence conditions. I derived some results on large-sample performance of the tests, as well as reasonable approximations of theoretical small-sample behavior. These classes of problems have applications in opportunistic spectrum usage for cognitive radio, where the alternative hypothesis corresponds to a channel in use.

Indian Institute of Technology, Kanpur

- Undergraduate Researcher — Aug 2012 – Apr 2013
  - Supervisor: Prof. R.K. Bansal

  I came up with universal compression-based (offline) algorithms to estimate change point(s) in a stream of data (points where the underlying data distribution changes) and derived asymptotic performance guarantees of the estimators.

PUBLICATIONS / PREPRINTS

- S. Ganguly, S.-E. Hong, and Y.-H. Kim, "On the Capacity Regions of Cloud Radio Access Networks with Limited Orthogonal Fronthaul", *arXiv:1912.04483 [cs.IT], Dec. 2019.*
- S. Ganguly and Y.-H. Kim, "Capacity Scaling for Cloud Radio Access Networks with Limited Orthogonal Fronthaul", *in Proc. International Symposium on Information Theory (ISIT), Paris, France, 2019*, pp. 1472–1476.
- S. Ganguly and Y.-H. Kim, "On the Capacity of Cloud Radio Access Networks", *in Proc. International Symposium on Information Theory (ISIT), Aachen, Germany, 2017*, pp. 2063–2067.
- S. Ganguly, L. Wang, and Y.-H. Kim, "A Functional Construction of Codes for Multiple Access and Broadcast Channels", *(accepted for presentation & publication at International Symposium on Information Theory (ISIT), Los Angeles, USA, 2020).*
- S. Ganguly, J. Ryu, Y.-H. Kim, Y.-K. Noh, and D. D. Lee, "Nearest Neighbor Density Functional Estimation based on Inverse Laplace Transform", *arXiv:1805.08342 [math.ST], May 2018.*
- S. Ganguly, K. Sahasranand, and V. Sharma, "A New Algorithm for Distributed Nonparametric Sequential Detection", *in Proc. 2014 IEEE International Conference on Communications (ICC)*, pp. 1409–1415.
- S. Ganguly, K. Sahasranand, and V. Sharma, "A New Algorithm for Nonparametric Sequential Detection", *in Proc. 2014 National Conference on Communications (Kanpur, India)*, pp. 1–6.
- S. Ganguly and L. Wang, "Marton Coding with Point-to-Point Codes" *(in preparation).*
- S. Ganguly, B. L. Ng, J. Zhang, and Y.-H. Nam, "Non-linear precoding for downlink MU MIMO: Costs and Benefits" *(in preparation)*.

PATENTS

- R. Wang, J. Sung, J. Zhang, Y.-H. Nam, and S. Ganguly, "Method and Apparatus for Channel State Information Estimation", US Patent Appl. No. 16/583142, filed Sep. 25, 2019.

COMPUTER SKILLS

MATLAB, Python, C, C++.

COMPUTING EXPERIENCE

- Implemented channel prediction algorithms using frequency-hopped SRS for MU-MIMO system-level simulator (on MATLAB) and evaluated throughput performance. Developed an understanding of working of the SLS and through it, a comprehensive picture of the different components of a modern communication system and their interplay. 2018

- Implemented different blocks of a nonlinear precoder for downlink MIMO (using MATLAB) including modulo operation-based offset, VBLAST encoding, and numerical maximization of minimum receiver SINR, based on solving generalized eigenvalue problems (using cvx toolbox). Performed link- and system-level simulations on the precoder via nested functional programming in MATLAB. 2017
- Implemented an efficient Viterbi decoder (using MATLAB) from scratch for a general convolutional code (with known octal tap connections) and used it to simulate, among others, the performance of the NASA Planetary Standard convolutional code. 2015
- Implemented a Turbo decoder (based on two MAP decoders employing BCJR algorithm) from scratch (using MATLAB) for a rate $1/3$ Turbo code with memory 2 (4 states). 2012
- Implemented a simplified realization of a bitwise MAP decoder using 4 Viterbi decoders with efficient scheduling. 2015
- Implemented a facial recognition system in MATLAB using DFT filterbanks followed by a hybrid of information-theoretic metric learning and large-margin nearest neighbor algorithms. 2014
- Implemented an Interference Alignment scheme in MATLAB for the 4-sender, 4-receiver Gaussian interference channel, and used it for transmitting and receiving jpeg images using QPSK and 16-QAM modulation schemes. 2013

RELEVANT COURSEWORK

- **Communication Theory**
  Baseband representation of signals, modulation schemes (continuous-phase modulation, continuous-phase frequency shift keying, Gaussian minimum-shift keying), power spectra of modulated signals, optimal receivers for AWGN channel with ISI (different modulation schemes), band-limited channels, adaptive equalization.
- **Network Information Theory**
  Distributed lossless compression, multiple access channels, broadcast channels, interference channels, channels with state, Marton coding, multihop relay networks.
- **Probabilistic Coding**
  Convolutional codes, Viterbi decoding, Turbo codes, modified BCJR algorithm, LDPC codes, message-passing decoders for BEC, BSC, and AWGN channels, performance of LDPC codes over BEC.
- **Convex Optimization**
  Convex sets and functions (equivalent characterizations), classes of convex problems: linear programming, quadratic programming, second-order cone programming, semidefinite programming, duality, KKT conditions, regularization.
- **Advanced Probability Theory**
  Lebesgue measure, distribution functions, expectation as Lebesgue integral, convergence theorems on Lebesgue integrals, convergence of random variables, uniform integrability, laws of large numbers, conditional expectation and Radon–Nikodym theorem, Fubini's theorem.
- **Stochastic Processes**
  Discrete and continuous time Markov chains, random walks, Martingale theory, discrete and continuous time Martingale convergence theorems, Brownian motion, stopping times and strong Markov property, Poisson point processes, general Lévy processes, exchangeable sequences and de Finetti's theorem, Pólya's urn, stochastic calculus and Black–Scholes formula.
- **Basic Mathematics**
  - Linear Algebra: Helped develop a new course on linear algebra and its applications for graduate students in engineering (with dual focus on theory and computer implementation) as a two-time teaching assistant.
  - Real Analysis: Measure theoretic formulation of analysis, Lebesgue measure on R and R^n, complex measures, Lebesgue decomposition theorem and Lebesgue–Radon–Nikodym theorem (incl. applications), Lebesgue differentiation theorem, Hausdorf measure.