

## Aly El Gamal

Assistant Professor, School of Electrical and Computer Engineering  
Purdue University

MSEE 350

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### EDUCATION

**University of Illinois at Urbana-Champaign**, Ph.D. in *Electrical and Computer Engineering*,  
May 2014, GPA: 4.0

Dissertation: *Interference Channels with Coordinated Multi-Point Transmission*

Advisor: Prof. Venugopal V. Veeravalli

**University of Illinois at Urbana-Champaign**, M.S. in *Mathematics*, May 2013,

GPA: 3.96

**Nile University**, M.S. in *Electrical Engineering*, Jul. 2009, GPA: 3.82

Thesis: *The Two-Way Wiretap Channel: Theory and Practice*

Advisors: Prof. Moustafa Youssef and Prof. Hesham El Gamal

**Cairo University**, B.S. in *Computer Engineering*, Jul. 2007

Grade: Distinction with Honors Degree

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### PROFESSIONAL EXPERIENCE

**Assistant Professor, School of Electrical and Computer Engineering, Purdue University**, August  
2015—Now

**Simons Postdoctoral Fellow, University of Texas at Austin**, May 2015 – August 2015

Advisors: Prof. Sriram Vishwanath and Prof. Francois Baccelli

**Postdoctoral Research Associate, University of Southern California**, May 2014 – May 2015

Advisor: Prof. Salman Avestimehr

**Summer Intern, Qualcomm Inc. The Office of the Chief Scientist**, May – Aug. 2012

Project Description: Indoor localization in Ultra Wide-Band Environments

Managers: Alok Gupta, Bin Tian

**Research Assistant, University of Illinois at Urbana-Champaign**, Aug. 2009 – May 2014

Advisor: Prof. Venugopal V. Veeravalli

**Research Assistant, Nile University**, Nov. 2007 – Aug. 2009

Advisors: Prof. Moustafa Youssef and Prof. Hesham El Gamal

**Teaching Assistant, Cairo University**, Sep. 2007 – Jan. 2008

Department of Computer Engineering

**Summer Intern, Ohio State University**, Jul. – Sep. 2006

Project Description: Developing a reliable Data Collection Protocol for Body Area Networks

Advisors: Prof. Emre Ertin and Prof. Hesham El Gamal

**Summer Intern, Ohio State University**, Jul. – Sep. 2005

Project Description: Developing a Multi-Hop Protocol for Wireless Sensor Networks

Advisor: Prof. Lee Potter

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## **AWARDS**

Huawei Innovation Research Program (HIRP) OPEN Award, Nov. 2015.

DARPA Contract Award for the Spectrum Collaboration Challenge (SC2), Nov. 2016.

Purdue Seed for Success, Oct. 2017.

DARPA Award for top 10 teams in SC2 Phase 1 Preliminary Event, Dec. 2017.

Seminal paper selected by Purdue ECE CNSIP area for showcase to dean, Mar. 2018.

## **RESEARCH AREAS**

### **Information Theory for Next Generation Wireless Networks**

Our goal is to build a theoretical framework that suits the nature of future wireless networks. With recent advances in the cloud and cooperative communication schemes (Coordinated Multi-Point or CoMP communication), it is possible to envision a paradigm where scheduling, modulation and coding schemes decisions are optimized in a centralized fashion for large networks. This poses interesting combinatorial problems with the potential of achieving rate gains that were considered infeasible before, through simple practical schemes that have minimal delay requirements.

### **Machine Learning for Wireless Communication Systems**

We are conducting research in both theoretical and applied aspects of emerging machine learning techniques. For the theoretical aspect, the goal is to provide statistical learning analysis and guarantees for promising machine learning techniques that are gaining popularity in the literature, as well as evidenced practical significance. One such class of techniques is that of semi-supervised learning based on recent advances in graph signal processing. The idea is to represent sample points as vertices over a graph, whose edge weights are inversely proportional to distances in a Euclidean feature space. The semi-supervised learning problem can then be cast as a problem of determining a function (signal) over the graph from its values at few vertices. Further, spectral properties of the graph and the bandwidth of the graph signal can be used to determine fundamental limits of the learning problem under reasonable smoothness assumptions.

For empirical machine learning research, we are investigating the value of using deep neural networks for tasks required in wireless communication systems. Recent work reveals the potential of deep neural networks for analyzing received wireless signals. Convolutional layers can mimic the convolutional operations of matched filters and Long Short-term Memory (LSTM) units can identify temporal correlations in the received signal. Further, unlike traditional methods for processing wireless signals, there is no need in the deep learning approach to have a mathematical model for the wireless channel; a task that could be daunting in presence of various uncertainties that could alter the signals due to environmental conditions.

### **Data Science for Sports Applications**

The goal of this line of research is to use machine learning and statistical analysis to provide guidance for the design of sports training sessions based on data collected from sensors worn by the players. This research is set up in collaboration with the Purdue Women's Soccer Team. So far, we had obtained new results for predicting dynamic stress load values for the players using previously collected data.

## **PUBLICATIONS**

### **Book**

Venugopal V. Veeravalli, Aly El Gamal: Interference Management in Wireless Networks: Fundamental Bounds and the Role of Cooperation. Cambridge University Press, Feb. 2018.

### **Journal Papers (In Preparation / Submitted)**

[J12] Diyu Yang, Xiaoyu Liu, Sharan Ramjee, Shengtai Ju, Aly El Gamal, Yonina Eldar: Deep Learning for Automatic Modulation Classification: Neural Network Architectures, Subsampling, and Principal Component Analysis. In preparation for submission to Journal of Selected Areas in Communications – Special Issue on Machine Learning in Wireless Communications, Dec. 2018.

[J11] Aly El Gamal: On the Value of Transmitter Cooperation with no CSIT in Locally Connected Interference Networks. In preparation for submission to IEEE Transactions on Information Theory, Nov. 2018.

[J10] Tolunay Seyfi, Aly El Gamal: A Number-Theoretic Approach for Fast Discovery of Wireless Networks. In preparation for submission to IEEE Wireless Communication Letters, Oct. 2018.

[J9] Manik Singhal, Aly El Gamal: Joint Uplink-Downlink Cooperative Interference Management with Flexible Cell Associations. In preparation for submission to IEEE Transactions on Information Theory, Aug. 2018.

[J8] Aly El Gamal, Hesham El Gamal: A Blockchain Example for Cooperative Interference Management. Submitted to IEEE Wireless Communication Letters, Jul. 2018.

[J7] Yasemin Karacora, Tolunay Seyfi, Aly El Gamal: Fundamental Limits of Dynamic Interference Management with Flexible Message Assignments. Submitted to IEEE Transactions on Information Theory, Jul. 2018.

[J6] Aamir Anis, Aly El Gamal, A. Salman Avestimehr, Antonio Ortega: A Sampling Theory Perspective of Graph-based Semi-supervised Learning. Submitted to IEEE Transactions on Information Theory, May 2017, revised May 2018.

[J5] Meghana Bande, Aly El Gamal, Venugopal V. Veeravalli: Degrees of Freedom in Wireless Interference Networks with Cooperative Transmission and Backhaul Load Constraints. Submitted to IEEE Transactions on Information Theory, Oct. 2016, revised May 2017, second revision Dec. 2017, third revision May 2018.

### **Journal Publications**

[J4] Navid Naderializadeh, Aly El Gamal, A. Salman Avestimehr: Fundamental Limits of Non-Coherent Interference Alignment via Matroid Theory. IEEE Transactions on Information Theory, vol. 63, no. 10, pp. 6573-6586, Oct. 2017.

[J3] Aly El Gamal, V. Sreerkanth Annapureddy, Venugopal V. Veeravalli: Interference Channels with CoMP Transmission: Degrees of Freedom, Message Assignment, and Fractional Reuse. IEEE Transactions On Information Theory, vol. 60, no. 6, pp. 3483-3498, May. 2014.

[J2] Aly El Gamal, Onur Ozan Koyluoglu, Moustafa Youssef, Hesham El Gamal: Achievable Secrecy Rate Regions for the Two-Way Wiretap Channel. IEEE Transactions On Information Theory, vol. 59, no. 12, pp. 8099-8114, Dec. 2013.

[J1] V. Sreekanth Annapureddy, Aly El Gamal, Venugopal V. Veeravalli: Degrees of Freedom of Interference Channels with CoMP Transmission and Reception. *IEEE Transactions On Information Theory*, vol. 58, no. 9, pp. 5740-5760, Sep. 2012.

### **Conference Publications**

[C20] Manik Singhal, Aly El Gamal: Optimal Cell Associations and Degrees of Freedom of Locally Connected Interference Networks with Message Passing Decoding. *IEEE International Symposium on Information Theory (ISIT)*, Jun. 2018.

[C19] Xiaoyu Liu, Diyu Yang, Aly El Gamal: Deep Neural Network Architectures for Modulation Classification. *Asilomar Conference on Signals, Systems, and Computers*, Nov. 2017

[C18] Yasemin Karacora, Tolunay Seyfi, Aly El Gamal: The Role of Transmitter Cooperation in Linear Interference Networks with Block Erasures. *Asilomar Conference on Signals, Systems, and Computers*, Nov. 2017

[C17] Manik Singhal, Aly El Gamal: Joint Uplink-Downlink Cell Associations in Interference Networks with Local Connectivity. *Allerton Conference on Communications, Control, and Computing*, Oct. 2017

[C16] Aly El Gamal: Topological Interference Management: Linear Cooperation is not useful for Wyner's Networks. *IEEE International Symposium on Information Theory*, Aachen, Jun. 2017.

[C15] Aly El Gamal: Cell Associations that Maximize the Average Uplink-Downlink Degrees of Freedom. *IEEE International Symposium on Information Theory (ISIT)*, Barcelona, Jul. 2016.

[C14] Aly El Gamal: Cloud-Based Topological Interference Management: A Case with No Cooperative Transmission Gain. *IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, Edinburgh, Jul. 2016.

[C13] Meghana Bande, Aly El Gamal, Venugopal V. Veeravalli: Flexible Backhaul Design with Cooperative Transmission in Cellular Interference Networks. *International Symposium on Information Theory (ISIT 2015)*, Hong Kong, Jun. 2015.

[C12] Aly El Gamal, Navid Naderializadeh, A. Salman Avestimehr: When Does an Ensemble of Matrices with Randomly Scaled Rows Lose Rank?. *International Symposium on Information Theory (ISIT 2015)*, Hong Kong, Jun. 2015.

[C11] Navid Naderializadeh, Aly El Gamal, A. Salman Avestimehr: Topological Interference Management with just Retransmission: What are the Best Topologies. *International Conference on Communications (ICC 2015)*, London, Jun. 2015.

[C10] Aamir Anis, Aly El Gamal, A. Salman Avestimehr, Antonio Ortega: Asymptotic Justification for Band-Limited Interpolation of Graph Signals for Semi-Supervised Learning. *International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2015)*, Brisbane, Apr. 2015.

[C9] Aly El Gamal, Venugopal V. Veeravalli: Flexible Backhaul Design and Degrees of Freedom for Linear Interference Channels. *International Symposium on Information Theory (ISIT)*, Hawai'i, Jun. 2014

[C8] Aly El Gamal, Venugopal V. Veeravalli: Dynamic Interference Management, *Asilomar Conference on Signals, Systems, and Computers*, Nov. 2013

[C7] Aly El Gamal, V. Sreekanth Annapureddy, Venugopal V. Veeravalli: Degrees of Freedom of Locally Connected Interference Channels with Cooperating Multiple-Antenna Transmitters. *International Symposium on Information Theory (ISIT)*, MIT, Cambridge, Jul. 2012

- [C6] Aly El Gamal, V. Sreekanth Annapureddy, Venugopal V. Veeravalli: Degrees of Freedom of Locally Connected Interference Channels with Coordinated Multi-Point (CoMP) Transmission. International Conference on Communications (ICC), Ottawa, Jun. 2012
- [C5] Aly El Gamal, V. Sreekanth Annapureddy, Venugopal V. Veeravalli: On Optimal Message Assignments for Interference Channels with CoMP Transmission. 46<sup>th</sup> Annual Conference on Information Sciences and Systems (CISS), Princeton, NJ, Mar. 2012
- [C4] V. Sreekanth Annapureddy, Aly El Gamal, Venugopal V. Veeravalli: Degrees of Freedom of Cooperative Interference Networks. International Symposium on Information Theory (ISIT), Saint Petersburg, Aug. 2011
- [C3] V. Sreekanth Annapureddy, Aly El Gamal, Venugopal V. Veeravalli: Degrees of Freedom of the K-user Interference Channel with Transmitter Cooperation. International Symposium on Information Theory (ISIT), Austin, Jun. 2010
- [C2] Aly El Gamal, Onur Ozan Koyluoglu, Moustafa Youssef, Hesham El Gamal: New Achievable Secrecy Rate Regions for the Two Way Wiretap Channel. Information Theory Workshop (ITW), Cairo, Jan. 2010
- [C1] Aly El Gamal, Moustafa Youssef, Hesham El Gamal: Randomization for Security in Half-Duplex Two-Way Gaussian Channels. Global Communications Conference (Globecom), Hawaii, Dec. 2009
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## TALKS

- “Tutorial on Interference Management in Wireless Networks”  
**IEEE 1<sup>st</sup> 5G World Forum, Santa Clara**, Jul. 2018
- “Deep Neural Network Architectures for Modulation Classification”  
**Information Theory and Applications Workshop (ITA), San Diego**, Feb. 2018
- “Information Theory of Cloud-Based Cooperative Interference Management”  
**University of Padova, Padova**, Jul. 2017
- “Information Theory of Cloud-Based Cooperative Interference Management”  
**EURECOM, Sophia Antipolis**, Jul. 2017
- “Topological Interference Management: Linear Cooperation is not useful for Wyner’s Networks.”  
**International Symposium on Information Theory (ISIT), Aachen**, Jun. 2017
- “Cooperation in Large Cellular Networks: Insights and Fundamental Limits”  
**Information Theory and Applications Workshop (ITA), San Diego**, Feb. 2017
- “Cell Associations that Maximize the Average Uplink-Downlink Degrees of Freedom.”  
**International Symposium on Information Theory (ISIT), Barcelona**, Jul. 2016
- “Cloud-Based Topological Interference Management: A Case with No Cooperative Transmission Gain.”  
**Workshop on Signal Processing Advances in Wireless Communications (SPAWC), Edinburgh**, Jul. 2016
- “Cloud-Based Cell Associations”  
**Information Theory and Applications Workshop (ITA), San Diego**, Feb. 2016
- “Cellular Interference Management and Spectral Graph Learning”  
**Purdue University**, Apr. 2015
- “Cellular Interference Management and Spectral Graph Learning”  
**Worcester Polytechnic Institute**, Mar. 2015

“Two Recent Results in Random Matrix Theory and their Applications in Wireless Interference Management and Semi-Supervised Learning”

**University of Texas, Austin**, Feb. 2015

“Two Recent Results in Random Matrix Theory and their Applications in Wireless Interference Management and Semi-Supervised Learning”

**Control, Communications and Networks Seminar, University of Southern California**, Oct. 2014

“Flexible Backhaul Design and Degrees of Freedom for Linear Interference Networks”

**International Symposium on Information Theory (ISIT), Hawai’i**, Jul. 2014

“Flexible Backhaul Design for Locally Connected Interference Networks”

**Information Theory and Applications Workshop (ITA), San Diego**, Feb. 2014

“Dynamic Interference Management”

**Asilomar Conference on Signals, Systems, and Computers, Monterey**, Nov. 2013

“Interference Channels with Coordinated Multi-Point Transmission”

**Massachusetts Institute of Technology (MIT)**, Oct. 2013

“Interference Channels with Coordinated Multi-Point Transmission”

**Télécom ParisTech, Paris**, Jul. 2013

“Dynamic Interference Management”

**International Symposium on Information theory (ISIT), Istanbul**, Jul. 2013

“Locally Connected Interference Channels with CoMP: Degrees of Freedom, Message Assignment and Fractional Reuse”

**International Symposium on Information theory (ISIT), MIT**, Jul. 2012

“Degrees of Freedom of Locally Connected Interference Channels with Coordinated Multi-Point Transmission”

**International Conference on Communications (ICC), Ottawa**, Jun. 2012

“Degrees of Freedom of Interference Channels with CoMP Transmission and Reception”

**Communication Theory Workshop (CTW), Hawai’i**, May 2012

“On Optimal Message Assignments for Interference Channels with CoMP Transmission”

**Conference on Information Sciences and Systems (CISS), Princeton**, Mar. 2012

“Degrees of Freedom of Cooperative Interference Networks”

**International Symposium on Information theory (ISIT), Saint Petersburg**, Aug. 2011

“Degrees of Freedom (DoF) of Locally Connected Interference Channels with Coordinated Multi-Point (CoMP) Transmission”

**North American School of Information theory, UT Austin**, May 2011

“On the connection between expander bipartite graphs and the degrees of freedom of the K-user Interference Channel with transmitter cooperation”

**Midwestern Conference on Combinatorics, Cryptography and Computing, Illinois State University**, Sep., 2010

“Degrees of Freedom of the K-user Interference Channel with transmitter cooperation”

**North American School of Information theory, USC**, Aug. 2010

“New Achievable Secrecy Rate Regions for the Two Way Wiretap Channel”

**Information theory Workshop, Cairo**, Jan. 2010

“Randomization for Security in Half-Duplex Two-Way Gaussian Channels”

## TEACHING EXPERIENCE

**Purdue University**, Department of Electrical and Computer Engineering,

ECE 270 Introduction to Digital System Design, Spring 2017, Instructor

ECE 301 Signals and Systems, Fall 2015, Fall 2016, Fall 2017, Spring 2018, Instructor

ECE 368 Data Structures, Spring 2016, Instructor

**University of Illinois at Urbana-Champaign**, Department of *Electrical and Computer Engineering*, ECE 563 Information Theory, Fall 2010, Teaching Assistant

**Cairo University**, Department of *Computer Engineering*

Database Systems, Fall 2007, Teaching Assistant

Logic Design, Fall 2007, Teaching Assistant

Operating System Design, Fall 2007, Teaching Assistant

Microprocessors, Fall 2007, Teaching Assistant

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## COURSE WORK

**University of Illinois at Urbana-Champaign**

**Department of *Electrical and Computer Engineering***

Random Processes, Coding Theory, Detection and Estimation Theory, Introduction to Optimization, Control System Theory and Design, Vector Space Signal Processing, Statistical Learning and Pattern Recognition

**Department of *Mathematics***

Real Analysis 1, Real Analysis 2, Combinatorial Mathematics, Mathematical Logic

**Department of *Computer Science***

Computational Complexity, Distributed Algorithms

**Department of *Psychology***

Models of Decision and Choice

**Nile University**

***Wireless Intelligent Networks Center***

Stochastic Processes, Information Theory, Circuits for Wireless Communications, Design of Communication Systems, Antenna Theory, Fundamentals of Wireless Communications, Computer Networks, Wireless Networks

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## PROFESSIONAL SERVICE

- Reviewer for American Mathematical Society (AMS) Mathematical Reviews
- TPC Member for IEEE 5G-WF'18, WCNC'17, WPMC'17, ICNC'18
- Proposal Reviewer for the Natural Sciences and Engineering Research Counsel of Canada (NSERC)
- Proposal Reviewer for the Chilean National Science and Technology Commission (FONDECYT)
- Reviewer for IEEE Transactions on Information Theory, IEEE Transactions on Wireless Communications, IEEE Transactions on Communications, IEEE Transactions on Signal Processing, IEEE Journal on Selected Areas in Communications - Signal Processing (JSAC), and

several conferences including Allerton, IEEE ISIT, IEEE ICC, IEEE Globecom, IEEE CAMSAP, and IWCIT

- Organizing Committee Member for 2012 Coordinated Science Lab (CSL) Student Conference
- On-Site registration for 2010 IEEE Information Theory Workshop (ITW) in Cairo

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## **PROGRAMMING LANGUAGES**

Java, C++, nesC, SQL, Assembly (8086 Family), Python, MATLAB

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