

# ARASH RAHNAMA

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## EDUCATION

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<b>University of Notre Dame, Notre Dame, IN</b> <i>Doctor of Philosophy in Electrical Engineering</i> Specialization in Systems and Control & Machine Learning	<i>Aug 2013 - Present</i>
<b>University of Notre Dame, Notre Dame, IN</b> <i>Master of Science in Electrical Engineering</i>	<i>Aug 2013 - May 2015</i> <i>3.53/4.00</i>
<b>Texas Tech University, Lubbock, TX</b> <i>Bachelor of Science in Electrical Engineering</i> Minor in Mathematics	<i>Aug 2008 - May 2012</i> <i>3.80/4.00</i> <i>4.00/4.00</i>
Magna Cum Laude, Member of Honors College	

## PROFESSIONAL PROFILE

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- Nine years of experience in electrical and computer engineering —specialization in learning-based control of multi-layer intelligent cyber-physical systems and statistical machine learning. Firm background in statistical/predictive modeling, mathematics, numerical analysis and optimization.
- Statistics and Probability:
  - Detection Theory, Hypothesis Testing, KS Test, Statistical Estimation (Method of Moments, Maximum Likelihood Estimation, Bayesian Estimation), Expectation-Maximization Algorithm, Regression (General Linear, Ridge, Logistic, LASSO, LOWESS, Nonlinear).
- Machine Learning and Data Mining:
  - Classification (Supervised and Unsupervised), Nearest-Neighborhood, Linear/Quadratic Discriminant Analysis, Principal Component Analysis (PCA), Multi-Dimensional Scaling (MDS), Isomap, Naïve Bayesian, Artificial Neural Networks (ANN), Stacked Denoising Auto-Encoder (SDAE), Support Vector Machines (SVM), Tree Based Methods (Bagging, Boosting, Random Forest), Clustering (Hierarchical and Normal), K-Means.
  - Model Assessment and Methods of Model Selection, Cross-Validation, Bootstrap, Jackknife, Plug-in Principle, Structural Risk Minimization, Growth Function, the VC Dimension, Bayesian and Akaike Information Criteria (BIC & AIC).
- Optimization and Mathematical Programming:
  - Linear/Quadratic/Mixed Integer/Nonlinear Programming, Convex Programming, Gradient/Steepest Descent, Newton's & Quasi-Newton's Methods, The Simplex Method, Genetic Algorithms, Penalty and Barrier Methods, The Primal-Dual Interior-Point Method, The Ellipsoid Method.
- Strong programming skills with languages such as C++, Python, MATLAB/Simulink and R,
  - Knowledgeable about Algorithm Designs, Data Structures and Graph Theory.
  - Experienced in Object-Oriented Programming (OOP).
- Experienced in Real-Time Learning-Based Control of Large-Scale Networked Systems.
- Knowledgeable about Verification and Synthesis Methods, Temporal Logic and Model Checking, Abstraction and Bisimulation, Automata (Finite, Timed, Hybrid), Supervisory Control.

## RESEARCH PROFILE

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### Graduate Research Assistant

*University of Notre Dame*

Aug 2013 - Present

*Funded by NSF and General Motors Research*

- Learning-Based Control and Design of Large-Scale Networked Systems
- Estimation and Control of Cyber-Physical Embedded Systems
- Statistics, Data Analysis, Data Mining and Machine Learning
- Security and Consensus in Multi-Agent Networked Systems
- Non-Model Based Optimization Methods for Nonlinear Systems
- Learning-Based Adaptive Control of Intelligent Reconfigurable Systems
- Applied Mathematics, Numerical Analysis and Optimization

## PROFESSIONAL AND RESEARCH EXPERIENCE

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### University of Notre Dame

*Systems and Control Researcher*

Jan 2016 - Dec 2017

*Notre Dame, IN*

- Designed a learning-based resilient control framework for synchronization of large-scale multi-agent networked systems.
- Examined the security vulnerabilities of consensus algorithms for multi-agent systems against adversarial attacks.
- Introduced a detection and mitigation framework based on likelihood hypothesis testing and learning-based parameter estimation.
- Utilized Expectation-Maximization (EM) and Method of Moments (MoM) algorithms to estimate attack parameters and mitigate negative adversarial effects.

### University of Notre Dame/Middle East Technical University

*Machine Learning Researcher*

Dec 2016 - Aug 2017

*Notre Dame, IN*

- Worked on a new framework, called Hierarchical Multi-resolution Mesh Networks (HMMNs), which establishes a set of brain networks at multiple time resolutions of fMRI signals to represent the underlying cognitive processes.
- Utilized machine learning and statistical methods to learn, decode and classify underlying cognitive processes in the human brain.
- Demonstrated the existence of underlying functional connectivity patterns in the brain, given specific cognitive states, independent of subjects, via unsupervised deep learning algorithms.
- Researched and understood the technology, structure, and operations of functional Magnetic Resonance Imaging (fMRI) machines.

### University of Notre Dame/General Motors Research

*Optimization and Machine Learning Researcher*

Jan 2014 - Dec 2015

*Notre Dame, IN*

- Conducted research to apply derivative-free optimization techniques to the design of an Adaptive Cruise Controller (ACC) and a Lane Keeping Controller (LKC) in a vehicle.
- Implemented black-box optimization algorithms such as extremum seeking and Hooke and Jeeves method of optimization in design of controllers.
- Developed an on-line (real-time) learning/optimization algorithm (Reinforcement Learning) for the ACC/LKC unit in a vehicle resulting in multiple conference publications.
- Carried out performance analysis by building a co-simulation testing platform using CarSim and Matlab/Simulink.

### X-FAB Semiconductor Foundries

*Electrical Engineer Intern/Marketing Department*

Jan 2012 - May 2012

*Lubbock, TX*

- Researched the technology, structure, operations, and manufacturing process of GaN LED Micro Displays and GaN Power Transistors.
- Analyzed and determined the market size, applications, and future of GaN based products.
- Proposed profit-based manufacturing processes for future investment in the area.

#### **X-FAB Semiconductor Foundries**

Aug 2011 - Jan 2012

*Data Mining/Electrical Engineer Intern*

*Lubbock, TX*

- Monitored the Phasor Management Unit (PMU) of an SEL-421 protective relay connected to a wind turbine, powering the foundry, for transient voltage spikes, current and frequency swings.
- Wrote a software to mine and perform statistical analysis on the data received from the PMU in real-time (Data Mining and Data Analysis).
- Modeled X-Fab's electric power system from their 15kV switchgear to 120/208V panels and motors.
- Performed short circuit, load flow and protective device coordination analysis using SKM (Arc Flash Evaluation).
- Calculated fault current, breaker switching time and built a single-line model for the main electrical room using SKM.

## **PUBLICATIONS**

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### **Peer-Reviewed Journal Publications:**

- **A. Rahnama**, M. Xia and P. J. Antsaklis, "Passivity-Based Design for Event-Triggered Networked Control Systems," *IEEE Transactions on Automatic Control*, 2017.
- **A. Rahnama**, M. Xia and P. J. Antsaklis, "A *QSR-Dissipativity* Based Design for Event-Triggered Networked Systems," *IEEE Transactions on Automatic Control*, Accepted to appear.
- M. Xia, **A. Rahnama** and P. J. Antsaklis, "Control Design Using Passivity for Stability and Performance," *IEEE Transactions on Automatic Control*, Accepted to appear.

### **Peer-Reviewed Conference Publications:**

- **A. Rahnama**, A. Alchihabi, V. Gupta, P. J. Antsaklis and F. Vural, "Encoding Multi-Resolution Brain Networks Using Unsupervised Deep Learning," *IEEE International Conference on Bioinformatics and Bioengineering (BIBE)*, 2017. <https://arxiv.org/abs/1708.04232>
- Y. Yan, M. Xia, **A. Rahnama** and P. J. Antsaklis, "A Passivity-Based Self-Triggered Strategy for Cyber-Physical Systems under Denial-of-Service Attack," *IEEE Conference on Control and Decision (CDC)*, 2017 Invited Session.
- **A. Rahnama**, M. Xia and P. J. Antsaklis, "A *QSR-Dissipativity* and Passivity based Analysis of Event-Triggered Networked Control Systems," *IEEE Conference on Control and Decision (CDC)*, 2016 Invited Session.
- **A. Rahnama**, M. Xia and P. J. Antsaklis, "Passivation and Performance Optimization Using an Extremum Seeking Co-Simulation Framework with Application to Adaptive Cruise Control Systems," *American Control Conference (ACC)*, 2016.
- M. Xia, **A. Rahnama** and P. J. Antsaklis, "Performance Optimization Based on Passivation of Systems with Applications to Systems with Input/output Delay," *American Control Conference (ACC)*, 2016.
- M. Xia, **A. Rahnama** and P. J. Antsaklis, "On Guaranteeing Passivity and Performance with a Human Controller," *Mediterranean Conference on Control and Automation (MED)*, 2015.
- P. Santosh, **A. Rahnama**, M. Tovar and S. Bayne, "Power Quality Analysis of a Sensitive Load Using a Phasor Measurement Unit," *IEEE Conference on Green Technologies*, 2012.

### **Peer-Reviewed Research Reports:**

- **A. Rahnama**, M. Xia and P. J. Antsaklis, "A Passivity-Based Design for Stability and Robustness in Event-Triggered Networked Control Systems with Communication Delays, Signal Quantizations and Packet Dropouts," *the Cornell University Library*, 2016. <https://arxiv.org/abs/1704.00592>

- **A. Rahnama**, M. Xia and P. J. Antsaklis, "QSR-Dissipativity and Passivity Analysis of Event-Triggered Networked Control Cyber-Physical Systems," *the Cornell University Library*, 2016. <https://arxiv.org/abs/1607.00553>
- **A. Rahnama**, M. Xia, S. Wang and P. J. Antsaklis, "An Extremum-Seeking Co-Simulation Based Framework for Passivation Theory and its Application in Adaptive Cruise Control Systems," *the Cornell University Library*, 2015. <https://arxiv.org/abs/1607.03958>
- M. Xia, **A. Rahnama**, S. Wang and P. J. Antsaklis, "Passivation Theory and its Application to Automotive Systems," *Interdisciplinary Studies in Intelligent Systems at the University of Notre Dame*, 2015. <http://nd.edu/~isis/techreports/isis-2015-001.pdf>

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## CONFERENCE PRESENTATIONS

- IEEE Conference on Decision and Control, 2016, Las Vegas, NV
- American Control Conference, 2016, Boston, MA
- IEEE Conference on Green Technologies, 2012, Tulsa, OK

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## DATA ANALYTIC SKILLS AND TECHNICAL STRENGTHS

<b>Programming Languages</b>	C/C++, MATLAB/Simulink, Python, CarSim, SKM, Labview
<b>Statistical Computing</b>	R
<b>Digital Design Languages</b>	Verilog, VHDL (FPGAs, Microcontrollers)
<b>Circuit Design Programs</b>	PSpice, EagleCAD, OrCAD Capture/Cadence (PCB Design)
<b>Software and Tools</b>	LaTeX, Mathematica, Excel

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## UNDERGRADUATE PROJECTS

### **Line-Following Smart Robots** *Spring 2010*

Designed and manufactured an autonomous smart line-following robotic car using Digilent BASYS2 FPGA board and Xilinx ISE (VHDL). Additional to reading the course, the robotic car, could be controlled by an ultrasonic remote, and was capable of detecting and filtering the signals coming from blinking LED beacons in daylight to interpret the direction of future turns.

### **Robotic Smart MIDI Glockenspiel** *Fall 2010*

Designed and built an autonomous robotic glockenspiel with a graphical user interface (GUI), equipped with a microcontroller (Arduino) capable of reading MIDI files, and playing music —The framework controlled the solenoids connected to the glockenspiel by manipulating pulse-width signals sent to them (the electric board was designed and implemented on a PCB board).

### **Wideband Signal Generator** *Spring 2011*

Designed and manufactured a wide-range comb generator —From the initial stage to the final design on a PCB board.

### **2D Game Development** *Spring 2008*

Designed, programmed and implemented 2D games using C++ and Pascal.

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## TEACHING EXPERIENCE

**University of Notre Dame**  
*Teaching Assistant*

Aug 2013 - May 2017  
*Notre Dame, IN*

- Mathematical Programming  
Taught classes, and graded assignments
- Advanced Linear Systems  
Conducted tutoring sessions, and graded assignments

- Electronics  
Conducted discussions, laboratory and tutoring sessions, held office hours, and graded assignments, lab reports and examinations, and helped with related administrative tasks.
- Power Systems  
Conducted discussions, tutoring sessions, and graded assignments

**Texas Tech University**  
*Teaching Assistant*

Jan 2011 - May 2011  
*Lubbock, TX*

- Linear Systems  
Conducted discussion, tutoring sessions, graded assignments, helped with related administrative tasks.

## ACADEMIC ACHIEVEMENTS

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<b>The Notebaert Professional Development Award</b>	<i>Fall 2016</i>
<b>Recipient of University of Notre Dame Research Fellow</b>	<i>Aug 2013 - May 2014</i>
<b>Recipient of Texas Tech Travis Simpson Scholarship</b>	<i>Aug 2011 - May 2012</i>
<b>Recipient of Texas Tech Travis Simpson Scholarship</b>	<i>Aug 2010 - May 2011</i>
<b>Texas Tech Honors Student</b>	<i>Jan 2009 - May 2012</i>
<b>Texas Tech President's Honors List</b>	<i>Spring 2009 and Spring 2010</i>
<b>Texas Tech College of Engineering Dean's Honors List</b>	<i>Fall 2008, 2009, 2010, 2011, 2012</i>

## RELEVANT COURSES

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### Core Courses

- Cyber-Physical Systems: Verification
- Mathematical Programming
- Static and Dynamic Game Theory
- Hybrid Dynamical Systems
- Optimal Control
- Advanced Control Systems
- Advanced Linear Systems
- Advanced Digital Communication
- Advanced Digital Signal Processing
- Computer Algorithms
- Data Structure

### Related Courses

- Statistical Methods in Data Mining and Prediction
- Statistics in the Computer era
- Estimation and Detection
- Probability and Random Processes
- Set Theory
- Modern Optics for Engineering
- Higher Mathematics for Engineers and Scientists
- Advanced Programming in C/C++

## REFERENCES

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**Dr. Panos J. Antsaklis**

*University of Notre Dame, Advisor*

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**Dr. Hai Lin**

*University of Notre Dame, Committee Member*

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**Dr. Vijay Gupta**

*University of Notre Dame, Committee Member*

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**Dr. Meng Xia**

*The MathWorks, Researcher/Co-Worker*

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**Marcus Borhani**

*X-Fab Semiconductor Foundries, Manager*

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