Nariman Farsad

CONTACT

Department of Electrical Engineering
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RESEARCH INTERESTS

Bio-inspired communication networks; molecular and chemical communication; application of machine learning and deep learning to communication systems; application of communication, information, and control theory to systems biology and bioengineering; experimental platforms for molecular communication; application of signal processing, information theory, and machine learning to study biology;

ACADEMIC BACKGROUND

Stanford University, Stanford 09/2015–Present
Electrical Engineering
Postdoctoral Research Scholar
- Hosted by: Prof. **Andrea Goldsmith**

York University, Toronto 07/2015
Ph.D., Electrical Engineering and Computer Science
- Thesis: Molecular Communication: From Theory to Practice
- Advisor: Prof. **Andrew Eckford**

York University, Toronto 06/2010
M.Sc., Computer Engineering and Computer Science
- Thesis: Low-Complexity Energy Optimization of Wireless Sensor Networks
- Advisor: Prof. **Andrew Eckford**

York University, Toronto 06/2007
B.Sc., Computer Science

HONORS & AWARDS

Best Demo Award for "Molecular MIMO Communication Link" at IEEE-INFOCOM 2015
NSERC of Canada Postdoctoral Fellowship ($90,000) 2015
Finalist in the **Bell Labs Prize** competition (final 7 among 500 applicants) 2014
Second Prize at IEEE ComSoc Student Competition 2014
Ontario Graduate Scholarship Award ($30,000) 2012–2014
Queen Elizabeth II Graduate Scholarship in Science & Technology Award ($15,000) 2011
York University Graduate Scholarship Award ($4,000) 2010
York University Graduate Scholarship Award ($4,000) 2007

RESEARCH EXPERIENCE

Stanford University, Stanford, *Postdoctoral Research Scholar* 09/2015–Present
Projects: Bio-inspired communication networks, implementing a molecular communication experimental platform for systems biology (supervised by Prof. **Andrea Goldsmith** and in collaboration with Profs. **Drew Endy** and **Stephen Quake** from Dept. of Bioengineering), information theoretic models for molecular communication, application of signal processing and control theory to chemical reactions and chemical signals.

Kinboshi Networks Inc., Toronto, *Founder* 04/2014–Present
A small spin-off company (out of my PhD research) that sells an experimental molecular communication platform to academic research groups around the world. A few units have been sold to date.

NTT DOCOMO Inc., Japan, *Research Subcontractor* 03/2010–03/2013
Project: Design and optimization of active transport molecular communication systems.

Research Experience (Continued)

York University, Toronto, *Research Assistant* 01/2010–07/2015
Project: Developing communication theoretic models for molecular communication, design and implementation of a tabletop experimental platform for these systems.

York University, Toronto, *Research Assistant* 09/2007–12/2009
Project: Low-complexity energy-optimization of wireless sensor networks using fractional cooperation and correlated sources.

Media Coverage

These media outlets have covered my research: **The Economist** (article), **The Wall Street Journal** (article), **IEEE Spectrum** (article) Science & Vie (article), **CTV News** (TV interview), CHCH (TV interview), **Discovery Channel** (TV news), PHYS.ORG (online article), **Engadget** (online article), **Globe and Mail** (web video), National Post (article), Slate (web video), **Wired** (online article), MSN News (online article), YAHOO! News (online article), **Gizmodo** (online article), **Chemistry World** (online article)

Supervisory Experience

Mr. David Pan Summer 2016
Stanford University, Stanford
Co-supervised summer undergrad research project: **a journal paper in preparation**
Project Title: "Machine Learning for Molecular Communication Channels"

Mr. Liam Hassen Neath Spring 2016
Stanford University, Stanford
Co-supervised research course project
Project Title: "Simulation of Chemical Reactions and Chemical Signal Propagation"

Miss Lida Jabbari 2014–2015
York University, Toronto
Co-supervised M.A.Sc. project
Project Title: "Optimal Detection Algorithms for a Tabletop Molecular Communication Setup"

Mr. LinChen Wang 2013–2014
York University, Toronto
Co-supervised M.A.Sc. project (publication: **a conference paper at IEEE-ICC'15**)
Project Title: "Communication Through Chemical Tags in Robotics"

Mr. Anthony Calce 2010–2011
York University, Toronto
Co-supervised M.A.Sc. project (publication: **a conference paper at IEEE-PIMRC'11**)
Project Title: "Implementation of Fractional Cooperation in Wireless Sensor Networks"

Teaching Experience

Experience as Lecturer
University of Ontario Institute of Technology, Greater Toronto Area
Advanced Communication Networks (graduate course, enrollment: 21) Winter 2015
Signals and Random Processes (third-year course, enrollment: 45, evaluation: 78/100) Fall 2012
Signals and Random Processes (third-year course, enrollment: 46, evaluation: 86/100) Fall 2011

Experience as Teaching Assistant & Lab Instructor
York University, Toronto 2007–2015
Object Oriented Programming from Sensors to Actuators (first-year course, term/year: W15)
Signal and Systems (third-year course, term/year: F14, F11, F09)
Digital Communication (fourth-year course, term/year: F12, F10, F09)
Mobile Communications (fourth-year course, term/year: W14)
Embedded Systems (third-year course, term/year: W12, W08)
Fundamentals of Data Structures (second-year course, term/year: S13)
Introduction to Computing for Mathematics and Statistics (first-year course, term/year: W11)
Introduction to Computer Science I (first-year course, term/year: F09, F07)

Professional Service

Area Associate Editor
IEEE Journal on Selected Areas in Communication–2013 Special Issue on Emerging Technologies in Communications

Standardization Project
P1906.1 - Recommended Practice for Nanoscale and Molecular Communication Framework

Technical Program Committee
IEEE International Conference on Communication (ICC), 2015
IEEE Global Communications Conference (GLOBCOM), 2015, 2016
International Conference on Bio-inspired Information and Communications Technologies (BICT), 2015, 2016

Technical Reviewer
IEEE Transactions on Signal Processing
IEEE Transactions on Information Theory
IEEE Transactions on Nanotechnology
IEEE Transactions on Biomedical Engineering
IEEE Transactions on NanoBioscience
IEEE Journal on Selected Areas in Communication
IEEE Transactions on Communication
IEEE Communications Letters
IEEE Wireless Communications Letters
IEEE International Symposium on Information Theory (ISIT)

Book Chapters

[B2] **N. Farsad**, A. Eckford, and S. Hiyama, "Channel design and optimization of active transport molecular communication," in *Bio-Inspired Models of Networks, Information, and Computing Systems*, ser., vol. 103, pp. 213–223, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, E. Hart, J. Timmis, P. Mitchell, T. Nakamo, and F. Dabiri, Eds. Springer Berlin Heidelberg, 2012.

[B1] **N. Farsad**, A. Eckford, S. Hiyama, and Y. Moritani, "Information rates of active propagation in microchannel molecular communication," in *Bio-Inspired Models of Network, Information, and Computing Systems*, ser., vol. 87, pp. 16–21, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, J. Suzuki and T. Nakano, Eds., Springer Berlin Heidelberg, 2012.

Journal Publications

Submitted and Published

[J17] W. Guo, Y. Deng, B. H. Yilmaz, **N. Farsad**, M. Elkashlan, C.-B. Chae, A. Eckford, and A. Nallanathan, "SMIET: Simultaneous Molecular Information and Energy Transfer," *IEEE Wireless Communications*, submitted (second round review), 2016.

[J16] **N. Farsad**, Y. Murin, A. W. Eckford, and A. Goldsmith, "Capacity Limits of Diffusion-Based Molecular Timing Channels," *IEEE Transactions on Information Theory*, submitted, 2016.

[J15] **N. Farsad**, B. H. Yilmaz, A. W. Eckford, C.-B. Chae, and W. Guo, "A Comprehensive Survey of Recent Advancements in Molecular Communication," *IEEE Communications Surveys & Tutorials*, vol. 18, no. 3, pp. 1887–1919, 2016.

[J14] B. Koo, C. Lee, H. B. Yilmaz, **N. Farsad**, A. W. Eckford, and C.-B. Chae "Molecular MIMO: From Theory to Prototype," *IEEE Journal on Selected Areas in Communications*, vol. 34, no. 3, pp. 600–614, 2016.

[J13] W. Guo, T. Asyhari,**N. Farsad**, B. H. Yilmaz, A. W. Eckford, and C.-B. Chae, "Molecular Communications: Channel Model and Physical Layer Techniques," *IEEE Wireless Communications*, vol. 23, no. 4, pp. 120–127, 2016.

[J12] W. Guo, C. Mias, **N. Farsad**, and J.-L. Wu, "Molecular Versus Electromagnetic Wave Propagation Loss in Macro-Scale Environments," *IEEE Transactions on Molecular, Biological, and Multi-Scale Communications*, vol. 1, no. 1, pp. 18–25, 2015.

[J11] **N. Farsad**, A. W. Eckford, and S. Hiyama, "Design and Optimizing of On-Chip Kinesin Substrates for Molecular Communication," *IEEE Transactions on Nanotechnology*, vol. 14, no. 4, pp. 699–708, 2015.

[J10] **N. Farsad**, N.-R. Kim, A. W. Eckford, and C.-B. Chae, "Channel and Noise Models for Nonlinear Molecular Communication Systems," *IEEE Journal on Selected Areas in Communications*, vol. 32, no. 12, pp. 2392–2401, 2014.

[J9] **N. Farsad**, A. W. Eckford, and S. Hiyama, "A Markov Chain Channel Model for Active Transport Molecular Communication," *IEEE Transactions on Signal Processing*, vol. 62, no. 9, pp. 2424–2436, 2014.

[J8] S. Qiu, W. Guo, M. Leeson, S. Wang, **N. Farsad**, and A. W. Eckford, "Nanoparticle Communications: from Chemical Signals in Nature to Wireless Sensor Networks," *Nanotechnology Perceptions*, vol. 10, no. 1, pp. 1–13, 2014.

[J7] **N. Farsad**, W. Guo, and A. W. Eckford, "Tabletop Molecular Communication: Text Messages Through Chemical Signals," *PLOS ONE*, vol. 8, no. 12, 2013.

[J6] **N. Farsad**, A. W. Eckford, S. Hiyama, and Y. Moritani, "On-Chip Molecular Communication: Analysis and Design," *IEEE Transactions on NanoBioscience*, vol. 11, no. 3, pp. 304–314, 2012.

[J5] **N. Farsad**, and A. W. Eckford, "Resource Allocation via Linear Programming for Fractional Cooperation," *IEEE Transactions on Wireless Communications*, vol. 11, no. 5, pp. 1633–1637, 2012.

[J4] **N. Farsad**, A. W. Eckford, S. Hiyama, and Y. Moritani, "Quick System Design of Vesicle-Based Active Transport Molecular Communication by Using a Simple Transport Model," *Nano Communication Networks*, vol. 2, no. 4, pp. 175–188, 2011.

In Preparation for Submission

[J3] **N. Farsad**, Y. Murin, W. Guo, C.-B. Chae, A. Eckford and A. Goldsmith, "Bit Error Rates in Stable Distributed Molecular Timing Channels," *IEEE Transactions on Signal Processing*, in preparation for submission, 2016.

[J2] V. Jamali, **N. Farsad**, R. Schober, and A. Goldsmith, "Non-Coherent Detection for Diffusive Molecular Communications," *IEEE Transactions on Communications*, in preparation for submission, 2016.

[J1] Y. Murin, **N. Farsad**, M. Chowdhury, and A. Goldsmith, "Optimal Detection for Diffusion-Based Molecular Timing Channels," *IEEE Transactions on Molecular, Biological and Multi-Scale Communications*, in preparation for submission, 2016.

Conference Papers

[C24] **N. Farsad**, Y. Murin, M. Rao, and A. Goldsmith, "On the Capacity of Diffusion-Based Molecular Timing Channels with Diversity," *Asilomar Conference on Signals, Systems, and Computers*, 2016.

[C23] **N. Farsad**, Y. Murin, W. Guo, C.-B. Chae, A. Eckford and A. Goldsmith, "On the Impact of Time-Synchronization in Molecular Timing Channels," *IEEE Global Communications Conference (GLOBECOM)*, 2016.

[C22] Y. Murin, **N. Farsad**, M. Chowdhury, and A. Goldsmith, "Communication over Diffusion-Based Molecular Timing Channels," *IEEE Global Communications Conference (GLOBECOM)*, 2016.

[C21] V. Jamali, **N. Farsad**, R. Schober, and A. Goldsmith, "Non-Coherent Multiple-Symbol Detection for Diffusive Molecular Communications," *ACM International Conference on Nanoscale Computing and Communication (NanoCom)*, 2016.

[C20] Y. Murin, **N. Farsad**, M. Chowdhury, and A. Goldsmith, "On Time-Slotted Communication over Molecular Timing Channels," *ACM International Conference on Nanoscale Computing and Communication (NanoCom)*, 2016.

[C19] **N. Farsad**, Y. Murin, A. W. Eckford, and A. Goldsmith, "On the Capacity of Diffusion-Based Molecular Timing Channels," *IEEE International Symposium on Information Theory (ISIT)*, 2016.

[C18] **N. Farsad**, and Andrea Goldsmith, "A Molecular Communication System Using Acids, Bases and Hydrogen Ions," *IEEE International workshop on Signal Processing advances in Wireless Communications (SPAWC)*, 2016.

[C17] **N. Farsad**, H. B. Yilmaz, C.-B. Chae, and Andrea Goldsmith, "Energy Model for Vesicle-Based Active Transport Molecular Communication," *IEEE International Conference on Communications (ICC)*, 2016.

[C16] **N. Farsad**, W. Guo, C.-B. Chae, and A. W. Eckford, "Stable Distributions as Noise Models for Molecular Communication," *IEEE Global Communication Conference (GLOBCOM)*, 2015.

[C15] C. Lee, B. Koo, N.-R. Kim, H. B. Yilmaz, **N. Farsad**, A. W. Eckford, and C.-B. Chae, "Molecular MIMO with Drift," *International Conference on Mobile Computing and Networking (MobiCom)*, 2015.

[C14] S. Qiu, **N. Farsad**, Y. Dong, A. W. Eckford, and W. Guo, "Under-Water Molecular Signalling: a Hidden Transmitter and Absent Receivers Problem," *IEEE International Conference on Communications (ICC)*, 2015.

[C13] N.-R. Kim, **N. Farsad**, C.-B. Chae, and A. W. Eckford, "A Universal Channel Model for Molecular Communication Systems with Metal-Oxide Detectors," *IEEE International Conference on Communications (ICC)*, 2015.

[C12] L. Wang, **N. Farsad**, W. Guo, S. Magierowski, and A. W. Eckford, "Molecular Barcodes: Information Transmission via Persistent Chemical Tags," *IEEE International Conference on Communications (ICC)*, 2015.

[C11] C. Lee, B. Koo, N.-R. Kim, H. B. Yilmaz, **N. Farsad**, A. W. Eckford, and C.-B. Chae, "Molecular MIMO Communication Link," *IEEE International Conference on Computer Communications (INFOCOM)*, 2015.

[C10] N.-R. Kim, **N. Farsad**, C.-B. Chae, and A. W. Eckford, "A Realistic Channel Model for Molecular Communication with Imperfect Receivers," *IEEE International Conference on Communications (ICC)*, 2014.

[C9] S. Qiu, W. Guo, S. Wang, **N. Farsad**, and A. W. Eckford, "A Molecular Communication Link for Monitoring in Confined Environments," *IEEE International Conference on Communications (ICC) Workshops*, 2014.

[C8] **N. Farsad**, W. Guo, and A. W. Eckford, "Molecular Communication Link," *IEEE International Conference on Computer Communications (INFOCOM)*, 2014.

[C7] **N. Farsad**, A. W. Eckford, and S. Hiyama, "Modelling and Design of Polygon-Shaped Kinesin Substrates for Molecular Communication," *IEEE International Conference on Nanotechnology*, 2012.

[C6] **N. Farsad**, A. W. Eckford, and S. Hiyama, "A Mathematical Channel Optimization Formula for Active Transport Molecular Communication," *IEEE International Conference on Communications (ICC) Workshops*, 2012.

[C5] A. Calce, **N. Farsad**, and A. W. Eckford, "An Experimental Study of Fractional Cooperation in Wireless Mesh Networks," *IEEE Symposium on Personal Indoor Mobile Radio Communications (PIMRC)*, 2011.

[C4] **N. Farsad**, A. W. Eckford, S. Hiyama, and Y. Moritani, "A Simple Mathematical Model for Information Rate of Active Transport Molecular Communication," *IEEE International Conference on Computer Communications (INFOCOM) Workshops*, 2011.

[C3] A. W. Eckford, **N. Farsad**, S. Hiyama, and Y. Moritani, "Microchannel Molecular Communication with Nanoscale Carriers: Brownian Motion versus Active Transport," *IEEE International Conference on Nanotechnology*, 2010.

[C2] **N. Farsad**, and A. W. Eckford, "Resource allocation via linear programming for multi-source, multi-relay wireless networks," *IEEE International Conference on Communications (ICC)*, 2010.

[C1] **N. Farsad**, and A. W. Eckford, "Low-complexity cooperation with correlated sources: diversity order analysis," *Annual Conference on Information Sciences and Systems (CISS)*, 2009.

Invited Talks

[12] "Molecular Communication: Theoretical Limits and Experimental Implementations", Department of Electrical and Computer Engineering, **University of British Columbia**, Vancouver, British Columbia. (June 2016)

[11] "Capacity Limits of Diffusion-Based Molecular Timing Channels", **Canadian Biennial Symposium on Communications (BSC)**, Kelowna, British Columbia. (June 2016)

[10] "Molecular Communication: Theoretical Limits and Experimental Implementations", School of Electrical and Computer Engineering, **Georgia Institute of Technology**, Atlanta, Georgia. (May 2016)

[9] "Molecular Communication: Theoretical Limits and Experimental Implementations", Department of Electrical and Computer Engineering, **Carnegie Mellon University**, Pittsburgh, Pennsylvania. (May 2016)

[8] "Molecular Communication: Theoretical Limits and Experimental Implementations", Department of Electrical and Computer Engineering, **Boston University**, Cambridge, Massachusetts. (May 2016)

[7] "Molecular Communication: Theoretical Limits and Experimental Implementations", Department of Electrical Engineering and Computer Science, **Massachusetts Institute of Technology**, Cambridge, Massachusetts. (May 2016)

[6] "Molecular Communication: Theoretical Limits and Experimental Implementations", **IEEE Toronto Section and University of Toronto**, Toronto, Ontario. (April 2016)

[5] "Molecular Communication: Theoretical Limits and Experimental Implementations", Department of Electrical Engineering, **Princeton University**, Princeton, New Jersey. (April 2016)

[4] "Capacity Limits of Molecular Timing Channels", **Information Theory and Applications (ITA) Workshop**, San Diego, California. (Feb 2016)

[3] "Molecular Communication using Acids and Bases", Communications, Inference, And Computing In Molecular And Biological Systems Workshop, **University of Southern California**, USA. (December 2015)

[2] "Tabletop Molecular Communication: Theory and Practice", School of Engineering, **University of Warwick**, United Kingdom. (September 2014)

[1] "Molecular Communication", School of Integrated Technology, **Yonsei University**, South Korea. (November 2013)

Technical Reports

[4] **N. Farsad**, and A. W. Eckford "Optimal Channel Design and Markov Chain Channel Model for Active Transport Molecular Communication," NTT DOCOMO Inc., Yokosuka, Kanagawa, Japan, March 2013.

[3] **N. Farsad**, and A. W. Eckford "Channel Design and Optimization in Active Transport Molecular Communication," NTT DOCOMO Inc., Yokosuka, Kanagawa, Japan, March 2012.

[2] **N. Farsad**, and A. W. Eckford "Information Transfer in Microchannel Systems: Effects of Flow and Mass Transport," NTT DOCOMO Inc., Yokosuka, Kanagawa, Japan, March 2011.

[1] **N. Farsad**, and A. W. Eckford "Mathematical Models of Information Transfer in Molecular Active Transport Systems," NTT DOCOMO Inc., Yokosuka, Kanagawa, Japan, March 2010.

Memberships

Engineering Intern at Professional Engineers Ontario, since 2011
IEEE Student Member, since 2007, and Member, since 2015
IEEE Communication Society Member, since 2007
IEEE Information Theory Society Member, since 2007
IEEE Signal Processing Society Member, since 2009
IEEE Engineering in Medicine and Biology Society Member, since 2009

List of References

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Prof. Andrew Eckford
Electrical Engineering and Computer Science
York University, Toronto, Ontario
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Prof. Christopher Rose
School of Engineering
Brown University, Providence, Rhode Island
Email: christopher_rose@brown.edu

Prof. Muriel Médard
Electrical Engineering and Computer Science
Massachusett Institute of Technology, Cambridge, Massachusetts
Email: medard@mit.edu

(More references available upon request)